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Draft Final Report

Carrying Capacity Based Developmental Planning for Greater Kochi region

(Volume I)

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Dedicated to

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Chapter I
Introduction

1.0 INTRODUCTION

1.1 Preamble

The State of Kerala is situated along a narrow strip of land between the Western Ghats and the Arabian sea, and has tropical climate. Abundant evergreen rain forests on the Western ghats, lush green midlands, and coconut groves in the coastal zones characterize the eye catching and breath taking landscape. The state of Kerala is endowed with an expansive body of back waters comprising lakes, lagoons, estuaries and mangrove swamps. The population density along the coastal area is around 2100 persons/km^2 as compared to the state's average of 748 persons/km^2.

In recent years, great concern has been expressed with regard to deterioration of Vembanad Lake and consequent loss of supportive functions of this wetland system, especially due to urbanization, industrialization, and agricultural activities in the down stream zones of the rivers; air quality in Greater Kochi industrial area and increasing soil erosion due to deforestation in the upland regions. As a result, the non-governmental organizations and people alike are apprehensive about the proposed developmental activities in the region. Major developmental activities proposed in the region include :

- Development of the Kochi Port as a container cargo terminal
- Urban Development Plan prepared by the Kerala Water Authority to augment water supply, sewerage, surface drainage, road and other civic facilities for Kochi, Thiruvananthapuram and Kozhikode
- Tourism development plans in Ernakulam, Thrissur, Kozhikode, Idukki, Pathanamthitta, Alleppy and Kollam
- An urban development plan connecting four islands with main land of Kochi through reclamation of land and construction of bridge
- An international stadium and a water sports stadium in the city of Kochi
- An international air port and expressways between Alwaye and Chertala
- Lower Periyar irrigation schemes besides many other private and community initiatives

With a view to ensure balanced and harmonious growth of this eco sensitive region experiencing high levels of anthropogenic pressures, the Ministry of Environment & Forests retained the National Environmental Engineering Research Institute as a coordinator of an inter institutional study on Carrying Capacity based Developmental Planning for Greater Kochi Region in April 1997. The other participating Institutions in the study are :

- Centre for Earth Science Studies (CESS), Thiruvananthapuram
- Centre for Water Resources Development and Management (CWRDM), Kozhikode
- Cochin University of Science and Technology (CUSAT), Kochi

- Kerala Forest Research Institute (KFRI), Peechi
- Kerala Sastra Sahitya Parishad (KSSP), Kochi
- Kerala State Pollution Control Board (KSPCB), Kochi
- Regional Centre of National Institute of Oceanography (NIO), Kochi

There are number of sites of cultural heritage, historical and architectural importance in the region, which should be protected and preserved. To prepare a comprehensive inventory of such sites in the region, two experts from Bombay Environment Action Group (BEAG) also participated in the study.

1.1.1 Objectives of the Project

The studies proposed herein, based on the concept of carrying capacity, include the baseline data collection through collaborating organizations/ institutions and concomitant modeling for establishing regional assimilative capacity with respect to air, water and land components of environment, as also supportive capacity analysis of the natural systems in the region. The studies will delineate a framework for developmental planning based on the premises of carrying capacity (interalia addressing the issues of regional and environmental concern) with a view to maximizing the quality of life in the region in a sustainable and environmentally compatible manner.

1.1.2 Methodology

The concept of carrying capacity is not new, and yet efforts to extend the same to the developmental planning are few. Environment, with its biotic and abiotic components, while providing the basic resources that support production consumption activities, assimilate the residues generated during the courses of these activities. The limits to development are therefore defined by supportive and assimilative capacity of a planning region. The important components of carrying capacity based developmental planning are estimation of supportive and assimilative capacities and optimal allocation of resource base to various socio-economic activities. Carrying capacity is a resource based planning tool and this capacity can be enhanced through technological and management interventions, albeit to a limited extent.

1.1.3 Overall Framework

The overall framework for the project work is planned in three phases as given below:

Phase I : (12 months, Inventorization of Resources and Assessment of Environmental Quality based on Secondary Data, Identification of Hot Spots and Action Plans)

- Inventory of resources and environmental quality from secondary data
- Identification of limiting resources and environmentally critical areas based on secondary data

- Estimation of supportive and assimilative capacities based on the analysis of most limiting resources and for limiting resources and most critical environmental areas

Phase II : (15 Months, Primary Data Collection & Analysis of Resources and Environmental Quality Data, and Evaluation of Sectoral Plans)

- Design of optimal networks for collection of air, water, land, biotic and socio-economic data as also meteorological and hydrological data
- Collection of data in critical seasons and its analysis for the estimation of assimilative capacity
- Identification of limiting resources and environmentally critical areas based on primary data
- Collection of data on indicators of supportive capacity using tools like remote sensing and GIS
- Impact of developmental activities on resources and environmental quality
- Resource allocation modeling based on secondary / primary data
- Development of action plans for limiting resources and critical environmental areas.

Phase III : (9 Months, Development of Alternate Growth Scenarios)

- Evaluation of sectoral plans vis-a-vis carrying capacity analysis
- Development of alternate growth scenarios with appropriate environmental safeguards through carrying capacity analysis
- Impact of developmental activities/growth scenarios on resources and environmental quality
- Detailing of preferred scenario to MEF
- Report preparation and submission to MEF
- Preparation of dissemination package

1.2 Study Region and its Constituents

The study region, watershed of Vembanad lake, includes catchment areas of Periyar, Chalakudi, Muvattupuzha, Meenachil, Manimala, Pamba and Achencoil rivers alongwith the adjoining coastal zones. The total study area is about 14017 km^2, located in Central Kerala, and includes three revenue districts (Ernakulam, Idukki and Kottayam) and parts of three other adjacent districts (Alappuzha, Pathanamthitta and Thrissur). The study area christened as "Greater Kochi Region" is depicted in **Fig. 1.2.1** and the district wise break up **(Fig. 1.2.2)** of the area is given below :

District	Coverage	Area (km^2)
Alappuzha	Part	1231
Ernakulam	Full	2408
Idukki	Full	4161
Kottayam	Full	2204
Pathanamthitta	Part	2357
Thrissur	Part	953
Other (Pallakkad & Kollam)	Part	603
Total		**14017**

In addition a small portion of other two districts; Palakkad in the north and Kollam in the south with 482 and 121 sq km area respectively also form a part of GKR region.

The study area accounts for about 34% of the total geographical area of Kerala with the boundaries consisting of Chalakkudy river in the North, Arabian sea in the West, Western ghats (Tamil Nadu border) in the east and Achencoil river in the South. The study area can be divided into three physiographic zones, viz. the Lowland (< 8 m above MSL), the Highland (> 76 m above MSL) and the Midland lying between Lowland and Highland.

1.2.1 Vembanad Lake

Vembanad lake is the largest of its kind on the west coast of India The chain of brackish water bodies and lakes on the coastal plains are inter-connected by extensive network of canals supporting navigation and other functions. The backwaters play a significant role in the socio-economic and cultural history of the State besides constituting an invaluable aesthetic resource. A map showing the Vembanad watershed is given in **Fig. 1.2.3**.

The Vembanad lake supports fishery wealth, waterfowls and other avian fauna, mangroves and associated vegetation, agriculture, recreation and tourism, inland navigation, port facilities and industries. Half of the population in the state of Kerala depends directly or indirectly on this wetland system or on the resources of the drainage basins of this system. A range of interventions, different from each other in type and magnitude, have taken place in the region such as salinity barriers, flood water drains, irrigation and hydroelectric reservoirs and industrial complexes in the drainage basins and have altered the dynamics of the system considerably.

The estuaries and the wetlands, that serve as buffer for draining 2100-5100 cum/sec of water in riverine systems, constitute the nursery grounds for one-third of the economically important fishery resources of the country. The Cochin backwaters, a constituent of Vembanad estuary are experiencing high levels of anthropogenic pressures during the last five decades.

The population pressure (population density in cochin corporation area is above 5500 persons/km^2); reclamation of land (694.19 ha during 1920-85) for harbour and urban development, intensive exploitation of nursery and breeding areas in backwaters; discharge of untreated/partially treated sewage and industrial effluents; and ever increasing sediment load being transported through rivers due to the deforestation in catchments areas contribute to the environmental pressures on this sensitive ecosystem.

1.2.2 River Basins

The associated drainage basins are situated in the region and the rivers of this region are generally short, steep, fast flowing and monsoon-fed. One of the striking features of the region is the continuous chain of lagoons or backwaters existing along its coastal region. These water bodies directly receive the river flows and convey the same to the sea through small openings in the sandbars called ***Azhi***, if it is permanent, or ***pozhi***, if it is temporary.

The river basin areas under the GKR are as follows :

River Basin	Basin Area (km^2)	Length (km)
Chalakudy	1700	130
Periyar	5400	244
Muvattupuzha	1550	121
Meenachil	1250	78
Manimala	850	90
Pamba	2250	176
Achencoil	1500	128
Total	**14500**	**967**

The basins altogether cover an area of about 14500 km^2 out of which 22% lies in the lowland, 23% in the midland, and the remaining 55% in the highland. The rivers flow down the highlands over steep slopes of almost 60m/Km and more, and traverse their midland stretches with much flatter slopes of about 1m/Km and more. The largest river joining the wetland system is Periyar with a basin area of 5400 km^2.

All these rivers originate from the Western Ghats, flow towards the west and join the Arabian sea, flowing through the wetland system (**Fig. 1.2.4**). There are four openings into the sea along the coastline of the study area where the backwaters join the sea. These are at Thottappally, Andakaranazhi, Kochi and Azhikode. At Thottappally, a spill way exists and the mouth is closed by a sand bar and it opens only during southwest monsoon season. The opening at Andakaranazhi also opens only seasonally. The major opening is at Kochi where the mouth is open throughout the year and the exchange between the Kochi backwaters and sea occurs here. At Azhikode (Munambam) also the barmouth is open throughout the year. These openings are important in exchanging the water between the backwaters and the sea that affects the ecology and controls the environmental quality of the backwaters.

1.2.3 Geological and Soil Characteristics

Geologically, the major rock formations of the area are classified into four groups:

- crystalline rocks of the Archaean age mainly in the highland.
- sedimentary rocks of the tertiary age,
- laterite capping over crystalline and sedimentary rocks mainly in the midland, and
- recent and sub-recent sediments forming the low-lying areas and the river valleys.

Forest loams occur in the highlands. The midland zone is characterized by lateritic formations interspersed with brown hydromorphic soils. Riverine alluvium is found in the flood plains of the rivers while coastal alluvium predominates in the coastal belt. Patches of black or kari soils are found in certain locations in the lower reaches of the basin system, mainly in the wetlands.

1.2.4 Hydrological Features

The study area experiences two distinct rainy seasons during the south-west monsoon (Jun-Aug) and the north-east monsoon (Sep-Nov). About 60% of the rainfall is during the south-west monsoon, 30% during the north-east monsoon and the remaining 10% in the summer months. The average annual rainfall in the area is 3200 mm with more rainfall in the highlands in comparison to the lowlands. During the period June-August, the average number of rainy days in a month is about 22, and during May, September, October and November, these are 15. There is a significant variation in the spatial and temporal distribution of rainfall in the drainage basins of the wetland system. It is estimated that on an average, these seven rivers discharge 19512 Mm^3 of water into the wetland system annually, of which 16175 Mm^3 is during the monsoon period (Jun-Nov) and 3337 Mm^3 in the lean period (Dec-May). The average annual discharges in the rivers range between 1167 Mm^3 in the Chalakudy and 5180 Mm^3 in the Periyar rivers

Situated in the humid tropics, the region experiences fairly uniform temperature throughout the year, ranging from a minimum of 21° C to a maximum of 36° C. The average relative humidity is 80%. Average evapo-transpiration rate is about 120 mm/month, the peak daily evapotranspiration being 5 mm in March.

The river Periyar, Muvattupuzha, Meenachil, Manimala, Pamba and Achencoil flow into the Vembanad lake which has its natural outlets at Kochi and Kodungallur. **Table 1.2.1** presents details on the monsoon and the lean flows of the rivers draining into the Vembanad wetland system alongwith the utilizable surface water potential.

1.2.5 Hydro-geological features

Strati-graphically, the wetland region, especially that of the southern river basins, may be divided into three major zones, viz. the coastal alluvium, lateritic and rock strata. Each of these present peculiar hydro-geological conditions in the river basins as established by geophysical studies which are essentially followed by exploratory drilling at selected sites in some of the river basins, viz, Pamba, Manimala, and Achencoil. Groundwater occurs under phreatic conditions in the alluvium, lateritic formations and the weathered and fractured crystalline rock aquifers and confined conditions in the Tertiary sediments.

The coastal alluvium comprises of sand, clay and silt and is associated with good groundwater aquifers. This zone supports large number of open wells which meets the domestic needs of the people to a great extent. The depth to water table varies from 1.5 to 4.0 m below ground level in the southern basins (from Periyar to Achencoil), and between 1.5 and 5.0 m below ground level in the case of northern basins (from Chalakkudy to Keecheri). Similarly, depths of the wells in the region generally range from 2.5 to 6.8 m in the southern regions, the corresponding values for the northern regions are 3.0 to 6.5 m.

The laterite formations peculiar to the west coast of the peninsular India, are potential aquifers due to their intrinsic water storing and transport characteristics. The laterites occur in the uplands towards the southern stretch of Kerala and move closer seawards in the northern parts. During the monsoon season, the laterites get fully recharged. But as soon as the rainy season recedes, these aquifers are rather completely drained dry causing acute water scarcity in the uplands.

Weathered, partly weathered and fractured rocks in the crystalline form potential phreatic aquifers supporting a large number of dug wells for domestic needs. The seasonal water table fluctuations range from 0.8 to 6.7 m.

1.2.6 Functions of the Vembanad Lake

1.2.6.1 Water Transportation

The waterways formed by backwaters, estuaries, lagoons and canals, spreading over 196 km in the north-south and 29 km in the east-west directions.

play an important role in the transportation system of the Vembanad region; almost all the villages here are accessible through water transport. The Muvattupuzha, Meenachil, Pamba and Achenocoil rivers, which drain into the lagoon, are navigable to a distance of about 30 km upstream in the tidal reach. The Kottappuram - Chettuva waterway supports the inland navigation through the heart of Kol lands.

The inland waterways handled 1.74 million MT (11.84%) of cargo in the year 1996. The major goods that move along the waterways include sand and clay, hay, rice, coconut copra, provisions, firewood, bricks and tiles, gravel, coconut husk, etc.

1.2.6.2 Tourism

The Vembanad backwater and its environs have great potential for ecotourism in India. The Vembanad Kayal backwater system with its extensive network of rivers, lakes, canals and lagoons fringed by lush green coconut groves and paddy fields harbouring a variety of birds is one of the most beautiful backwater systems. There are many historic places situated on the banks and hinterlands of the Vembanad backwaters.

During monsoon season, several spectacular boat races of magnificent wooden boats take place in the backwaters which attract thousands of spectators including foreign tourists. The history of the boat races dates as far back as 15th century when the boats were used for military battles between warring kings. The most exciting races of different categories of boats are the Nehru Trophy, and the race associated with the Lord Parthasarthy temple festival at Aranmula in which the procession of decorated boats is a breath-taking spectacle.

The Vembanad wetland system is a heaven for ornithologists and bird lovers because of its rich avifauna. The bird sanctuary situated in the tourist complex at Kumarakom shelters different types of resident and migratory (including Siberian storks) bird species and provides excellent opportunities for bird watching. A special feature of this sanctuary is its richness of both nocturnal (owls and certain storks) and diurnal birds which make the woods lively round the day.

Pathiramanal is a charming island situated in the middle of the Vembanad lake which is a true gift of nature. This sandy island of coconut groves has the potential to become the focal point of backwater tourism in the area. Further, various small islands of Kochi that appear as string of jewels in the Kochi backwaters can become important centers of tourism, if properly developed.

1.2.6.3 Agriculture

The area cultivated with rice in the Kuttanad lies generally between Mean Sea Level and 2.5 m below it. The rice fields are surrounded by open water channels which are directly linked to the fresh water sources. In the areas lying between Mean Sea Level and 1 m above, coconut, cocoa, banana and other mixed crops are cultivated. The six agro-ecological zones of Kuttanad with details of rice production are given in **Table 1.2.2**. The details of land reclaimed from Vembanad for agriculture and industrial purposes are given in **Table 1.2.3**.

1.2.6.4 Aquaculture

Data on nutrients and primary productivity available from the estuarine tracts of Kerala are encouraging and it throws up great hope for developing aquaculture in the State. Generally, concentration of nutrients is less in surface water than in the rest of the water column owing to phytoplankton growth; this is periodically replenished by the decomposition of organic matter and by the diffusion and turbulent mixing from the water below.

Prawn filtration in the adjoining rice fields of backwaters is a unique feature of the inland fisheries of Kerala. The earliest form of brackish water aquaculture is represented by the conventional prawn farming being undertaken in the low-lying rice fields close to the estuaries and lower reaches of rivers confined to Ernakulam, Thrissur, Alappuzha and Kottayam districts (**Table 1.2.4**)

1.2.6.5 Assimilation of Waste

The Vembanad backwater receives considerable quantities of industrial effluents, agrochemical, municipal and domestic wastes, most of these untreated. Though the water body has been resilient enough to effectively assimilate the pollution load in the past, symptoms of deterioration have already been observed. The major townships of Kochi and Alapuzha release a pollution load of 195547 and 64237 kg/day of BOD respectively to the Vembanad backwaters (KSPCB 1991). The annual fertilizer consumption in the Kuttanad area is given in **Table 1.2.5**.

1.2.6.6 Ground Water Recharge

Various water bodies of the region serve as percolation tanks to recharge the groundwater. Lean flow of Muvattupuzha river is about 1020 Mm^3 and the same reaches the wetland. The details on lean flow of other rivers are given earlier in **Table 1.2.1**, whereas the details of utilizable yield and storages in the important rivers are given in **Table 1.2.6**.

1.2.6.7 Flood Control

The drainage characteristics strongly influence the fluvial features of the rivers in the basin and in turn the basic hydrology of the wetlands. The wetland system functions as receptacle to the monsoon flood flows. It is estimated that such monsoon flows into the Vembanad Lake is around 18840 Mm^3 and the lake protects the areas west of it from severe floods. Occurrence of annual average flows (1984-88) and peak discharges (1964-92) alongwith the data of the five rivers draining into the Vembanad are given in **Table 1.2.7**.

The major intervention for flood control in the Kuttanad area of the Vembanad backwater was the Thottappally spillway constructed in 1955. The channel was expected to drain water from Manimala, Meenachil, Pamba and Achenocoil rivers. It was also envisaged to divert 142 m^3/s to the adjacent Kayamkulam backwater. However, the spillway, as it turned out later, could not considerably change the flood condition of the Kuttanad area. Major limitations of the Thottappally spillway are:

- the spillway intended to drain 1811 m^3/s of flood waters could never drain more than one-third of it since its completion in 1955;
- required information on hydraulic characteristics was not available at the time of designing;
- alignment of the channel was not scientifically done;
- the monsoon swells and formation of sand bars at the mouth were not considered;
- the original design length and width of the channel were cut down from 1311 m to 348 m and from 368 m to 30 m respectively.

1.2.7 Major Interventions in the Vembanad Wetland System

1.2.7.1 Port of Kochi

Within the wetland system, the earliest human intervention was in the form of dredging for a major natural harbour at Kochi and subsequent reclamation for locating the port facilities. In order to house the berths and wharves and other facilities, an entirely new island - the Wellington island - was created during 1838-1845 with a land area of 6.5 km^2. Presently, the Kochi harbour, a railway terminal and an airport are located in this island

1.2.7.2 Embankments for Rice Cultivation

In the Kuttanad region, construction of embankments (bunds) in the shallow parts of the backwaters started at least a century ago. The purpose was to create large tracts of land in which the non-monsoon season rice crop could be grown between the end of the flood season (Nov) and the time in the dry season when water becomes too saline for agriculture. In course of time, these *padasekharams* or group of fields have grown even to areas where water is 2.5 m deep, and people started to settle on the embankments. Construction of embankments halted about four decades ago and the emphasis switched over to making the land more productive.

1.2.7.3 Thottappally Spillway

The Thottappally spillway, completed in 1955, was built in the southernmost part of Kuttanad to divert a part of the combined flood waters of Achencoil, Pamba and Manimala are easy and more direct outlets to the sea flood waters of which would otherwise find their exit through the Kochi mouth after traversing about 75 km. The objective was to limit flood below the embankment Regulating the flood waters had the objective of enabling cropping during the wet season in the *padasekharams*. Flood carrying capacity of the spillway is far below the actual flood. Moreover, every year, a sand bar is formed at the mouth of the spillway which has to be removed at the onset of the monsoon to release the flood waters

1.2.7.4 Thanneermukkom Bund

Thanneermukkom bund constructed across the Vembanand lagoon to prevent salinity intrusion was commissioned in 1975. It was built in the narrowest portion of the Vembanad lake to prevent the ingress of salinity into the plodders of Kuttanad during summer and also to retain the fresh water from the rivers flowing into the lake. It is about 1250 m long with 93 ventways, each 12.2 m wide and 5.5 m high and the sill is at an elevation of 4.28 m below Mean Sea Level Only two-third of the originally designed numbers of gates have been constructed

For navigation purposes, a twin-lock has been provided. The shutters of the barrier are opened in July to let out flood discharge and closed by mid-November The structure has been relatively successful in keeping the water in the kuttanad free from salinity, enabling increased cropping in the dry season. Several drawbacks have been noticed, the major ones are: reduction in the upstream migration of marine fish and prawns and increase in weed growth in the upstream. It has severely restricted the natural flushing of pollutants too

1.2.7.5 Pathalam Bund

The Pathalam bund, a temporary barrage, is constructed each year on the Eloor branch of Periyar river since 1981, to prevent salinity ingress from Vembanad backwater and contamination of the water supply for the industrial units (Rare Earths, FACT etc.) located there.

Table 1.2.1

Selected Hydrologic Parameters of the River Basins

River	Drainage Area (km^2)	Monsoon Flow (Mm^3)	Lean Flow (Mm^3)	Total (Mm^3)	Utilizable Yield (Mm^3)
Chalakudy	1404	1102	65	1167	575
Periyar	5284	4725	455	5180	3572
Muvattupuzha	1554	3760	1020	4780	2270
Meenachil	1272	887	303	1190	562
Manimala	847	1070	147	1217	737
Pamba	2235	3221	740	3961	2700
Achencoil	1484	1410	607	2017	1101
Total	**14080**	**16175**	**3337**	**19512**	**11517**

Source: Department of Public Works, 1974

Table 1.2.2

Agro-ecological Zones of Kuttanad: Area and Production of Rice

(Year 1987-88)

Name	Area (ha)	Production of Rice (MT)	
		Punja	Virippu
Upper Kuttanad	8276	34400	7200
Kayal	9168	38900	7700
Vaikom	7749	7500	14500
Lower Kuttanad	16280	64000	30600
North Kuttanad	6556	13700	8100
Purakkad Kari	4310	8400	5600
Total	**52339**	**166900**	**73700**

Source: Secondary data collected by KSSP, 1992

Table 1.2.3

Land Reclaimed from Vembanad for Agriculture and Industrial Purposes

Purpose of Reclamation	Period	Land Reclaimed (ha)	% of Lake Area
Rice cultivation	1834-1903	2226.7	6.10
Rice cultivation	1912-1931	5253.2	14.40
Rice cultivation	1941-1950	1325.0	3.63
Thanneermukkom bund etc.	1975	6900.0	10.90
Thanneermukkom bund etc.	1970-1984	800.0	2.20
Agriculture, residential plots, husk retting etc.	1900-1984	1500.0	4.11

Source: Secondary data collected by KSSP, 1992

Table 1.2.4

Prawn Filtration in Rice Fields (Pokkali)

District	Alapuzha	Kottayam	Ernakulam	Thrissur	Total
Area (ha)	2364	75	4663	724	7826

Table 1.2.5

Annual Fertilizer Consumption in Kuttanad Region

Crop	**Fertilizers Consumption (MT)**		
	N	**P**	**K**
Paddy-Virippu (First crop)	2358	1273	1577
Paddy-Mundakan and Punja (Second and third crop)	4481	2393	3144
Coconut	914	757	1399
Banana	111	77	193
Cocoa	67	40	102
Vegetables	33	36	29
Tapioca	18	16	64
Plantain	83	82	86
Others	344	380	192
Total	**8409**	**5044**	**6786**

Source : Indo-Dutch Mission Report, 1989

Table 1.2.6

Annual Utilizable Yield and Storages in the Rivers

River	Utilizable Yield (Mm^3)	Storage (Mm^3)	Storage (%)	Outflow (Mm^3)
Periyar	3572	3258	91	314
Pamba	2700	495	18	2205
Chalakudy	575	186	32	3905
Muvattupuzha	2270	-	-	-
Kanuvannur	720	436	605	284
Keecheri-Puzhakkal	345	1812	5	3269

Table 1.2.7

Annual Average Discharges, Peak Discharges and the Dates of Occurrence

(Year 1984-88)

River	Annual Average Discharge (Mm^3)	Peak Daily Discharge (m^3/s)	Date of Occurrence
Pamba	3961	1725	Aug 9, 1990
Achencoil	2017	605	Oct 11, 1992
Manimala	1217	553	Jun 8, 1991
Meenachil	1190	991	Oct 10, 1992
Muvattupuzha	4780	1530	Jun 26, 1985

Source: Secondary data collected by CWRDM

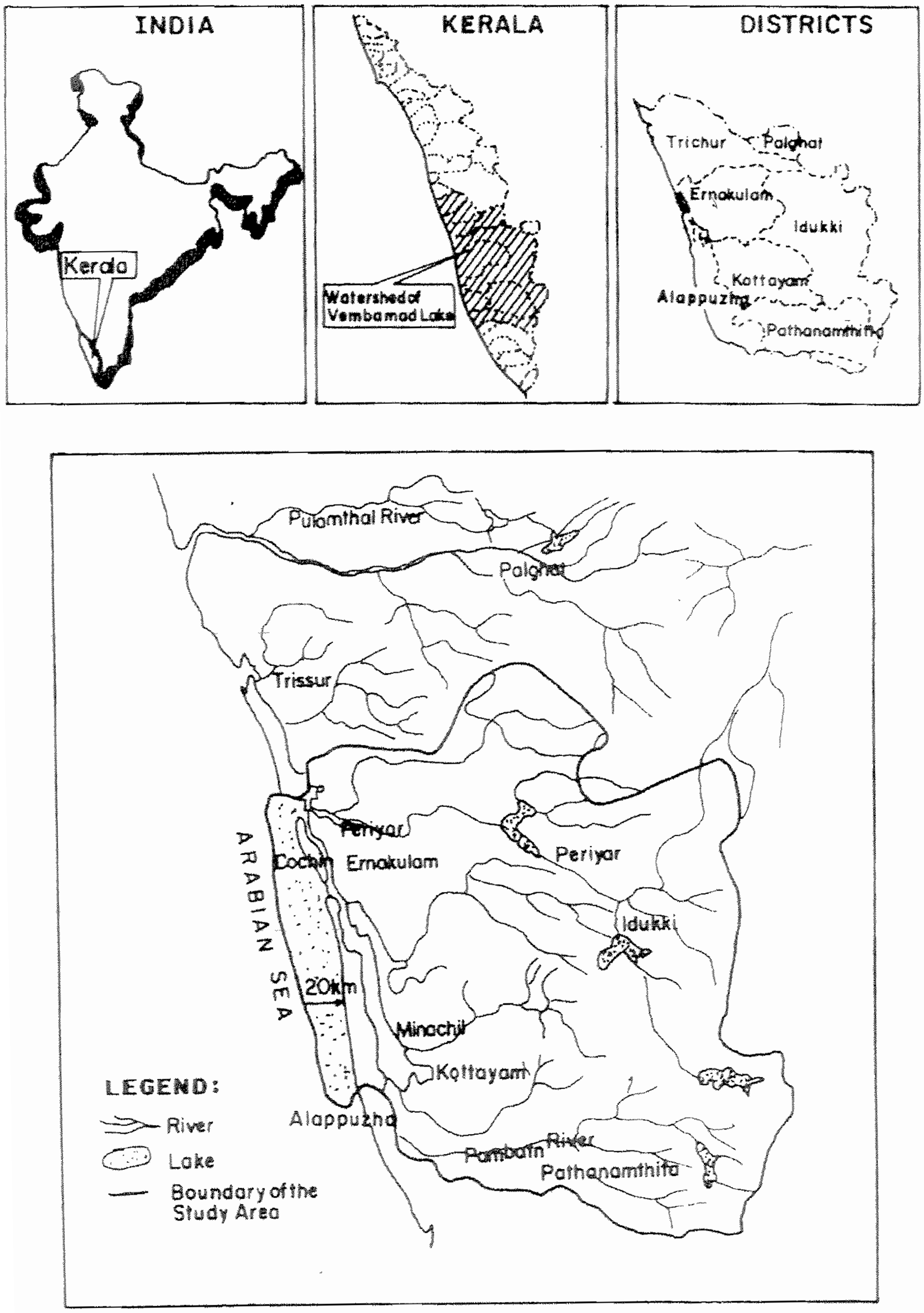

Fig. 1.2.1 : Location of the Study Region

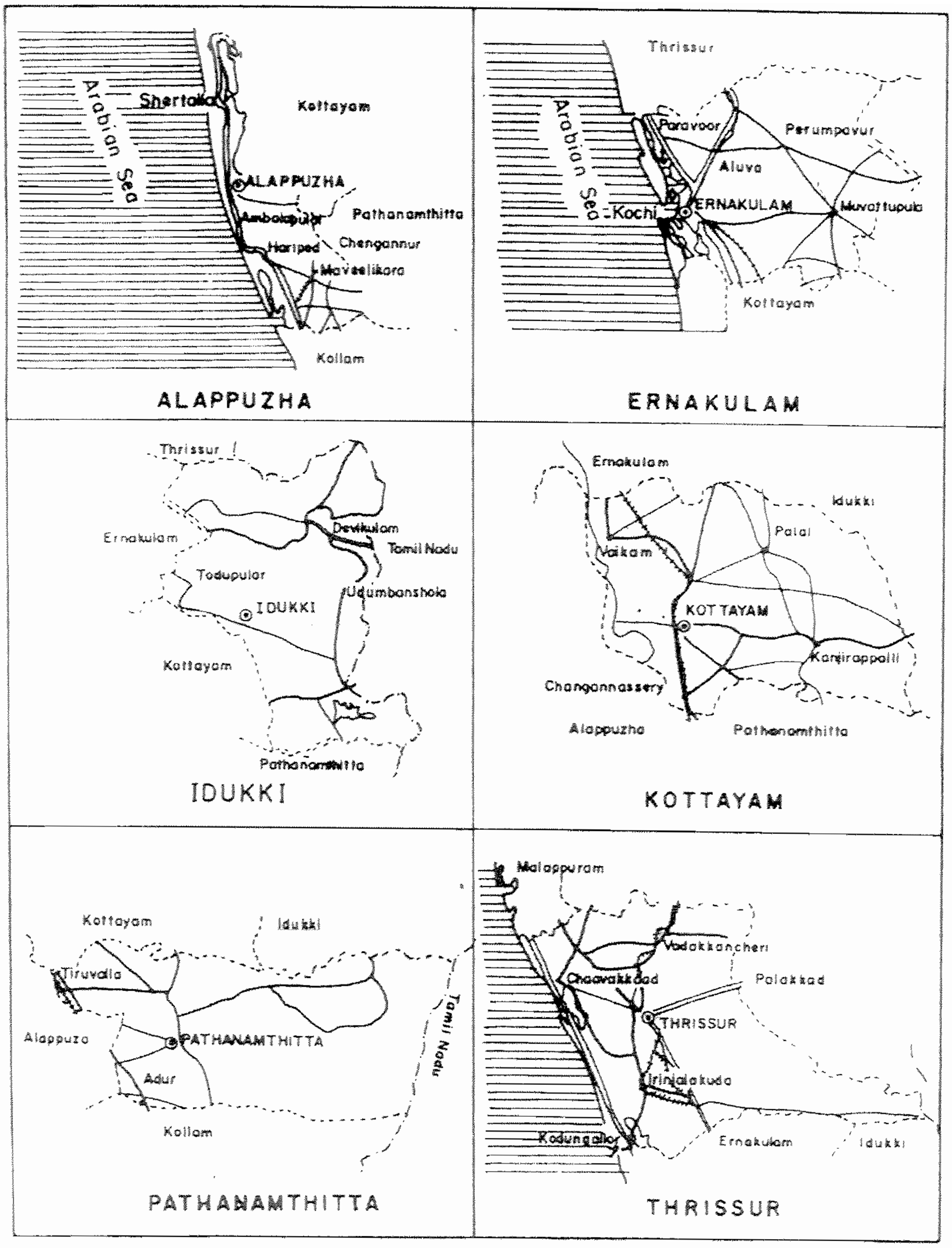

Fig. 1.2.2 : Different Districts of the Greater Kochi Region

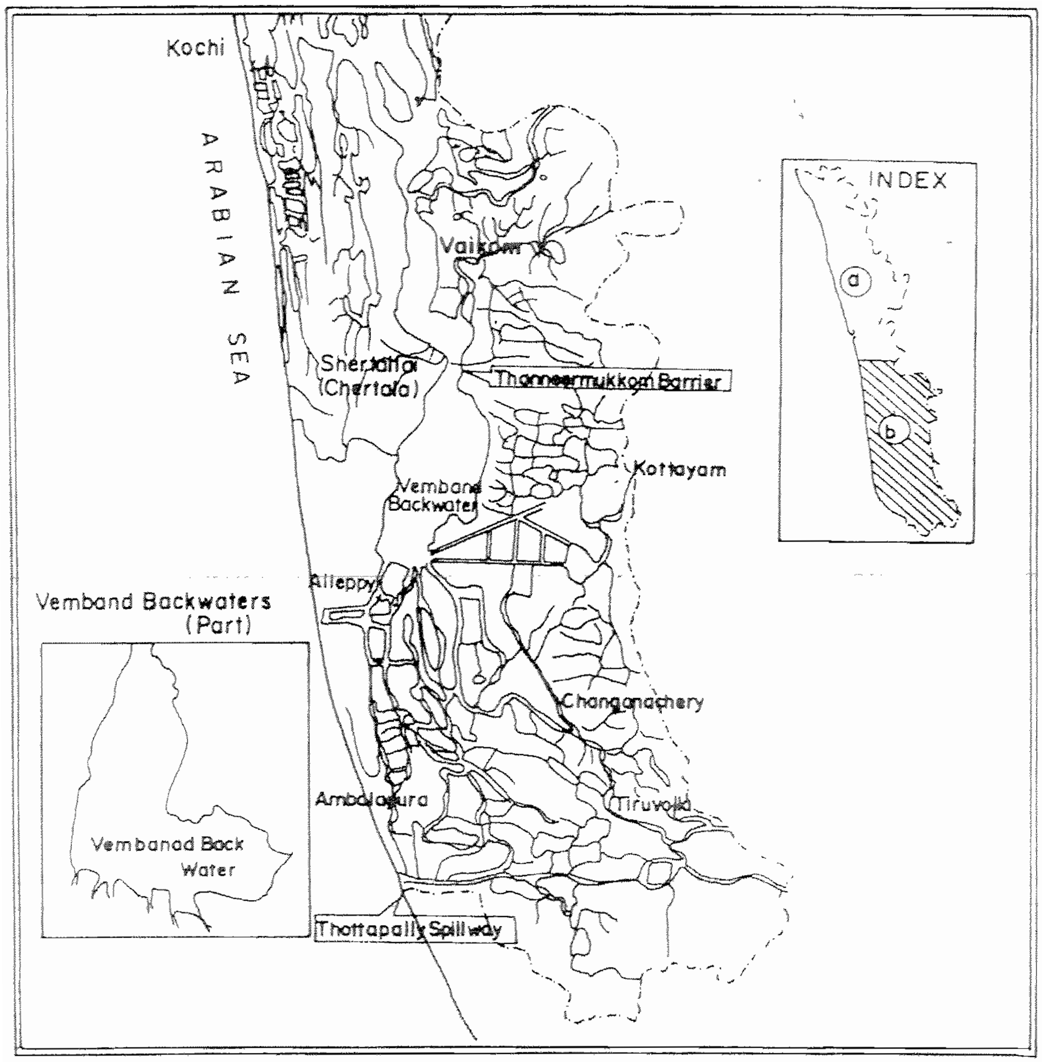

Fig. 1.2.3 : Watershed of Vembanad Lake

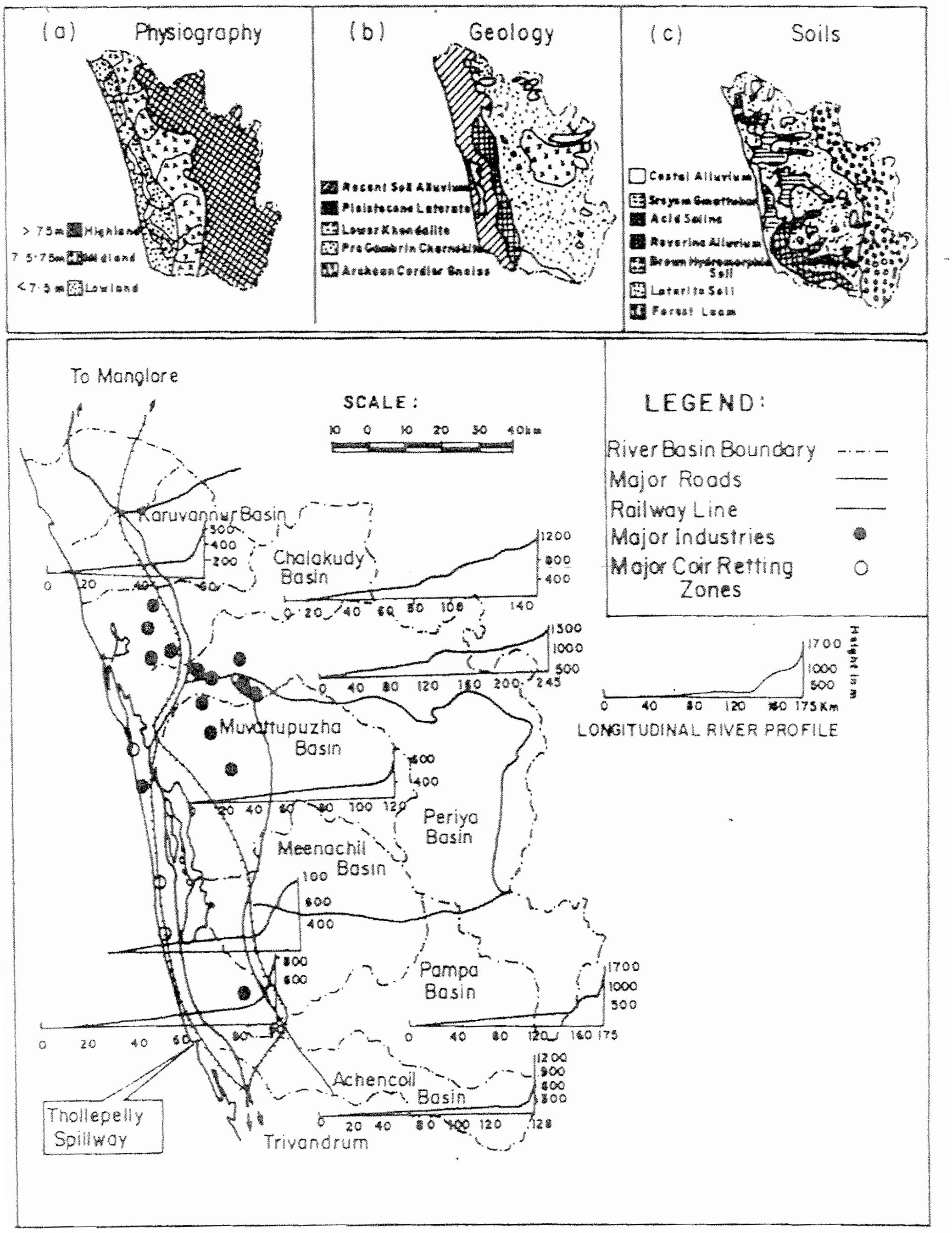

Fig. 1.2.4 : Physiography, Geology and Soil Characteristics and Longitudinal Profiles of the Rivers in Greater Kochi Region

1.3 Carrying Capacity based Developmental Planning Process for Greater Kochi Region (GKR)

1.3.1 Concept of Carrying 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 the bio-productivity and ecological integrity. For ecosystem, carrying capacity provides the physical limits to economic development governing the maximum rate of resource consumption and waste discharges.

While recognizing societal dependence on many ecological resources and functions for its survival and well-being, carrying capacity is ultimately determined by the single vital resource or function in least supply. Working within the limits of carrying capacity does not, however, preclude some unavoidable environmental damage in the course of development.

The concept of carrying capacity implies that improvement in the quality of life is possible only when the pattern and levels of production-consumption activities are compatible with the capacities of natural environment as well as societal preferences. The carrying capacity based planning process thus involves the integration of societal expectations and ecological capabilities by minimizing differentials between realized and desired supply/demand patterns, infrastructure/congestion patterns, resource availability/resource use patterns, and assimilative capacity/residual patterns.

Given certain flow of resources, the carrying capacity based planning process uses various modeling and analytical techniques to estimate changes in carrying capacity indicators, and makes trade-offs like changes in technology and pricing pattern, changes in environmental system structures, changes in socially acceptable capacity levels, and control of exogenous forcing functions.

1.3.2 Framework for Carrying Capacity based Developmental Planning Process for Greater Kochi Region (GKR)

Planning for development within the limits of carrying capacity recognizes that mankind is dependent on the productive capacity of ecosystems, and that some minimal level of ecosystem integrity is, therefore, essential for human survival. The elements of carrying capacity are depicted in **Fig. 1.3.1**.

The estimation of carrying capacity provides an operational framework enabling planning for sustainable development. In ecological terms, any level of economic activity that does not exceed the carrying capacity of the planning region is sustainable. While human society depends on many ecological and economic resources for survival, carrying capacity is ultimately determined by the single vital resource in least supply.

Carrying capacity may be viewed as the ability to produce desired outputs (goods and services) from a limited resource base while maintaining desired environmental quality levels in the planning region. For an open system, the definition should further allow for import of resources (raw materials, goods and services), and export of products.

Planning for sustainable development calls for trade-offs between the desired production-consumption levels through the exploitation of supportive capacity within its regenerative capacity and environmental quality within the assimilative capacity of regional ecosystem. The utilization of carrying capacity, thus, requires a series of adjustments to reconcile competing operations in developmental process. The ecological interactions of production-consumption processes with environment are depicted in **Fig. 1.3.2**.

In keeping with the concept of carrying capacity, improvement in the quality of life is possible only when the pattern and levels of production-consumption activities are compatible with the capacities of the natural environment as well as with societal preferences. The carrying capacity based planning process thus involves the integration of societal expectations and ecological capabilities. A conceptual model for the carrying capacity based planning process is depicted in **Fig. 1.3.3**.

The operational framework for the internalization of the concept of carrying capacity in decisions related to developmental planning involves :

- Estimation of supportive capacity
- Estimation of assimilative capacity

Allocation of resources to various socio-economic activities for maximization of the quality of life.

The operational framework for carrying capacity based planning process is depicted in **Fig. 1.3.4**. The role of various participatory groups, viz. the study groups, experts, analysts, decision makers and people are indicated in **Fig. 1.3.5**. Thus the carrying capacity based developmental planning is translated into a bottom-up and participatory planning exercise for internalizing the environmental considerations in developmental planning.

As both supportive and assimilative capacities can be enhanced through technological, managerial and organizational interventions; albeit to a limited extent; the carrying capacity studies also necessitate evaluation of the role of these interventions. Accordingly, this project aims at the delineation of guidelines for decision-making related to overall regional development within the GKR The project addresses the following specific issues :

- Study of existing human settlements alongwith related issues and projection of regional growth scenarios in future
- Assessment of supportive and assimilative capacities
- Delineation of optimum resource allocation strategy
- Study of administrative, institutional and interagency issues

- Preparation of guidelines for decision-making based on environmental considerations
- Preparation of short and long-term action plans to be implemented by concerned agencies
- Delineation of alternate developmental / growth scenarios and the preferred scenario for a period of 25 years.

The studies have been undertaken in three phases as indicated in previous section.

1.3.3 Carrying Capacity Dimensions in GKR

1.3.3.1 Assimilative Capacity Dimensions

Human health and welfare, food security, industrial development and the ecosystem on which they depend are all at risk, unless the resources are managed more effectively during the present decade and beyond, than they have been in the past. The well-being of people at present and future demands immediate and effective action. Concerted action is needed to reverse the present trend of inequitable resource consumption, and overwhelming shortages and environmental degradation. A proper management plan is essential for judicious utilization of resources for sustainable development.

The socio-cultural roots of present environmental crisis lie in the paradigms of scientific materialism and economic determinism which fail to recognize the physical limit imposed by ecological system on economic activity. The economies must expand within ecosystems which have limited regenerative capacities. Contrary to neoclassical theory of continuous material growth, economic activities directly determine the potential for development through over exploitation of natural resources and indirectly compromise future production through discharge of residuals. There is a limit to the capability of ecological systems in accepting the residuals without discernible changes in the quality of recipient bodies.

1.3.3.1.1 Air Environment

Assimilative capacity of air environment is the maximum amount of pollution load that can be discharged without violating the best designated use of the air resource in the planning region. The phenomena governing the assimilative capacity of air environment include dilution, dispersion, phase transformation, deposition and absorption.

The air pollution assimilation potential of an air shed, primarily encompassing plain terrain, can be estimated as the ventilation coefficient which is an indicator of horizontal as well as vertical mixing potential. Estimation of assimilative capacity for air environment involves :

- Delineation of air shed based on topography of the area and identification of micro-climatic zones depending upon sources, topography and wind fields data
- Preparation of inventory of point, area and line sources
- Quantification of emissions from all existing sources and determination of emission factors of all possible futuristic sources
- Establishment of temporal and spatial variations of micro-meteorological parameters through in-situ measurements; portable monitoring system, minisonde or acoustic radar, and temperature and wind profiles
- Prediction of temporal and spatial variations in air pollutants concentration for existing sources using multiple source-receptor model to establish source-receptor relationships
- Estimation of available assimilative capacity in critical micro-climatic zones for various pollutants vis-a-vis air quality standards for sensitive receptors
- Establishment of the upper limits of pollution load in critical pockets
- Stipulation of permissible emission levels for point and line sources and associated control technologies based on cost benefit analysis
- Delineation of assimilative capacity based area development plan for different growth alternatives.

The majority of non-point (non industrial) sources, predominantly encountered in GKR, have the emission heights within few meters from ground level and the assimilative capacity shall be governed by deposition of pollutants and micro-meteorology. However, vertical convective transport of pollution is low during night hours. The assimilative capacity in the coastal region shall vary with the ventilation coefficient. As such, it involves :

- Delineation of explicit zone of high emission industrial estates and quantification of temporal emission variations
- Collation of baseline information on meteorological characteristics and spatial distribution of source types on qualitative demarcation of air sheds
- Estimation of the assimilative capacity through quantification of pollutants, vertical and horizontal diffusion and removal kinetics

1.3.3.1.2 Noise Environment

The assimilative capacity of the acoustic environment is the maximum amount of noise load that can be discharged into the environment without causing private or public nuisance (unlawful interference to individuals or community) for the designated use of land units. The phenomena governing assimilative capacity for noise include propagation of sound through ambient air, and its absorption, scattering and divergence. There is a decrease in sound pressure levels with distance from the source due to atmospheric effects or interaction with the objects in the transmission path. This decrease, called attenuation, is due to air absorption, availability of vegetation, and barriers

The air absorption is significant at longer distances and at higher frequencies The consideration of air absorption in reducing noise levels in the environment is accorded low priority

Walls or barriers located in the transmission path provide a significant noise reduction The barrier consists of solid walls, earthberms and other solid nonporous objects interrupting direct path or line of sight between the source and the receiver An attenuation of 24 dBA is regarded as a practical limit for barrier attenuation. Attenuation due to vegetation is also important and is of the order of 10 dBA per 100 m width of vegetation at the frequency of 1000 Hz. The study of assimilative capacity for the noise environment involves :

- Identification of driving forces i.e. location of industries, commercial zones, traffic activities etc. in the region that are likely to result in increase of noise levels
- Characterization of sources of noise by measurement of noise equivalent levels (Leq) during day and night
- Monitoring of spatial and temporal variations of noise in sampled land units
- Prediction, and distribution, of noise equivalent levels in sampled land units
- Estimation of assimilative capacity in critical zones vis-a-vis noise standards considering the attenuation factors
- Establishment of upper limits of noise load in the critical pockets

1 3 3 1.3 Water Environment

Assimilative capacity of water bodies is defined as the maximum amount of pollutant load that can be discharged without impairing water quality for their designated best usage. The basic phenomenon governing the assimilative capacity of water sources is the self-purification capacity. Estimation of assimilative capacity of water environment involves :

- Delineation of watersheds based on topography of the area
- Identification of receiving bodies of water
- Identification of present and designated usages for various stretches of water bodies
- Preparation of inventory of point and non-point sources of water pollution
- Collection of hydrological data in critical seasons
- Estimation of assimilative capacity in critical season vis-a-vis the designated best usage of identified stretches
- Establishment of upper limits of pollution load in critical stretches

1.3.3.1.4 Land Environment

Assimilative capacity of the land environment is expressed as the upper limit of extraneous constituents which can be accommodated in the soil matrix without impairing its productivity for best designated usage.

Land quality dimensions which play important role in the determination of the assimilative capacity are cation exchange capacity of soil, presence of carbonates, oxides, and hydroxides; organic matter content; hydraulic conductivity of soil; and physiological nature of plant species. Estimation of land assimilative capacity involves following considerations:

- Compounds that degrade or require plant uptake for assimilation in the plant-soil system, e.g. oils or specific organics
- Compounds that are relatively immobile and non-degradable and thus have the potential to accumulate in soils to critical levels, e.g. heavy metals
- Mobile and non-degradable compounds which must be assimilated over land areas so that the contagious surface water and ground water bodies are not affected/altered to a degree that would require further treatment

Disposal of sewage sludge, and municipal and industrial wastewaters on land has been practiced in India since ages. It helps in promoting the concept of waste recycle by taking advantage of physical, chemical and biological processes; reuse of useful components in the waste for bio-mass production; replenishment of natural resources; and recharge of ground water. However, the assimilative capacity of soils vary considerably and it is necessary to ascertain the physico-bio-chemical properties of soil, nature of waste, biomass to be grown; and environmental conditions in the design of an environmentally compatible waste management system. The land environment assimilative capacity estimation warrants :

- Preparation of inventory of municipal and industrial solid wastes
- Preparation of inventory of waste disposal sites
- Identification of degraded/wastelands and productive lands presently in use for waste disposal
- Estimation of assimilative capacity of soils for liquid and solid wastes through soil-waste interaction using lysimeters
- Establishment of upper limits of pollution levels in critical pockets

1.3.3.1.5 Biological Environment

Assimilative capacity of biological environment is the capacity of plants to adsorb or absorb pollutants without plant damage. It is dependent on plant-specific and pollution-specific parameters. There are significant variations in pollution assimilation capacity of different plants. The phenomenon for assimilation of waste generated from anthropogenic activities remains same in the hilly as well as plain terrains. The assimilative capacity being assessed by quantifying the sink potential index shall be applicable to both the zones. The estimation of assimilative capacity of biological environment involves:

- Delineation of study zones based on secondary data and initial (literature) survey
- Selection of study-grids on the basis of bio-environmental and pollutant-specific features
- Collection of base-line information on vegetation characteristics
- Study of spatial distribution of species through quantification of diversity indices
- Estimation of the assimilative capacity through quantification of sink potential indices
- Modification of sink potential indices for more precise quantification of the assimilative capacity
- Establishment of upper limits of pollution load in critical pockets

1.3.3.2 Supportive Capacity Dimensions in GKR

The supportive capacity of a region is the capacity of the ecosystems to provide resources for various anthropogenic activities in the defined planning region without impairing bio-productivity and ecological integrity. The resource base of a region could be categorized into ecological and economic resources; transformational resources; infrastructural and distributive resources; and socio-cultural and amenity resources. The scheme of resource classification for a typical region is presented in **Table 1.3.1**.

Pragmatic utilization of these resources warrants establishment of functional relationships between the resources and their usages. The resources should also be assessed for renewability, mobility, and quality. Thus, the estimation of supportive capacity involves:

- Assessment of present and future levels of consumption vis-a-vis requirements for the salient resources
- Assessment of potential for resource enhancement and management through technological, organizational and managerial interventions

The steps involved in estimation of supportive capacity of resources are:

- Assessment of land-water interaction, delineation of present uses of land and water resources and detailing guidelines for future use
- Assessment of current land use in agriculture, mining, forestry, industry, human settlements, and wastelands sectors
- Assessment of current agricultural practices vis-a-vis agro climatic conditions

- Assessment of scope for improvement in agricultural productivity through technological interventions
- Assessment of land under mining vis-a-vis location of mineral resources
- Assessment of maximum amount of minerals that can be extracted without significantly affecting environmental quality
- Assessment of competing demands on land for mining, industry, agriculture, forestry, and human settlements
- Assessment of available surface and groundwater sources in terms of quality and quantity
- Assessment of recharge potential
- Assessment of present water use and estimation of water demand for residential, industrial, commercial and irrigation needs alongwith the water conservation potential
- Assessment of present potential of commercial and noncommercial energy sources including renewable
- Evaluation of energy potential vis-a-vis exploitation of commercial and non-commercial sources of energy including conservation potential
- Assessment of financial requirements for exploitation of commercial and non-commercial sources
- Estimation of availability of skilled and unskilled workforce, and training opportunities for formal and non formal up gradation of skills
- Assessment of competing demands for workforce in agriculture, industry mining, tourism, commerce, human settlements and tertiary sector
- Assessment of availability of basic facilities like water supply, electricity, cooking energy, public transportation, road networks and traffic pattern, communication, recreational, medical, educational and other basic facilities
- Assessment of institutional and administrative structures
- Delineation of alternate resource utilization strategy that is sustainable

The carrying capacity of an ecosystem is greatly influenced by the availability of resources and the manner in which they are utilized. The availability of resources at any particular time is the result of the interactions amongst the physical occurrence of the resource, and the quantum of requirement, as also the technological and managerial means of their exploitation. Estimation of future requirements of resources for the production of goods and services necessitates assessment of:

- Quantum and quality of the total stock of resources
- Combination of economic, technological and organizational capabilities that determine present production of goods and services
- Level of production under different economic conditions where the resource unit price increases due to its scarcity

- Level of production under different economic, technological and organizational scenarios

The salient elements of supportive capacity analysis are indicated in **Fig. 1.3.6**

Resource Allocation Strategies

In keeping with the concept of carrying capacity, improvement in the quality of life is possible only when the pattern and levels of production-consumption activities are compatible with the capacities of the natural environment as well as with social preferences. It is possible to analyze these issues with recourse to a resource allocation exercise that aims at optimum allocation of natural as well as man made resources to various anthropogenic activities of the regional system with a view to achieve equitable maximum quality of life.

In order to study the means of devising optimum resource allocation strategies for a regional system, the following four categories of regional planning models, cited from literature, have been critically assessed:

- Input-output models
- Simulation models
- Externality models
- Other models

A detailed review of individual models and their applicability to carrying capacity based regional planning are discussed in **Tables 1.3.2** and **1.3.3**.

1.3.3.2.1 Quality of Life Considerations

Quality of life in a given area is a function of the "objective conditions" and "subjective attitudes" of the population involving a defined "area" of concern. The "objective conditions" are defined as numerically measurable artifacts of a physical event, sociological event or economic event. Objective conditions may be defined by numbers which stand for a given quantity of a variable of interest so long as it is independent of subjective opinion. The "subjective attitudes" are primarily concerned with effective and cognitive dimensions and are specifically concerned with how aspects of cognition vary as objective conditions vary.

Quality of life estimation is based on the concept of a five level hierarchy of human values (Maslow, 1954)*. According to this concept, human experience is needs organized, and the human needs are arranged in hierarchy such that when the lower level needs are satisfied, the higher level needs emerge and come into play. Maslow argues that human beings can have a proper quality of life only when each level of human needs has been properly satisfied. These levels are identified as:

- Physiological needs, e.g. food, shelter, clothing
- Security needs, e.g. protection of life, assurance of a continuing income
- Social needs, e.g. acceptance by other people
- Ego needs, e.g. achievement of independence
- Self fulfillment needs, e.g. job satisfaction

Based on this, in the present study, attributes considered for QOL estimation differ in the nature of priority and ranking with reference to the topographic and demographic nature of the area under consideration, viz.: urban, rural, plains and hills. The attributes vary as :

- For the urban centers, sanitation, water supply, environmental pollution and social security have been weighted higher than the rural areas. This has a reference to tourism and strain on infrastructure.
- For the rural areas, income and employment, health and education facilities, fuel availability (due to deforestation and unavailability of other fuel sources), transportation and communication have been weighted higher than the urban centers

1.3.3.2.2 Ecosystem Considerations

The following factors constitute ecological sensitivity of the coastal region

- Shrinking backwaters have adversely impacted the potential of aquatic eco-systems, that used to support high levels of bio-productivity and biodiversity
- Shrinking hydrological features of backwaters, that used to provide high buffering capacity against flooding and saline water intrusion, as also for navigation, waste assimilation, and aesthetics
- Degradation of forest cover in the upland areas
- Reclamation and obstructions in natural drainage channels
- High population density in the State along the coastal region
- Dependence of 3.2% of population on aquatic resources

Suitability Indices

Two sets of indicators, viz. Gross Ecological Product (GEP) and Emergy based indicators are the emerging concepts in the theory of carrying capacity. The GEP provides a measure of qualitative growth of economy duly incorporating the environmental concerns in terms of abatement and restoration costs. The concept of GEP is depicted in **Fig. 1.3.7**.

The emergy based indicators would aid in identification of main resources that support quality of life, estimation of importance of environmental resources in the socio-economic activities and identification of near optimal levels of growth in activities and the mix that minimizes ecological loading ratios. Salient emergy based indictors are

- Emergy use per person
- Empower density
- Emergy investment ratio
- Ecological loading ratio

In the present study, emergy based ecological loading ratio is used.

Resource Flows and Resource Allocation Strategies

Given certain flow of resources, the resource based developmental planning process uses various modeling and analytical techniques to estimate changes in carrying capacity indicators, and makes tradeoffs like changes in environmental system structures, changes in socially acceptable capacity levels, and control of exogenous forcing functions. Resource analysis and resource allocation play a critical role in resource based planning as it facilitates optimum utilization of natural resource base of the hinterland on which the regional economy is critically dependent.

1.3.4 Options Available for Intervention in GKR

Based on the study of supportive and assimilative capacity assessment, the options available for intervention in the region are identified and the applicable policy interventions are discussed here. A range of technological, organizational and managerial interventions is delineated in subsequent chapters

1.3.4.1 Policy Interventions

The needed policy interventions for carrying capacity based developmental planning of the region involve the following:

- Balanced and harmonious development of the region with recourse to dispersal of economic activities and population redistribution through economically sustainable village ecosystems
- Determination of levels and type of industrialization in different districts of GKR based on local resources
- Augmentation of infrastructure facilities, viz. power, housing, water, sanitation, education, health, communications and transportation to meet basic minimum needs of growing population in regional towns
- Upgradation of services in urban slums and rehabilitation programmes for slum dwellers
- Optimum and rational use of urban land and conservation of sensitive zones like parks, and national monuments

- Privatization of urban services like water supply, sanitation, and solid waste collection and disposal
- Institutional development for effective implementation of plan proposals with community participation
- Implementation strategy for environmental monitoring and control
- Provision of information and extension facilities for health, nutrition, immunization and education in rural areas
- Awareness and promotion of hygiene and sanitation in slums, residential areas and rural areas
- Promotion of water tourism in the coastal and upland areas

1.3.4.2 Generation of Alternate Development Scenarios

The expected final outcome of carrying capacity studies of GKR involves developing short term and long term action plans for the region. Accordingly, the envisaged goals of short and long term scenarios are delineated hereunder :

Short term : The planning efforts mainly aim at enhancing the quality of life levels of the inhabitants of the region by the year 2005, the growth trends of various activities of the region follow business as usual pattern during the plan period.

Long term : The planning efforts mainly aim at guiding the growth patterns of various activities that enhance the quality of life levels of the inhabitants of the region by the year 2025 and also to maintain equitable quality of life levels amongst various sections of society.

The objective of generating a scenario is to narrate the desirable pattern of growth for the targeted future encompassing all activities. The process of scenario building is an exploratory and imaginative exercise and it involves several iterations of discretising the problem into various parameters and attributing growth rates to each and assembling these components into a congruent mosaic by which the intended growth pattern could be visualized. Thus, the scenario building activity incorporates the aspirations, preferences, interests and priorities of planners, experts, interest groups and citizens of the region as inputs to the planning process.

The planning process involves enabling growth trends exogenously by policy intervention and the plan implementation triggers various mechanisms that result in development of the region. In other sense, the scenario building process facilitates the analyst in defining the boundaries of the problem, and helps in formulating a framework for modeling the intrinsic processes of development of the region. The modeling activity facilitates evaluating various alternate growth scenarios in terms of their consequences. The evaluation of consequences provides the tradeoffs that are to be resolved by decision makers

The methodology suggested for scenario building involves the following steps

- Identification of salient driving forces, mainly the trends (i.e. continuous changes) and events (i.e. one time changes) that govern the future development of the region
- Delineation of these into the trends and events which are exogenous (external) or endogenous (internal) to the region
- Analysis of these trends and events vis-a-vis SWOT analysis of the scenario
- Assessment of various conditions of existing status of the region and delineating each whether it is a potential strength or weakness from the point of view of proposed development
- Indicate how the identified strengths, during the plan period could be converted into potential opportunities and delineate what actions would constitute the development
- Identify the needed technological, institutional and policy interventions to pursue these opportunities into action of development
- Similarly indicate how the identified weaknesses, could be potential threats during the plan period and delineate what actions would require to alleviate these threats
- Identify the needed technological, institutional and policy interventions that avoid or mitigate these threats

1 3 4 2 1 Short Term Scenario

In order to generate alternate regional development scenarios for preparing the short term action plan, the strategy is aimed at initiating corrective actions before 2005 to ensure that identified hot spots do not grow excessively. The time horizon of 2005 for the short term is kept mainly in view of the available time of 4 to 5 years for initiating required activities by implementing agencies. Hence, various projections for the planning period are made based on the business as usual assumptions incorporating the available plans for GKR.

Since the business as usual assumptions generate a single scenario, the required alternatives are generated for this scenario based on various options available for technological interventions that are oriented to mitigation of adverse environmental quality levels and consequences.

The business as usual scenario for short term will be analyzed based on a resource allocation exercise involving resource activity modeling of the regional resources within the constraints of assimilative and supportive capacities. The modeling exercise will be designed to aim at enhancing the resource sustainability, maximizing regional domestic product and quality of life levels of the regional population and maintaining the equitable distribution of quality of life across different socioeconomic groups. The modeling exercise generates consequences of the scenario in terms of allocations, residuals generated, shortage/surplus status of resources vis-a-vis growth assumptions of various activities.

These consequences are required to be further analyzed and evaluated for efficiency, effectiveness, feasibility and preferences besides supportive and assimilative capacity indicators. In order to facilitate a meaningful and explicit evaluation that compares one alternative with the other, it is proposed to carry out an in depth study of each alternative in terms of scope of technological interventions and the options available for the same; feasibility of various alternatives besides their cost benefits and implications for organizational and managerial development. The alternatives thus developed are ranked explicitly based on the evaluation, which will enable the selection of a preferred scenario.

1.3.4.2.2 Environment Management Strategy for Short Term

The environment management strategy for short term would involve implementation of end-of-pipe treatment measures to maintain standards prescribed by Central Pollution Control Board for air, noise, water and land environments.

1.3.4.3 Long Term Scenario

The development of alternate regional development scenarios in the long term are required to be evolved exogenously involving the aspirations of the citizens as well as different interest groups, fulfilling overall objectives of planning like enhancement of quality of life levels with equity across different sections of the society, besides pursuing envisioning the possible modernization patterns of technological, organizational and managerial innovations. The time horizon for long term scenario is envisaged for the year 2025, in order to realize the benefits of various measures of developmental planning in terms of enhanced quality of life levels.

All scenarios generated for long term will be analyzed individually based on a resource allocation exercise involving resource activity modeling of the regional resources within the constraints of assimilative and supportive capacities. The modeling exercise will be designed to aim at enhancing the resource sustainability, maximizing regional domestic product and quality of life levels of the regional population and maintaining the equitable distribution of quality of life across different socioeconomic groups. The modeling exercise generates consequences of the scenario in terms of allocations, residuals generated, shortage/surplus status of resources vis-a-vis growth assumptions of various activities.

These consequences are required to be further analyzed and evaluated based on perspective analysis of consequences for efficiency, effectiveness, feasibility and preferences besides supportive and assimilative capacity indicators. The perspective analysis involves sectoral studies for a given resource or activity sector involving explicit choice of location, distribution or redistribution strategies within the region, possible means of augmentation of a given resource for supporting one or more activities, technological and economic feasibility of various options within the context of available institutional managerial and human resources. The expert judgment for evolving and assessing these options forms a vital input for carrying out these studies.

Further, to facilitate a meaningful and explicit evaluation that compares one alternative with another, it is proposed to carryout in depth studies of each alternative to detail the needed technological interventions and the options available for the same; feasibility of various alternatives besides their cost benefits and implications for organizational and managerial development. The alternatives thus developed are ranked explicitly. Based on the evaluation, the selection of a preferred scenario could be possible with the interaction of planners and community.

1.3.4.3.1 Alternate Growth Scenarios for Long Term

The scenario development would involve a range of methods for projecting various growth assumptions as perceived by the experts, planners, citizens and different interest groups. In order to generate feasible and salient alternative scenarios of the region, the following exercises will be pursued:

- Business as Usual
- Growth Rates as envisaged by Planning Agencies of the region
- Preferences indicated by different interest groups and citizens
- Scenarios developed based on brain storming and Delphi study of experts

1.3.4.3.2 Evaluation of Consequences

A long term scenario is to be delineated incorporating the following:

- Population level in different districts
- Desired participation levels of population in primary, secondary and tertiary sectors of the economy in different districts.
- Levels of different activity types and typology, resource-use-intensities, employment intensity and value addition potential
- Choice of technology and its residual generation
- Activity mix and inter-linkages within the region
- Desired level of amenities and technology characteristics

Goals and Sub goals

The long term scenarios are evaluated based on the consequence analysis using a Neural Network - Structural Modeling (System Dynamics based modeling). The consequences of a proposed scenario are expressed in terms of the following approach goals and sub goals :

- Quality of life and its equity within a district and across districts

- Ecological loading ratios that express the use of free and non renewable ecological resources to produce a unit of output in the economy measured in terms of emergy
- The status of different components of the environment, i.e. air, water, land, noise and biological

The criterion for environmental goal for the long term scenario is ecological health rather than the human health considerations. Similar criterion for quality of life and ecological loading ratios are also used.

Assimilative Capacity Criteria

Environmental status goals identified to facilitate evaluation of consequences, indirectly incorporate assimilative capacity criteria. The assimilative capacity criteria for evaluation of the long term scenarios involve estimation of residuals generated by proposed mix of activities and whether this is within the assimilation potential of the media or not. The different environmental components that were considered here are air, water, land, noise and biological.

The goals for the environmental status under the long term scenario being different, the potential of the media to assimilate any additional residues is also constrained. This has to guide the technological choices and typology of activities for a preferred scenario.

Supportive Capacity Criteria

The supportive capacity analyses for evaluation of proposed scenarios are to be carried out for critical resources identified from the analysis of Business as usual scenario.

The supportive capacity criteria include balancing of available/potential resource and the requirement of the resource in the proposed scenario. Besides, such detailed balancing some indicators of stress and crowding are also designed, viz resource intensity indices and man-land ratios. Besides, the supportive capacity criteria also ensure that the extraction of a resource lies within the regenerative capacity.

1.3.4.4 Selection of Preferred Scenario

The selection of a preferred scenario goes through three stages. The scenarios are generated in Brainstorming and Delphi sessions among experts, taking into consideration the supportive and assimilative capacity of the districts. However, in the consequence analysis, the scenarios are again evaluated in detail to check whether these developmental propositions are within the assimilative and supportive capacity of the region or not. The second stage involves the trade-off analysis and the third is the conflict resolution

1.3.4.4.1 Trade-off Analysis

The consequence analysis provides us with the future levels of Quality of Life and its equity, Ecological Loadings Ratios and Environment Status Indices for different districts if the plan proposals of a preferred scenario are implemented. The plan proposals would also indicate the financial, institutional resource requirements. The trade-offs among the different set of consequences and resource requirements are to be guided by preferences of the decision makers and the people of the region.

1.3.4.4.2 Conflict Resolution

Since the plan takes into account the district's resource endowment differentials, the preferred scenario would not advocate similar growth patterns for all the districts. Hence, the different districts conflicts that could manifest are to be solved at the design stage of the plan itself. It is for this reason; the activity mix that has optimum inter-linkages amongst districts is to be preferred

Similarly, the conflicts within a district amongst different sections of the people could be ensured by the goal i.e. Equitable Quality of Life.

The conflicting requirements of resources for different activities, the conflict between ecological protection and developmental imperatives could be resolved by identifying suitable activity mix, technological choices, effecting changes in consumption patterns and by imparting new skills to local population.

1.3.4.5 Detailing of Preferred Scenario

The preferred scenario is only an indicative plan detailing guidelines for development strategy, criteria for location of activities and services, guidelines for environmental management. The details of preferred scenario would also indicate monitoring and facilitating mechanisms, financial resource requirements and institutional mechanisms. To provide such an indicative plan, base line studies, discipline specific mathematical and simulation-prediction models, expert assessment based technological and social forecasting are used as tools.

1.3.5 Salient Techniques and Tools

1.3.5.1 Assimilative Capacity

Assimilative capacity is a limit to the capability of ecological systems in accepting the residuals without discernible changes in the quality of recipient bodies. The associated techniques and tools to be used are summarized for quantification through matrix (**Table 1.3.4**).

1.3.5.2 Supportive Capacity

To estimate the supportive capacity of different districts of GKR various indices were defined such as developmental indices, man-land ratios, resource intensity indices, amenity inaccessibility indices and emergy based ecological loading ratios. The indices are designed to indicate the additional activity levels these districts could support without impairing ecological integrity. The concepts, formulae used for the indices are illustrated in the **Table 1.3.5**.

1.3.5.3 Regional Systems Modeling

The regional systems modeling exercises is to seek a mathematical / algorithmic /linguistic representation of the understanding of the processes that are critical for the development of the region. The important techniques employed are artificial intelligence techniques such as neural networks and the interfacing models. The interfacing models represent the relationships amongst different socio-economic-resource variables and their dynamic evolution using techniques such as structural modeling and system dynamics. The characteristics of these techniques and application areas are indicated in the **Table 1.3.6**.

1.3.5.4 Developmental Planning

The developmental planning process envisaged in this study involves generation of alternate scenarios within the assimilative and supportive capacity of the region. The generation of alternative scenarios would incorporate aspirations of the people, preferences and feasibility assessments of decision makers and planners and expert opinions. To achieve this, the study uses exploratory forecasting techniques such as Brainstorming and Delphi. However, to limit the developmental scenarios to the carrying capacity of the region, the strength- weakness, opportunity - threat analysis was carried out by analysts and presented to the participants of Brainstorming and Delphi exercises. The salient features of these techniques are presented in the **Table 1.3.7**.

Table 1.3.1

Resource Classification

Category	Components
Ecological and economic resources	Air, water, land, sunlight, space, green plants, non-green plants, animals, biodiversity, and CO_2 sinks, inputs for production processes, viz. raw materials, mineral resources, capital, human resources and organizational resources
Transformational resources	Processes for extraction, beneficiation and conversion of ecological and economic resources into productive goods and services with minimal residuals
Infrastructural resources	Transportation, water supply distributive resources, sanitation, communication and energy systems
Socio-cultural resources	Educational & cultural facilities; health services; security services, infrastructure resources; scenic and recreational areas

Table 1.3.2

Review of Some Important Regional Planning Models

Model	Authors	Capabilities	Remarks
A. Input-Output Based Models			
Residuals Management Models	Russel & Spofford (1972)	Inter-industry input-output model capable of estimating primary residuals from production process based on optimizing economic efficiency objectives. It uses a set of steady state deterministic environmental models to predict ultimate concentration of some specified pollutants and their health effects are predicted using receptor damage models	This model will be able to measure economic impacts in terms of supply demand changes and to some extent social impact changes due to changes in infrastructure and congestion. Though it is possible to analyse decision of residual management by using this model, supportive capacity and assimilative capacity dimensions cannot be analysed. The data needs are very high and there is no consideration of environment as a source and sink
Ecologi-economic Analysis Model	Isard (1972)	A single input-output model that considers interrelations between ecology and economy. Cost comparisons of alternative activities can be analysed. The interrelationships can be used in an optimization frame work also	Though this study was implemented for estuarine ecosystem of Plymonth Bay Area and for Philadelphia study, it was felt cumbersome to estimate coefficients of economy-ecological interactions. The data needs are very high and it may not be possible to construct a single input-output model as envisaged
Inter-industry Forecasting Model (RFF)	Herzog & Ridker (1972)	A basic inter-industry input-output model, expanded by several other models, to consider spatial distributions of natural resource demand and that of pollution loadings. It can be used as a good policy simulation tool	To a limited extent, it can be used as a tool for analysing various dimensions of regional carrying capacity. The data requirements are enormous and pollution costs are difficult to estimate
Strategic Environmental Assessment System (SEAS)	Laksh-manan & Nijkamp	It is an integrated economic, environmental and energy model which is an extension of input-output model to include energy & environment sectors, and has been used for the assessment of wide range of public environmental & energy policies in USEPA & US Dept. of Energy. It can be scaled down to a regional level by using a REGION Module	Some modifications may be needed before using this model for determination of regional carrying capacity, as it is designed for studying energy impacts. The data needs for this model are enormous

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Table 1.3.2 Contd...

Model	Authors	Capabilities	Remarks
B. Simulation models			
Regional Environmental System Model	Craven, et al (1973)	It is employment oriented policy simulation model consisting of a socio-economic model to project population and unemployment, a land use model to spatially allocate population and employment, a socio political model to consider impacts of environment by man and an ecological model to analyse land use impacts on environmental quality	This is a region specific and basic employment oriented model, which cannot be applied elsewhere. Its capabilities and dynamic responses in other regions are not known. It calls for a detailed study of the region and its structure to construct this model
Vancouver Regional Simulation Study	Goldberg, Holling and Kelly (1971)	It consists of 7 sub models, viz., demographic model, economic model, transportation model, land utilization model, health care model, pollution model, and human ecology model	This is also a region specific model. It may not be possible to study regional carrying capacity dimensions using this model
Regional Modelling (REGMOD)	Watt & Wilson (1973)	It is general model and can be applied to any region. It was used to study impacts of planning policy in urban centres of California. It consists of 14 sub-models. It is in piecewise simulation study mode	Though its applications are made in urban centers, its utility to a district is not known. Some aspects related to assimilative capacity are reflected in the submodels
Arizona Trade off Model (ATOM)	Myers (1973)	It is simulation model to economic (in terms of employment) and environmental quality units (in Battelle terms). The policy simulation is carried out on the basis of regional industrial allocation model. Total environment is evaluated	It is not known whether this can be applied in case of non-industrial development also. Spatial considerations and regional carrying capacity considerations are not directly measurable as the model is a activity oriented one
State of the System Model (SOS-1)	Williams & House (1973)	It is a futuristic policy simulation model. It consists of a basic model of production component out put generated from population growth. For various conditions of growth, development, quality of life and future goals, the simulation is carried out	Carrying capacity conditions are exogenously treated here. The process of regional development is not accurately modeled

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Table 1.3.2 Contd...

Model	Authors	Capabilities	Remarks
C. Externality Models			
Agglomeration Economics	Alonso (1971)	They explain market behaviors of externalities using economic rationale	These can be used as prescriptive tools for deriving norms of environmental quality. They have relevance in measuring regional carrying capacity
External Cost rate Increase	Baumol (1967)		
D. Other Models			
Equilibrium Model	Koeing & Tummala (1972)	Non-quantitative models which can be used for intuitive understanding	Qualitative dimensions of regional carrying capacity can be understood

Table 1.3.3

Review of Some Important Urban Planning Models

Model	Authors	Capabilities	Remarks
Pittsburgh Urban Renewal Simulation Model	Lowry & Grain (1972)	It is a deterministic policy simulation model for urban renewal. It determines the attractions by urban growth centers using gravity model and allocates urban population to these centers using entropy maximization principle	Most widely used technique for development of existing and new urban regions. It is based on population growth and is used for designing various urban land uses using transportation models (gravity models)
North Carolina Simulation Model	Stuart Chapin (1965)	It is a policy simulation of residential development. It considers conversion of rural vacant lands for residential use on theory of land use succession. It employs Monte-Carlo Simulation technique	It studies only economic aspects of residential development
San Francisco Housing Simulation Model	Arthur D. Little (1966)	It is used for testing alternative urban renewal policies. It is in a dynamic programming framework and employs Markov processes to develop transitional states	Its novel method of employing dynamic programming and Markov process techniques is interesting
Bay Area Simulation Study (BASS)	Went and goldbeng (1969)	It includes transportation and accessibility characteristics using a probabilistic time-distance matrix over the framework of San Francisco housing Simulations	An extension to earlier study interests transportation planners
NBER Urban Simulation Model	Kain and Ingram (1976)	Most ambitious urban model pertaining to unidirectional relationship of transport and urban land use. It uses a hybrid simulation technique	This model is of interest to planners of transportation systems
Urban Dynamics Model	Jay W. Forester (1969)	This initiates the growth of urban systems by using 369 generating equations with 360 different variables which are both deterministic and random. It uses DYNAMO-special simulation language. It divides urban growth into 11 sectors and uses interactive feed back loops for simulation of 250 year profile of urban growth	Severe criticism of counter initiative bias built in the system that anything can be explained and be proved either way for any policy. However, it is a flexible, most synergistic simulation when compared to other techniques. This has great potential for application in regional context and regional carrying capacity

Table 1.3.4

Assimilative Capacity Assessment Techniques and Tools : Matrix

Environment / Zone	Algorithm / Models	Brief Description	Remarks
Air Environment			
*Plain Terrain	- Ventilation Coefficient (VC) = Mixing Height X Wind Speed - Assimilative Capacity : Maximum allowable pollution load is calculated based on detailed emission inventory and meteorological data generation using following models:	In an airshed assimilative capacity assessment is based on quantification of air pollutant's removal mechanism. viz. dilution / diffusion, removal by rain / smog fog / snow phase transformation, chemical reaction and attenuation by vegetation. Based on VC, different zones of air pollution potential are classified. Categories 1, 2 & 3 (i.e. VC < 6000 m^2/s) represent high pollution potential, leading to wide spread occurrence of high concentration of pollution, categories; 4,5 and 6 (i.e. VC in the range of 6000-12,000 m^2/s) represent medium pollution potential and categories 7,8 & 9 (i.e. VC greater than 12,000 m^2/s) represent low pollution potential which leads to high dilution of pollutants	Management Plans are based on CPCB standards promulgated for areas of residential / rural settlements. Whereas, WHO standards have been adopted for evolving management plans for long term developmental scenarios.
	* Point Source = ISCST3 and Box * Area Source = ISCST3 and Box *Line Source = California line Source model for highway, ISCST & Box model for intracity road network		
* Hilly Terrain	- Air Pollution Sink Potential index - Pollution attenuation through green zone can also be used for assimilative capacity assessment	Biological sink forms the major natural phenomenon for removal of air pollutants from the air basin within hilly terrain ecosystem because surface wind profile is largely governed by topography	For hilly terrain, the standards prescribed for sensitive zone have been used.

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Table 1.3.4 Contd...

Environment / Zone	Algorithm / Models		Brief Description
	$$Af = \frac{F_D (X_1 + X_2)}{F_D(X_1)\ erF \frac{he}{\sqrt{2}\sigma (X_1)}\ \lambda\text{-}X_2 + erFc \frac{he}{\sqrt{2}\sigma (X_1)}\ F^1_D (X_2)}$$ Where : X_2 = Width of green belt he = effective height of green belt λ = Pollution attenuation coefficient X_1 X_1 = distance between the green belt and pollution sources, $F_D (X_1 + X_2)$ and FD (X_1) are plume depletion factors $\lambda = K\rho_1\ Vd / Vc$ Where: ρ_1 = Foliage surface area density of single tree, $K = \rho_c / \rho_p$ ρ_c = Foliage surface area density of green belt Vd = dry deposition velocity of pollutants		
Noise Environment			
*Plain Terrain	Attenuation through Atmospheric Media $Ae_1 = 7.4f^2\ r/\phi \times 10^{-8}$ dB where: f= frequency of sound wave ϕ = relative humidity r = distance between source and receptor Attenuation by solid barriers = A+B+C Where: A = distance between source and barrier B= distance between barrier and receptor C= distance between source and receptor	For the acoustic environment assimilative capacity is based on characterisation of noise and consideration of sound attenuation so as to ascertain the maximum amount of noise load that can be discharged without causing private or public nuisance for the designated use of land categories. In the plain terrain, the attenuation is due to solid barriers e.g. buildings/ houses social / avenue forestry etc.	CPCB ambient noise standards Leq (dBA) Day Night Industrial 75 70 Commercial 65 55 Residential 55 45 Silence Zone 50 40

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Table 1.3.4 Contd. ..

Environment / Zone	Algorithm / Models	Brief Description	Remarks
Point Sources	• Wave divergence $Lp_2 = Lp_1 - 20 \log r_2/r_1 - Ae_{1,2}$ $Ae_{1,2}$ = excess attenuation along the path $r_2 - r_1$		EPA noise criteria for residential area Ldn = 55 dBA Barriers, vegetation, and air attenuation forms major part of sound attenuation in this region
Area Sources	Ldn : Day-night noise levels Ldn = 10 log {1/24 [15($10^{Ld/10}$)]+ 9}		
Line Source	Federal Highway model Leq(h) total = 10 log [$10^{Leq\ A/10} + 10^{Leq\ MT/10} + 10^{Leq\ HT/10}$]		
* Hilly terain	Attenuation by Grass, Shrubs or trees $Ae_s = (0.18 \log f - 0.31)r$ Attenuation by forests $Ae_f = 0.01 f^{1/3} r$ Where f = frequency of sound (Hz) r = path length through shrubbery or over grass (m)	The vegetation in the form of forests, tea garden etc. are major attenuators of sound	Day Night Leq/dBA 50 40 Attenuation by Vegetation (dB) at 1000 Hz. frequency **Item** **Path Length(m)** 10 50 100 Grass/shrubs 2.3 11.5 23 Trees 1.0 5.0 10.0
Water Environment			
Plain terrain	iver DO-BOD nutrient interaction model, QUAL2E ssimilative capacity of given river stretch for the inimum river flow condition is estimated for any desired ater quality parameters / goals e.g. BOD, DO etc. by omputing maximum load the river can assimilate without eteriorating the river water quality beyond the ermissible threshold as specified for the designated sages.	River water quality model QUAL2E can simulate upto 15 parameters under steady state or as a dynamic model. It assumes that the major transport mechanisms, advection and dispersion are significant only along the main direction of flow. The model includes the major interaction of the nutrients cycles (N&P), algae production, benthic oxygen demand, carbonaceous oxygen uptake, atmospheric aeration and their effects on the total oxygen balance Coliforms and arbitrary non-conservative constituents are modeled as non-conservative decaying constituents.	Classification of river as per CPCB guidelines

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Table 1.3.4 Contd...

Environment / Zone	Algorithm / Models	Brief Description	Remarks
Hilly terrain			QUAL2E model may also be applied for fast flowing river.
Land Environment	ssimilative Capacity = Maximum allowable ollution load	Assimilative capacity of land environment is calculated by estimation of degradation and assimilation potential of soil-plant system for critical Land Limiting Constituents (LLC) Degradation, adsorption and precipitation are major phenomenon in determining the assimilative capacity	Adsorption, degradation, mmobilization, precipitation and plant uptake are major natural phenomena for removal of pollutants in land component
	Major Reactive Parameters **Soil** * Physical-hydraulic conductivity, texture and structure * Chemical - Soil CEC, organic matter, pH, $CaCO_3$ * Microbial - bacteria, actinomycetes, fungi etc. **Plant Canopy** * Pollutant uptake capacity of plants	Efficiency of biological barrier system of plants in controlling the absorption of pollutants or assimilation of pollutants without showing toxicity are significant phenomena	
Biological Environment	**Importance Value Index** IVI = (RD+RDOM+RF) / 3 Where, RD = Relative Density RDOM = Relative Dominance RF = Relative Frequency	IVI, which is a combination of three indices viz. density, dominance, and frequency is an appropriate measure for assessing the overall significance of a species in a given ecosystem. Thus, it gives information about the most important species in the sampled system	
	Sink Potential Index $SPI = (n_2 - n_1) \times SD_{(n)} / n_2$ Where, n_2 = Stomatal Density of Controlled plant n_1 = Stomatal Density of polluted plant $SD_{(n)}$ = Stomatal Density of species under study	SPI has been construed as an appropriate measure of site-specific Sink Potential of a dominant species with respect to air pollutants within the ecosystem	Plant leaves function as efficient gas exchange systems having large surface area bearing stomatal pores. Therefore, differences in frequency and size of stomata play an important role in determining the assimilative capacity of a particular vegetation structure of a region

Table 1.3.5

Supportive Capacity Assessment Techniques and Tools : Matrix

Item	Algorithm / Model	Brief Description	Remarks
Development Indices	* Population indices * Population density * landuse indices * Agriculture and irrigation levels * Yields of various crops * Productivity indicators * Levels of economic development * Per capita consumption levels of salient resources * Per capita availability of various amenities * Income and expenditure levels * Worker participation ratios	Simple ratios of various parameters of development expressed as percentages across various planning zones to indicate the levels of development	These simple indicators provide basis for comparison of levels of development across various planning zones and bring out inter and intra regional disparities of development
Man-Land Ratios	* Geographical and land per person in ha * Agricultural land per person in ha * Forest land per person in ha * Wasteland per person in ha	The ratios are the prima-facie tools of carrying capacity assessment that indicate the population pressure on land	FAO and UNDP utilize these as policy and assessment tools vis-à-vis level of technology that is required for development
Resource Intensity Index (RII)	* Resource available per unit area RII = Population density x per capita requirement of resource	Resource intensity index indicates the level of utilization of a given natural resource in a planning zone. This is applicable to renewable resources	This provides an useful criteria for over or under utilisation of a resource in a region or in an activity sector and also to identify substitution possibilities to a given resource

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Table 1.3.5 Contd...

Item	Algorithm / Model	Brief Description	Remarks
Resource Accounting	Resource base $_{t+1}$ = Resource base + (Resource base x Regeneration x t) – (Resource base x Extraction rate x t) + Imports$_t$	The resource accounting procedure is applicable to both renewable and non-renewable resources and indicate the sustainability of a resource for different exploitation levels	This is an useful tool to study the sustainability of a given resource under various scenarios of exploitation and regeneration
Amenity Intensity Index (AII)	Weightage based index AII = Wi Fi Where, Wi = Weightage or importance to a given mode of amenity, e.g. primary health centre, sub centre, dispensary etc. and Fi= Number of all types of amenities that are available in study area	Amenity Intensity Index indicates the total level of amenities of a given type that are available in a study area. The weightage or relative importance indicates the utility, size and other factors the amenities considered for the study are education, health, water supply, recreation, banks and market centres	Since Amenity Intensity Index is correlated highly with quality of life, it provides good insights for taking decision concerning enhancement of quality of life levels
Amenisty Inaccessibility Index (AinI)	AinI = Nn x n^2 Where, N1, N2, N3 and N4 are the number of villages within 1, 1-3, 3-5 and beyond 5 km distance from the amenity respectively	The amenity inaccessibility index facilitates the location decisions of amenities and suggest the scope for their enhancement	
Emergy Based Ecological Loading Ratios	* Emergy use per person * Empower density * Net-emergy yield ratio * Emergy investment ratio * Ecological loading ratio Ecological loading ratio = Free non-renewable emergy used in the economy / Emergy Produced in the Economy	The emergy based indicators would aid in identification of main resource that support quality of life, estimation of importance of environmental resources in the socio-economic activities, identification of near optimal levels of growth in activities and the mix that minimises ecological loading ratios	Emergy analysis provides common unit of analysis of activity, activity-resource and resource activity interactions

Table 1.3.6

Regional System Modeling

Item	Algorithm / Model	Brief Description	Remarks
Population Dynamics Modeling	Demographic simulation models involve the parameters such as: *age specific population * fertility *marital status * literacy *birth rates * death rates *migration	A growth oriented simulation model to study the demographic trends and rates and their impacts on long-term growth characterization of population	A powerful and potential tool for making population projections under various policy interventions
Structural Modeling	Verbal model : Structure based system analysis model depicting controls and feedbacks in a casual loop diagram Structural Model : Computer simulation of the verbal models	A policy simulation approach involving state variables, parameters and exogenous forcing functions in the models corresponding to real life components of an ecosystem. The endeavor relates to study of feedback and control loops, stability of the system and sensitivity of one component of the system to changes in another components. It is a structure based system behavior model	It is a very flexible and powerful model for simulating complex regional system behaviour. The data requirements for the model are based on the structural connections and policies envisaged
System Dynamics Moelling	Policy simulation models involve stock and flow resources dynamics with activity systems involving time dependent relations. DYMOSIM Software	The technique is used to understand the supportive capacity of water resources system in GKR. The structural changes driven by policy interventions are investigated to limit the growth of industrial and agricultural activities and population	It is very potential tool for application of policy based regional systems analysis involving study of time dependent dynamic behaviour of large societal systems

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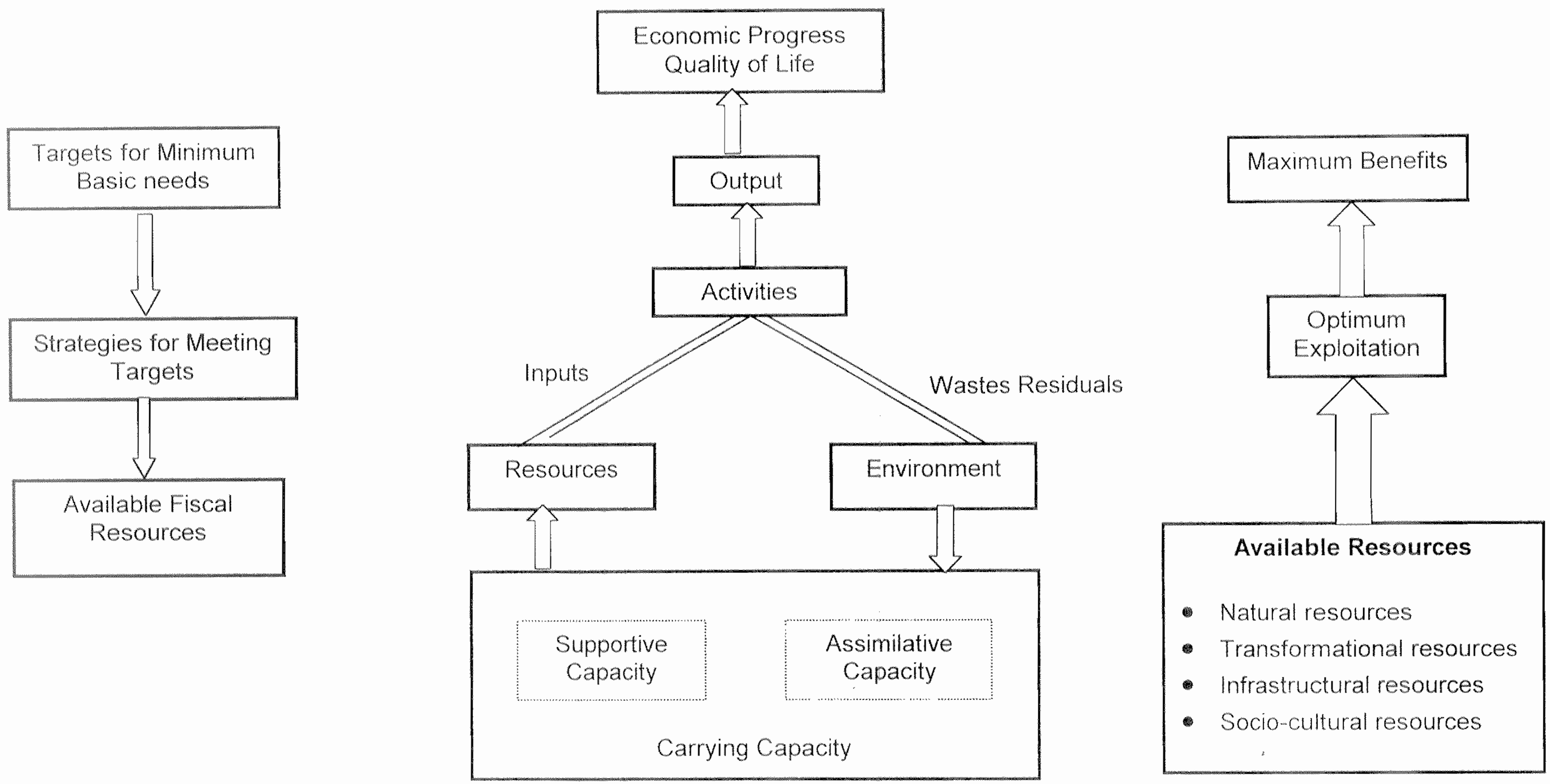
Table 1.3.6 Contd...

Item	Algorithm / Model	Brief Description	Remarks
Neural Network Modelling	Neural Network I : Economic Activity Resource endowment → Environmental Quality Neural Network II : Environmental Quality – Amenities → Quality of Life (QOL)	Artificial Intelligence based predictive tool involving non-linear regression built over several learning epochs. The input for neural network involves several learning epochs. The input for neural network involves several salient parameters concerning • Environment status • Climatic conditions • Demographic conditions • Economic conditions • Amenities • Social conditions	A very powerful and potential tool for analysis of complex regional systems involving several parameters of study. Besides the baseline data of the regional system, the expert understanding of the regional area serves as the input.
Genetic search based	Water quantity-quality balance achieved through genetic algorithm based search procedure to minimize treatment cost, meet the requirements with minimum of 0.7 satisfaction level resource allocation	The model is used for allocation of water resources across the subregions to different demand sectors considering the quality and consequent treatment costs. The optimum point achieves minimum cost and also maximum satisfaction levels	The model incorporates the non linearities involved in satisfaction levels and also constant satisfaction. The output of the model point around 'global' optimum out of which desired solution can be selected using decision makers, expert and citizens preference structure
Gross Ecological Product	GEP=GNP-Depreciation on capital Stock for environment protection-Compensatory expenditures to regulate environmental damages-remaining net loss to national capital and impairment of quality of life levels	A measure of regional income after duly accounting for environmental concerns within the economy. This is a good indicator of qualitative growth i.e. growth in the value of production at constant decreasing levels of resource depletion and environmental pollution	The computation of GEP may be difficult in the sense that the quantification of abatement and damage costs suffer from inherent limitations

Table 1.3.7

Developmental Planning

Item	Algorithm / Model	Brief Description	Remarks
Alternate Scenario generation	* SWOT analysis * Brain Storming * Linear and non-linear regressions	SWOT analysis is an exploratory exercise for visualizing a scenario Brain storming provides the inputs from experts to refine the scenarios for their feasibility	Interactive and iterative exercise involving experts, decision-makers, interest groups and public
Business as usual projections	Econometric models involving linear and non-linear regressions, Times series and analysis. SPSS software package Forecast Master (FCM) software package		Assumes that the present cause effect relationships are valid in the future also
Selection of a preferred scenario	Consequence analysis * Indicators * Preference * Feasibility * Trade-off analysis * Conflict resolutions		



A : Top-down Planning Process

B: Concept of Regional Carrying Capacity

C: Bottom-up Planning Process

Fig. 1.3.1: Elements of Carrying Capacity

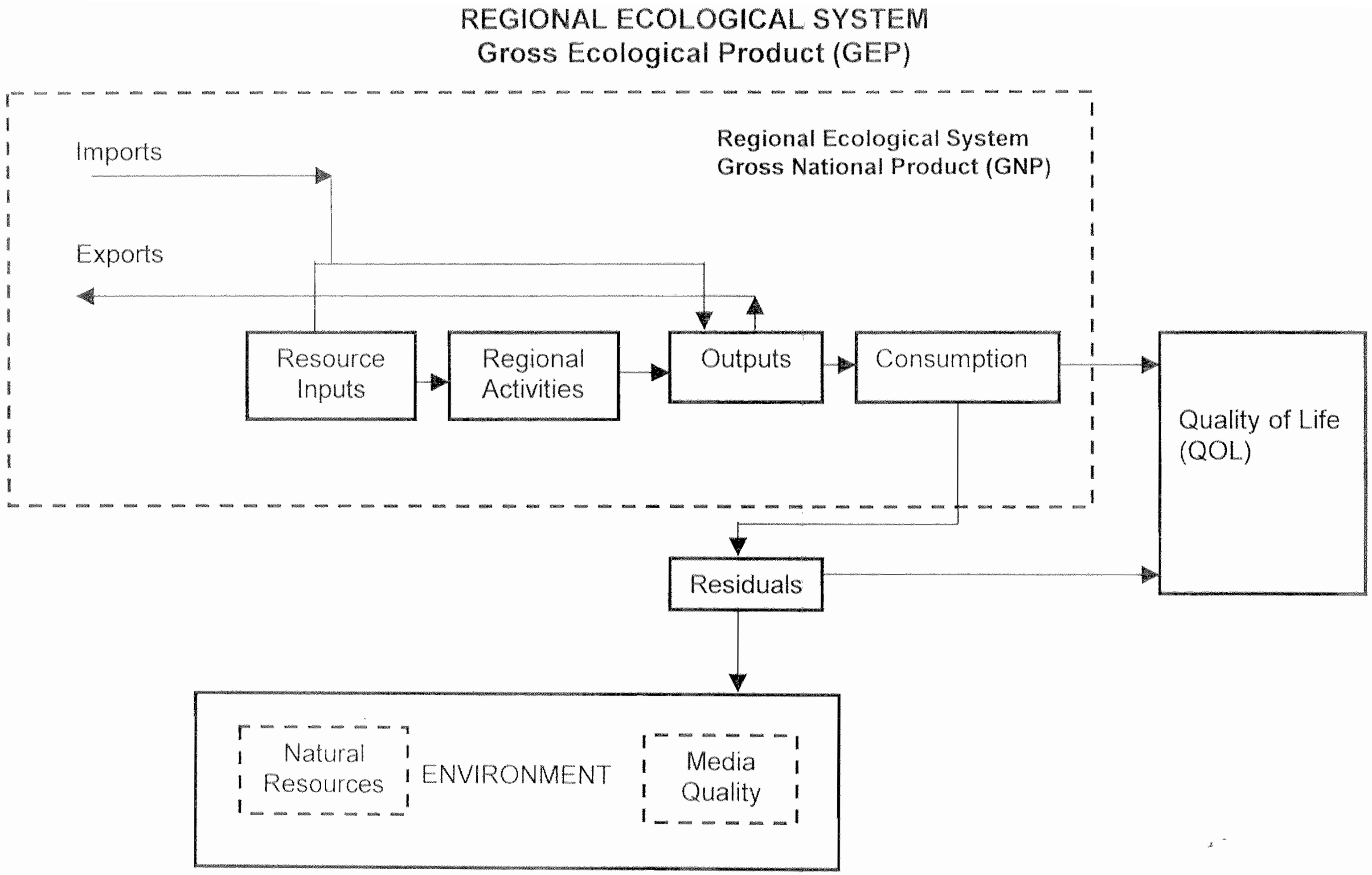


Fig. 1.3.2 : Interaction in Regional Ecological System & Gross Ecological Product (GEP)

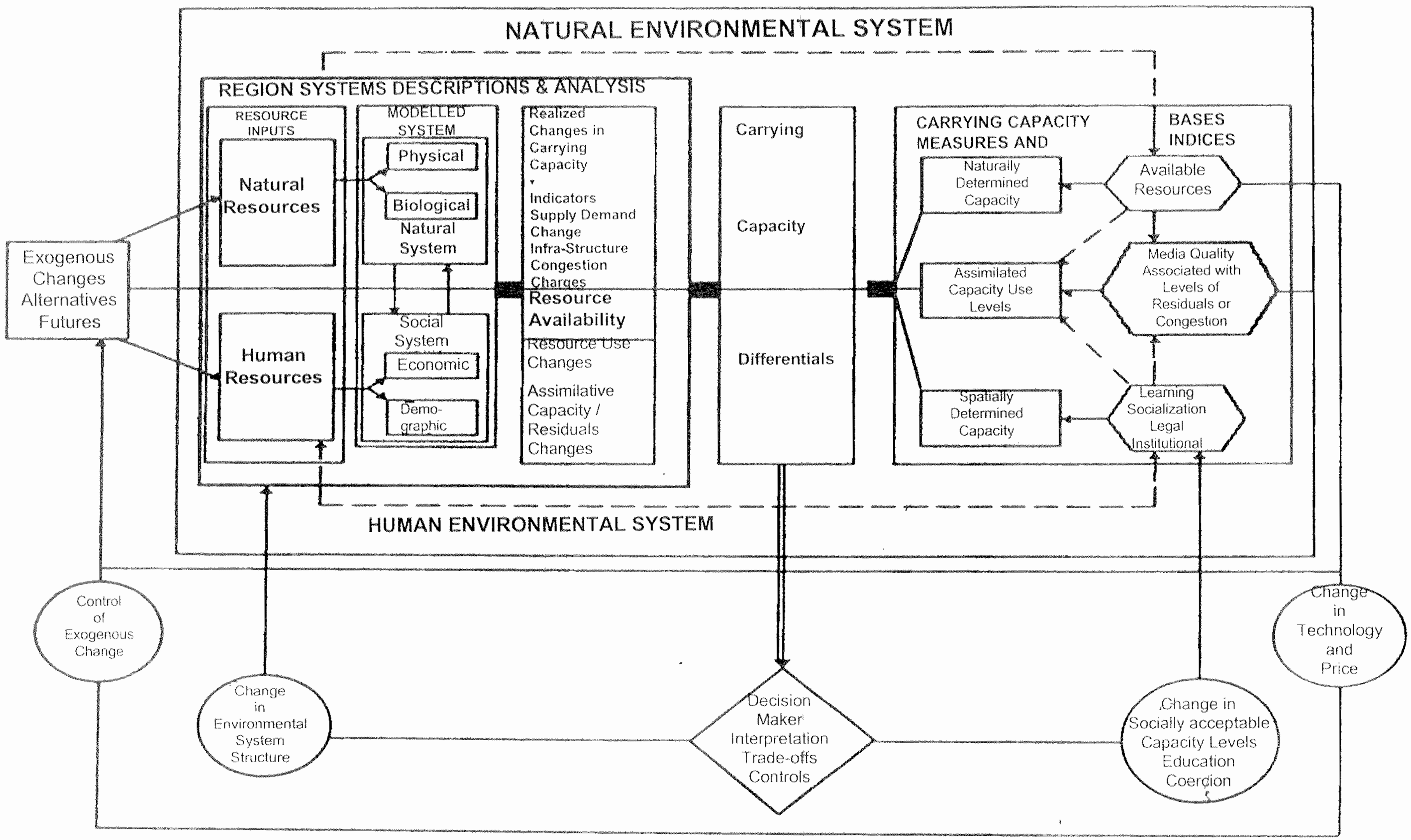


Fig. 1.3.3 : Carrying Capacity based Planning Process

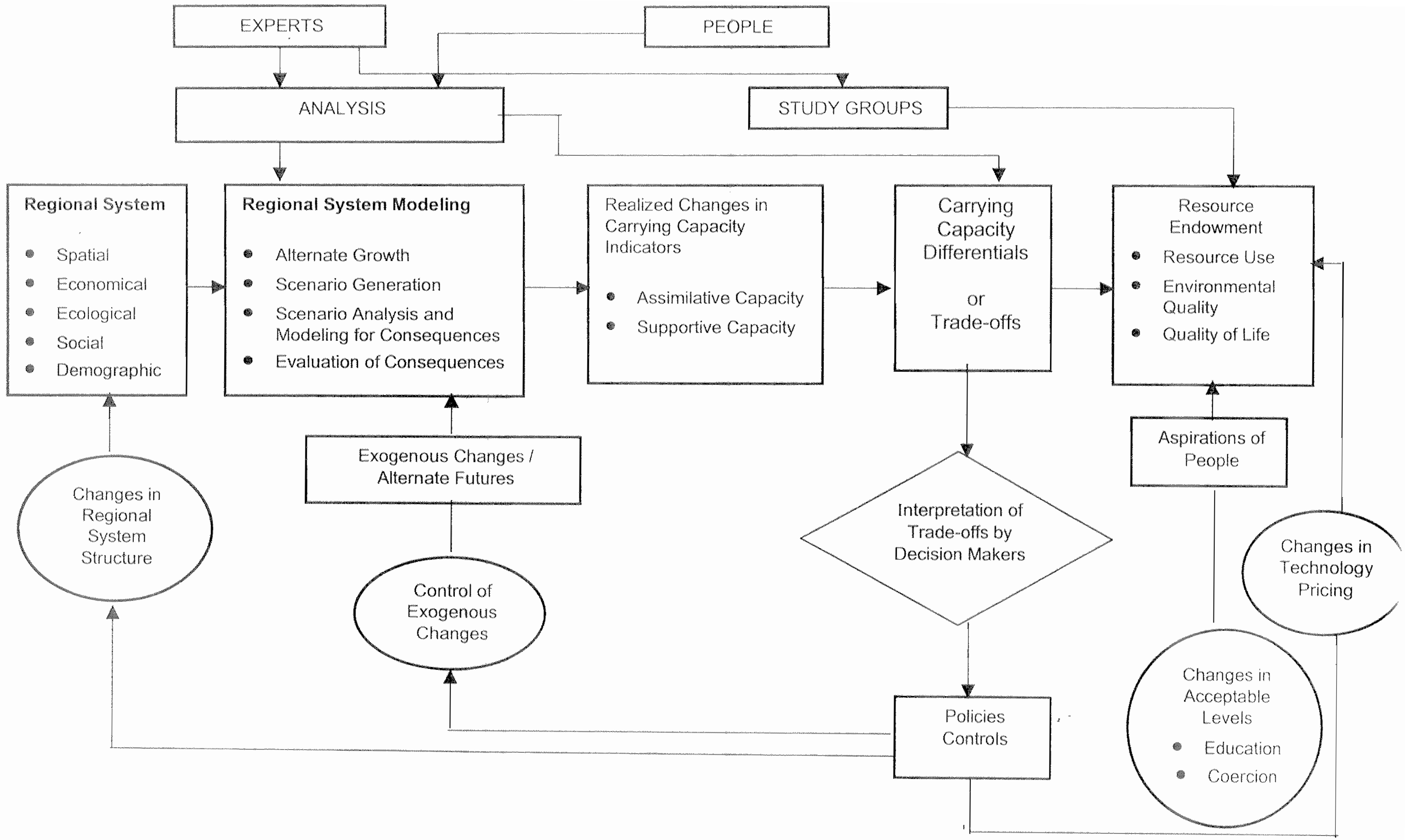


Fig. 1.3.4 : **Operational Framework of Carrying Capacity based Developmental Planning Process**

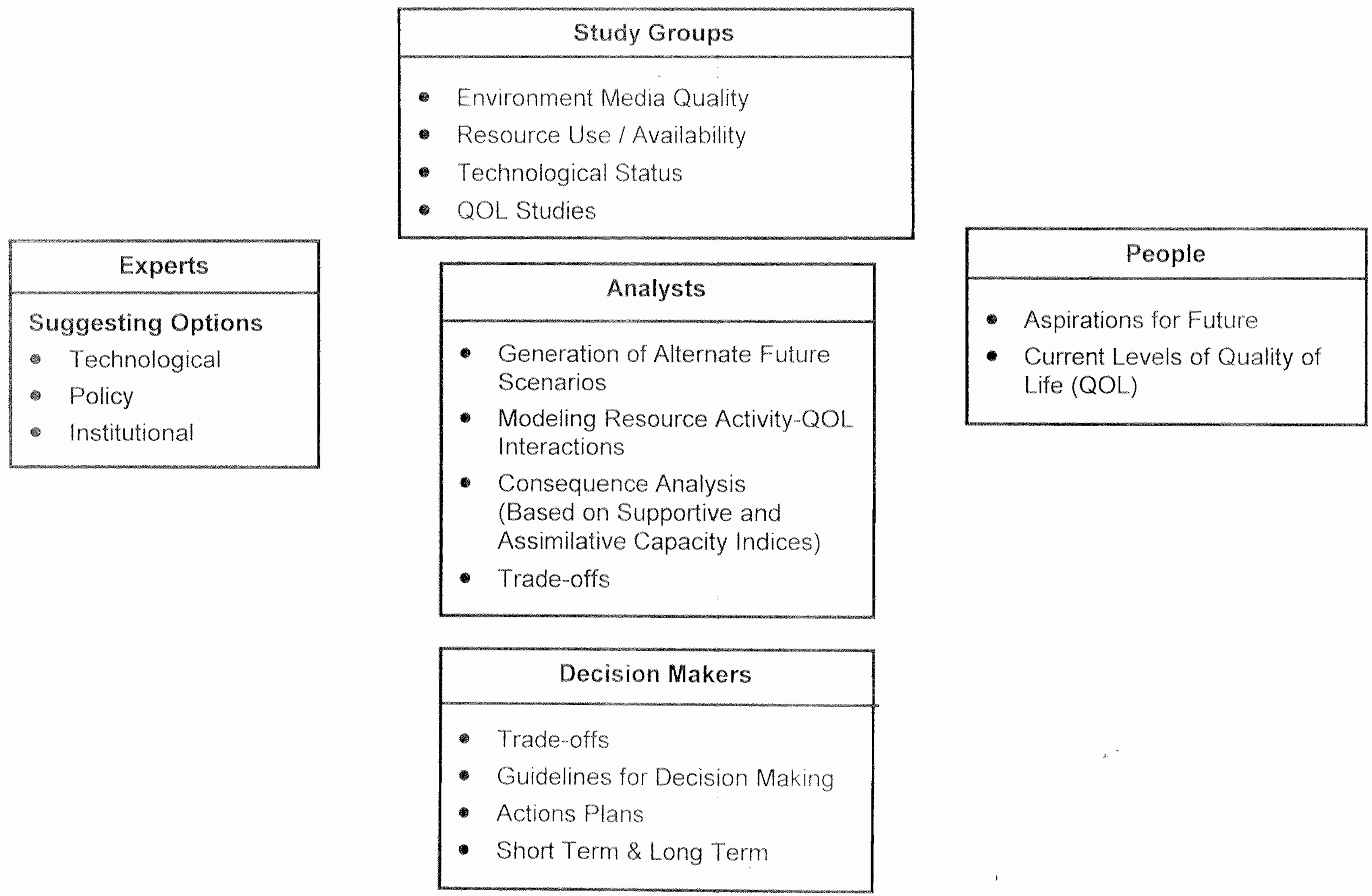


Fig. 1.3.5 : Carrying Capacity based Planning Process : Participatory Groups

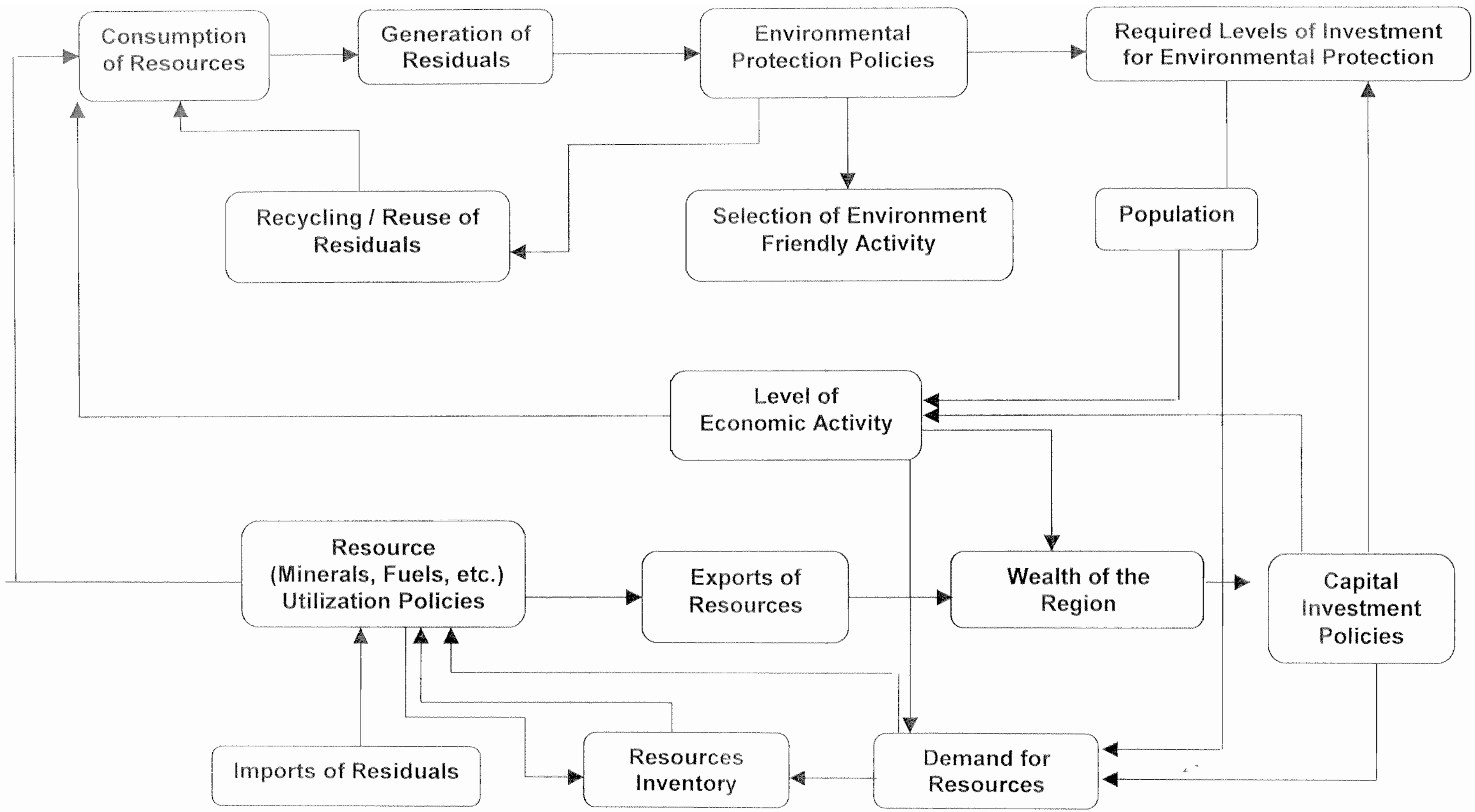


Fig. 1.3.6 : Elements of Supportive Capacity Analysis

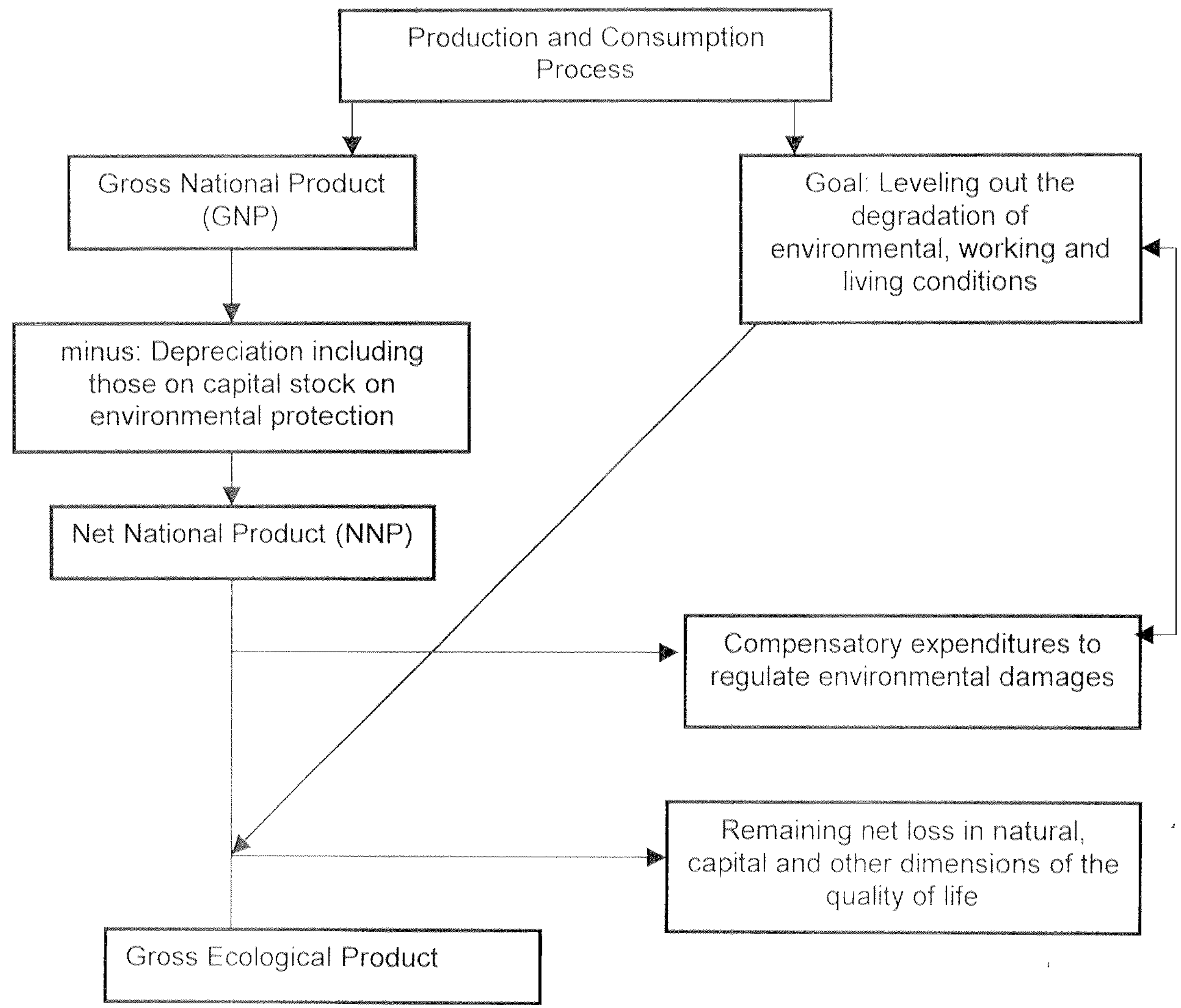


Fig. 1.3.7 : Concept of Gross Ecological Product

Chapter II

Resource Base of the Region

2.0 RESOURCE BASE OF THE REGION

2.1 Land Resources

2.1.1 Geology

Geologically, the rock types falling within Kerala belong to three major groups, namely; Achaean, Proterozoic and Cenozoic. All these major groups are also represented in GKR as shown in **Fig. 2.1.1.** The geological formations falling under each type of rock are given in **Table 2.1.1.**

GKR is not as rich as the Kerala is in mineral deposits. However, it is rich in lime shells, silica sand, china clay, fire clay, brick and tile clays, which are found in Recent and Sub-Recent deposits. Deposits of graphite are found in Archaean rocks.

Groundwater occurs under sub-artesian condition in the coastal tracts in Warkalli Formation, which is being tapped through tube wells. The major source of water in Archaean group is open wells. Fractured zones produce copious groundwater, which is also being tapped through tube wells.

2.1.2 Physiography and Agro-Ecological Regions

On the basis of physiography, Kerala has been divided into three natural regions; the Highland, the Midland and the Lowland. The same divisions apply to GKR also. The part of the land falling less than 8 m above MSL comes under the Lowland, whereas, areas from 8 m to 75 m above MSL under the Midland and above 75 m MSL under the Highland.

The district-wise distribution of these natural regions in GKR is given in **Table 2.1.2.** Idukki district of GKR has no Lowland at all, whereas Alappuzha district has no Highland region. About 96% of the Idukki district falls under the highland category. Altogether, the high altitudinal zone constitutes about 11,110 km^2, lying above elevations of 750 m of Palakkad, Idukki and Kollam districts. About 80% of Alappuzha district is Lowland, and some areas like Kuttanad is even below MSL. The region is a depositional realm or basin and a sink for clays, silts and sands from the Midland and Highland regions. For the same reason, this region is highly dynamic and the drainage canals and backwaters are prone to very high siltation. About 50% of the area of GKR comes under the Highland region and about 36% under the Midland region whereas Lowland covers about 14% area of GKR. These natural divisions and its diversity are a reflection of the uniqueness of GKR in terms of agro-climatic zones, climate, soils, vegetative cover, production and productivity of land, proneness to natural hazards, etc. The physiographic zones of GKR are depicted in **Fig. 2.1.2.**

The agro-climatic zones of Kerala and the districts coming under each category, provided by ICAR (1991), are given in **Table 2.1.3**. In Thrissur and Ernakulam, coastal tracts are known as kole land and pokhali respectively. The coastal tracts of Kottayam and Alappuzha are known as Kuttanad and

Onattukara, respectively. These four regions viz., Pokkali, Kole, Kuttanad and Onattukara have been treated as "special zones" and problematic areas on account of acid saline, acid sulphate, alkaline and Kole soils, which require special management practices to improve their productivity. The agro climatic zones of GKR are depicted in **Fig. 2.1.3.** The agro-ecological regions of GKR are given in **Table 2.1.4.**

2.1.3 Major watersheds

The Greater Kochi Region (GKR) covers the entire districts of Ernakulam, Kottayam, Idukki and parts of Pathanamthitta, Alappuzha, Palakkad, Thrissur and Kollam districts covering the drainage basins of Chalakkudi, Periyar, Muvattupuzha, Meenachil-Manimala, Pamba and Achankovil rivers. It covers an area of about 14,931 km^2. In the case of Idukki district, parts of Chinnar basin is also included even though it is not falling within GKR, while a portion of Periyar basin falling in the Tamil Nadu State is excluded. The number of subwatersheds and microwatersheds in each river basin is given in **Table 2.1.5**.

2.1.4 Land use pattern

Land use/ land cover is an important aspect to be studied since it forms the base for all land-based activities. It not only shows the availability of land under various landuse practices, but also reflects the pressure on land. Land use keeps on changing due to external interference – both natural and anthropogenic – over a period of time. Spatio-temporal change of land use/ land cover analysis needs at least data products of two time intervals.

In order to study the spatio-temporal variation in land use/land cover, firstly data were collected from the Survey of India's topographic maps on 1:50,000 scale, covering 39 sheets, (surveyed during 1968-72) as given below:

58 B/4, 58 B/7, 58 B/8, 58 B/11, 58 B/12 and 58 B/16; 58 C/1 and C/5, 58 C/6, 58 C/7, 58 C/8, 58 C/9, 58 C/10, 58 C/11, 58 C/12, 58 C/13, 58 C/14, 58 C/15 and 58 C/16; 58 F/3, 58 F/4, 58 F/7 and 58 F/8; 58 G/1, 58 G/2, 58 G/3, 58 G/4, 58 G/5, 58 G/6 58 G/7 and 58 G/8.

All possible land use classifications (**Table 2.1.6**), at two levels, were made making use of the above.

Secondly, in order to study the current land use/land cover, a land use/ land cover map was prepared using satellite remote sensing digital data for the year 1999, employing digital image processing method with limited field checking. Since data should be comparable with that of 1968-72, the classification made from the Survey of India's topographic maps was retained for the 1999 data also.

The IRS 1C and 1D LISS III digital data for the period February 1999 with a spatial resolution of 24 m have been used for digital image processing. For the study of trend analysis, land use/ land cover map prepared on a scale of 1:2,50,000 by Kerala State Land Use Board and NRSA based on satellite imagery (1988) were also referred. Accordingly, the landuse/landcover map prepared for the years, 1968-72 and 1999 are given in **Figs. 2.1.4** and **2.1.5** respectively. The following limitations/ assumptions are considered in the spatio-temporal analysis:

- The maps are prepared using different methodologies
- There may be slight difference in the area of each category because of the scale factor of the mapping. In 1:50,000 scale, area below 2.25 ha is omitted since it is not mappable.
- Area calculated herein may not be comparable with the figures of Bureau of Economics and Statistics as it uses sampling techniques to estimate the area and production and productivity of crops
- In the Survey of India topographic maps, paddy is not demarcated separately. It is called as cultivable land and shown in yellow colour. Interpreted IRS 1C LISS III data indicates that in the midland and highland region, "cultivable land" of Survey of India topographic map is comparable with paddy-cultivated area. However, in lowland region, the cultivable land could be either paddy or coconut or both.

Current land use/ land cover in GKR

Agricultural lands occupy a major portion (36.9%) of the total area, followed by forest (29.6%), agricultural plantations (24.4%), water body (4.6%), grassland (3.6%), built-up area (0.5%) and barren and scrub land (0.4%). Agricultural lands include paddy lands, coconut, and mixed crops like banana, tapioca, arecanut, pepper, jack, mango, etc. Agricultural plantation includes rubber, tea, coffee and cardamom. Forest includes canopy area of evergreen, semi-evergreen and moist deciduous forests and forest plantations. Water body includes rivers, reservoirs, backwaters/lagoons, lakes and major tanks. Barren land includes rock outcrops, beaches and open scrublands. **Table 2.1.7** shows different categories of land use/ land cover and their percentage of the total area. **Fig. 2.1.5** shows the landuse/ landcover categories of the GKR for the year 1999.

It is observed from the **Table 2.1.8** that agricultural lands are predominant in Idukki district followed by Ernakulam and Kottayam districts. Forest area is found more in Idukki and Pathanamthitta districts. Ernakulam district dominates in built-up area among all the districts. Water bodies are found more in Ernakulam district followed by Alappuzha, Idukki and Kottayam districts.

2.1.5 Geomorphology and Soil

Classically, geomorphology would cover such areas as origin of topographical features, which are (1) carved by erosion on primary physiographic units and (2) built-up of erosional products. Geological structures, erosional processes and the stage of the streams that drain across the region control these.

Structurally, the entire region is highly dissected and criss-crossed with tens of thousands of streams of Ist to 7th orders. Major streams are controlled by fault lineaments, of which there are two major types, namely, NW-SE and ENE to SSW trending ones. Slopes control minor streams.

Kerala State, in general, and GKR, in particular, is famous for its lofty mountains and palm-fringed plains, which present an imposing spectacle. The Western Ghats attains their maximum height in Anamudi (2964 m) in Idukki district, which happens to be the highest peak in Kerala and the highest in India, outside the Himalayas. In an average distance of 60 to 80 km across GKR; from the high Western Ghats region to the coastal plain, the elevation drops from 2000 m (average) to Mean Sea Level (**Fig 2.1.6**), which is amazing and, probably, unique in the world.

Process-wise, the diversity of physical features has resulted in corresponding diversity of climate, soil, geomorphic characters, habitats, floral and faunal assemblages etc. Complementary to the terrain / physiography, there are 44 river basins in Kerala and 7 in GKR. On an average, the coastal plain of GKR receives about 200 cm to 300 cm of mean annual rainfall, whereas, the midland-highl and about 300 cm to 400 cm, which is received during the SW and NE monsoons. There are high range forest areas where the annual mean rainfall is as low as 100 cm or even less.

The mean annual temperature of GKR varies considerably from east to west, from 17.5°C in Munnar region to 27°C in Alappuzha with spatial variation of 17.5° to 19.5°C; 19.5 to 21.5°C; 21.5 to 23.5°C; 23.5 to 25.5°C and 25.5 to 27.5°C, from east to west. In Munnar, the monthly mean temperature in January – February remains around 7°C. There are temperate shola forests where the temperature goes even to sub-zero level. In short, while the high ranges experience, in general, a cool bracing climate, the rest of GKR experiences a hot and humid climate.

It is no wonder, in the circumstances, that the region entails a unique geomorphology with an array of diverse habitats for flora and fauna. Again, to emphasize the point that within a very short distance of 60 to 70 km, one comes across the temperate shola forests and grasslands of the high ranges to the mangroves of the estuaries of the coastal plains, on the one hand, and the wet/moist evergreen and moist deciduous forests of the midland-highland region. This is a gift of nature unique to GKR, making this land a 'God's own country', which, at the same time, is extremely fragile, about which many are not aware.

Soil

Conventionally, the land has been subdivided into three physiographic zones, namely, highlands (75 m and above), midlands (75 – 8 m above msl) and lowlands or coastal plain (upto 8 m above msl). Due to the very diverse nature of the geomorphology, no soil classification has been made based on the same, nor based on the three physiographic zones. However, the major soil types falling within the three physiographic zones can be taken from the soil map prepared by the National Bureau of Soil Survey and Land Use Planning (NBSSLUP vide KSLUB, 1995)

According to NBSSLUP, the major soils, falling in each physiographic zone are

- **Highlands:** Ustic Haplohumults, Oxic Humitropepts, Ustic Palehumults
- **Midlands** : Oxic Humitropepts
- **Lowlands:** Acquic Ustipsamments, Typic Ustipsamments, Typic Tropaquepts, Typic Sulfaquents, Aeric Tropaquepts, Typic Dystropepts

District-wise soil map is given in **Fig. 2.1.7** and physico-chemical characteristics of soils of GKR are given in **Annexure 2.1.1**.

Table 2.1.1

Geological Formations of GKR

Age	Geological Formations
• Present to Sub-Recent	• *Beach sands and soil*: clays, shell limestone, shelly sands, etc. • *Laterite*
• Lower to Upper Miocene	• *Workalli Formation;* sandstone, clays, lignite • *Quilon Formation*; fossiliferous limestone and clays, sands
• Archaean	• Charnockites, migmatic ortho-gneisses, etc. • Hornblende biotite gneisses, etc.

Table 2.1.2

Natural Regions of GKR - District-wise Area by Regions

District	Low land Area		Mid land Area		High land Area		Total area (Km^2)
	Km^2	% of total	Km^2	% of total	Km^2	% of total	
Kollam	366.6	14.69	1,041.6	41.73	1,087.6	43.58	2,495.8
Pathanamthitta	48.9	4.01	717.1	58.76	454.3	37.23	1,220.3
Alappuzha	1,131.6	79.86	285.3	20.14	--	--	1,416.9
Kottayam	398.4	18.15	1,287.7	58.65	508.8	23.17	2,195.5
Idukki	--	--	188.8	3.68	4,937.9	96.32	5,126.7
Ernakulam	577.5	28.15	1,261.5	61.49	212.4	10.35	2,051.4
Thrissur	465.5	15.55	1,546.9	51.67	981.5	32.78	2,993.9
Palakkad	--	--	1,562.6	34.91	2,913.2	65.09	4,475.8
GKR	**2,988.5**	**13.60**	**7,891.5**	**35.91**	**11,095.7**	**50.49**	**21,976.3**
Kerala	**3,918.7**	**10.56**	**15,909.7**	**42.89**	**17,267.8**	**46.55**	37,096.8

Source: Census of India 1971 and 1981, Report of the Committee on Agro-climatic Zone and Cropping Patterns; Dept. of Agriculture and Land Resources of Kerala State; KSLUB, 1995.

Note: The area is based on the Census Reports of 1971 and 1981. It is specified in the Census Reports that the total area figures of the State taluks will not tally with the district figures, etc.

Table 2.1.3

Agro-Climatic Zones of Kerala – National Agricultural Research Project (NARP) Classification

Zones	Zonal Features	Districts Covered
Northern Zone	Long narrow strip in the northern coastal line of length 293 km. From the forest clad Western Ghats, the land undulates to the west presenting a series of hills and valley intersected by rivers and streams. Numerous small lakes and backwaters adorn this narrow coastline. About 300 km^2. high land lies on the Western Ghat slopes. Low land area is about 4000 km^2.	*Kasaragod, Kannur, Kozhikode and Malappuram*
Central Zone	Area excluding the high ranges, coastal saline tracts and kole lands with special soil	*Palakkad,* ***Thrissur*** *and* ***Ernakulam***.
High Altitude Zone	Part of Western ghat with an elevation of about 750 meters above mean sea level, having a total geographical area of about 11140 Km^2	*High ranges of Wayanad, Palakkad,* ***Idukki****, Kollam and Thiruvana-nthapuram.*
Problem Area Zone	Special zone of problem areas lying in the coastal line from Kollam and Thrissur. It covers an area of 5254 Km^2. The zone is low land and is divided into 4 tracts; Onattukara, Kuttanad, Pokkali and Kole.	***Thrissur****,* ***Ernakulam****,* ***Kottayam*** *and* ***Alappuzha***.
Southern Zone	The zone comprises of the Southern districts covering 16.8% area of the State. The zone has a tropical hum id climate with an oppressive summer and seasonal rainfall.	***Kottayam****,* ***Alappuzha****,* ***Pathanamthitta****, Kollam and Thiruvanantha-puram.*

Note: Districts coming under GKR are given in bold italics
Source: Agro-Climatic Zone Specific Research, I.C.A.R, 1991

Table 2.1.4

Division of the State by Agro-Ecological Regions

Sr. No. of Regions	Zonal Features	Districts Covered
8	Eastern Ghats (TN Uplands) and Deccan Plateau, hot semi-arid ecoregion with red loamy soils and length of Growing Period between 90 and 150 days	A narrow strip along the eastern boundary of the State stretching from Thiruvananthapuram district in the South to Wayanad in the north covering the districts of *Kollam*, ***Pathanamthitta***, ***Idukki***, ***Thrissur***, *Palakkad* and Malappuram in between
20	Western Ghats and Coastal Plains, hot humid – pre humid eco-region with red, lateritic and alluvium derived soils and length of Growing Period exceeding 210 days.	Major part (towards the western side) of the districts of Thiruvananthapuram, *Kollam*, ***Pathanamthitta, Idukki, Thrissur***, *Palakkad* and Malappuram and the entire districts of ***Alappuzha***. ***Kottayam, Ernakulam***, Kozhikode, Kannur and Kasaragod.
5 Southern Zone	The zone comprises of the Southern districts covering 16.8% area of the State. The zone has a tropical humid climate with an oppressive summer and seasonal rainfall	***Kottayam***, ***Alappuzha***, ***Pathanamthitta***, *Kollam* and Thiruvananthapuram

Note: Districts coming under GKR are given in bold italics

Source: Agro-Climatic Zone Specific Research, I.C.A.R, 1991.

Table 2.1.5

Watersheds in Various River Basins of the Study Area

River Basin	No. of Sub Watersheds	No. of Micro Watersheds	Area of River Basin (km^2)
Chalakkudi	57	104	1704
Periyar	183	448	5398
Muvattupuzha	103	202	1554
Meenachil	47	114	1272
Manimala	58	99	847
Pamba	73	158	2235
Achencoil	47	87	1484
Total	**568**	**1248**	**14,494**

Table 2.1.6

The Two Levels of Land use Classification Used

Level I	Level II
1. Agricultural land	1.1 Paddy 1.2 Mixed crops
2. Agricultural plantations	2.1 Rubber 2.2 Tea 2.3 Coffee 2.4 Cardamom
3. Forest land	3.1 Dense/mixed/open jungle 3.2 Forest Plantations
4. Grass land	
5. Barren land	
6. Built-up area	
7. Water body	

Table 2.1.7

Land Use/ Land Cover Categories of 1999 and Percentage Coverage

Land use category	Area (km^2)	% of the Total Area
Agricultural land	5503.6	36.9
Agricultural plantation	3648.5	24.4
Forest	4415.6	29.6
Grass land	537.1	3.6
Barren land	63.1	0.4
Built-up area	78.6	0.5
Water body	684.5	4.6
Total area	**14931.0**	**100.0**

Table 2.1.8

District wise Land use/ Land cover Area (km^2) : 1999

Land use/land cover	Palak-kad	Thrissur	Erna-kulam	Idukki	Kotta-yam	Pathana-mthitta	Alap-puzha	Kollam
Agricultural lands	13.8	565.5	1004.4	1501.0	916.5	602.6	899.7	0.1
Agricultural plantations	0.0	8.7	976.6	1046.3	1078.9	535.5	2.5	0.0
Forest	497.4	337.0	204.8	1827.1	83.2	1321.7	0.0	144.4
Grassland	0.0	1.7	1.5	501.4	12.4	20.1	0.0	0.0
Barren land	19.2	9.6	0.2	21.1	0.9	9.4	0.0	2.7
Built-up area	0.0	0.0	40.2	2.1	9.1	1.6	25.6	0.0
Water body	25.9	45.3	179.3	120.0	102.0	66.1	145.2	0.7
Total	556.3	967.8	2407.0	5019.0	2203.0	2557.0	1073.0	147.9

Source : Primary data collected by CESS

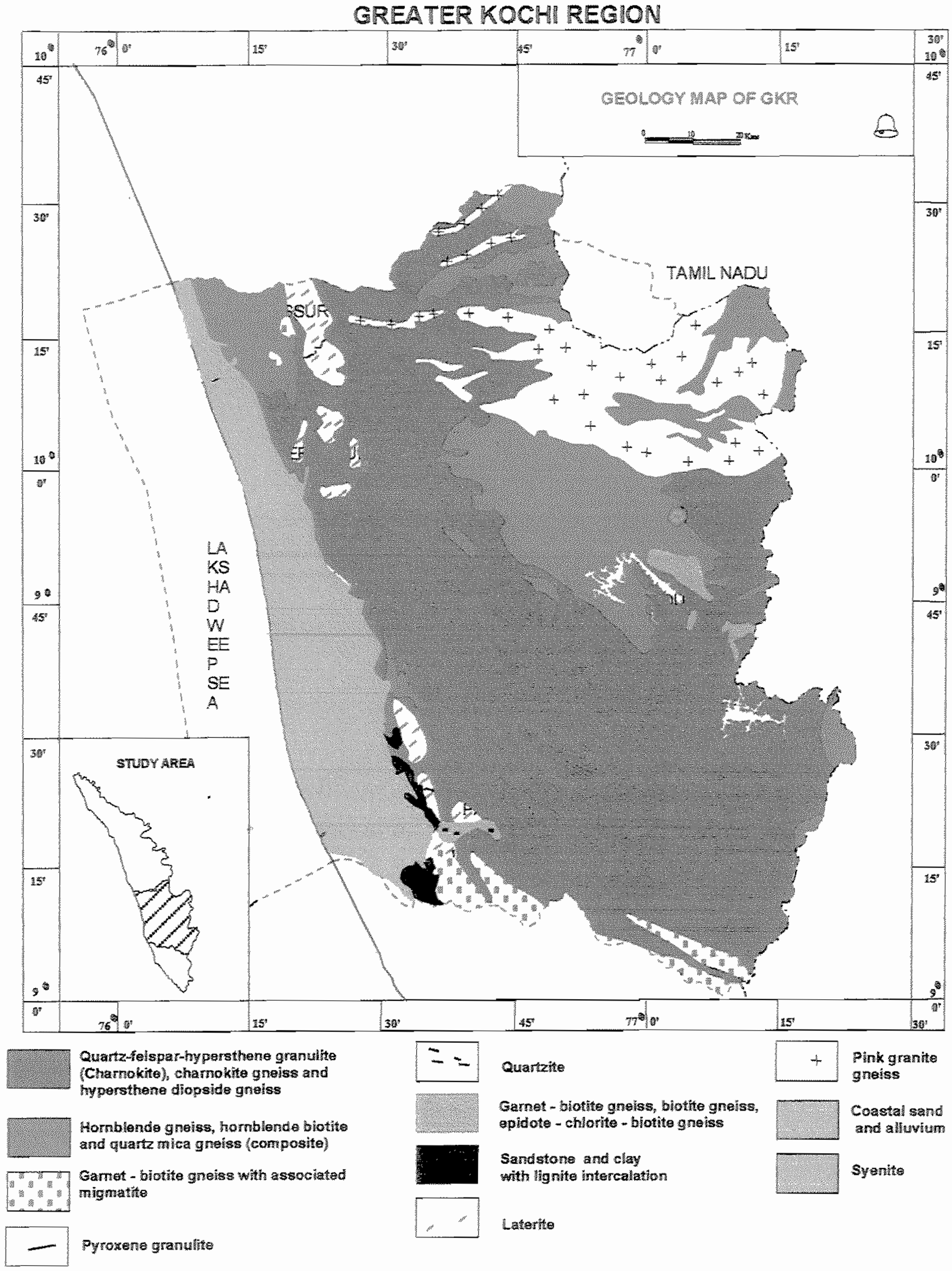


Fig. 2.1.1 : Distribution of Rock Types in GKR

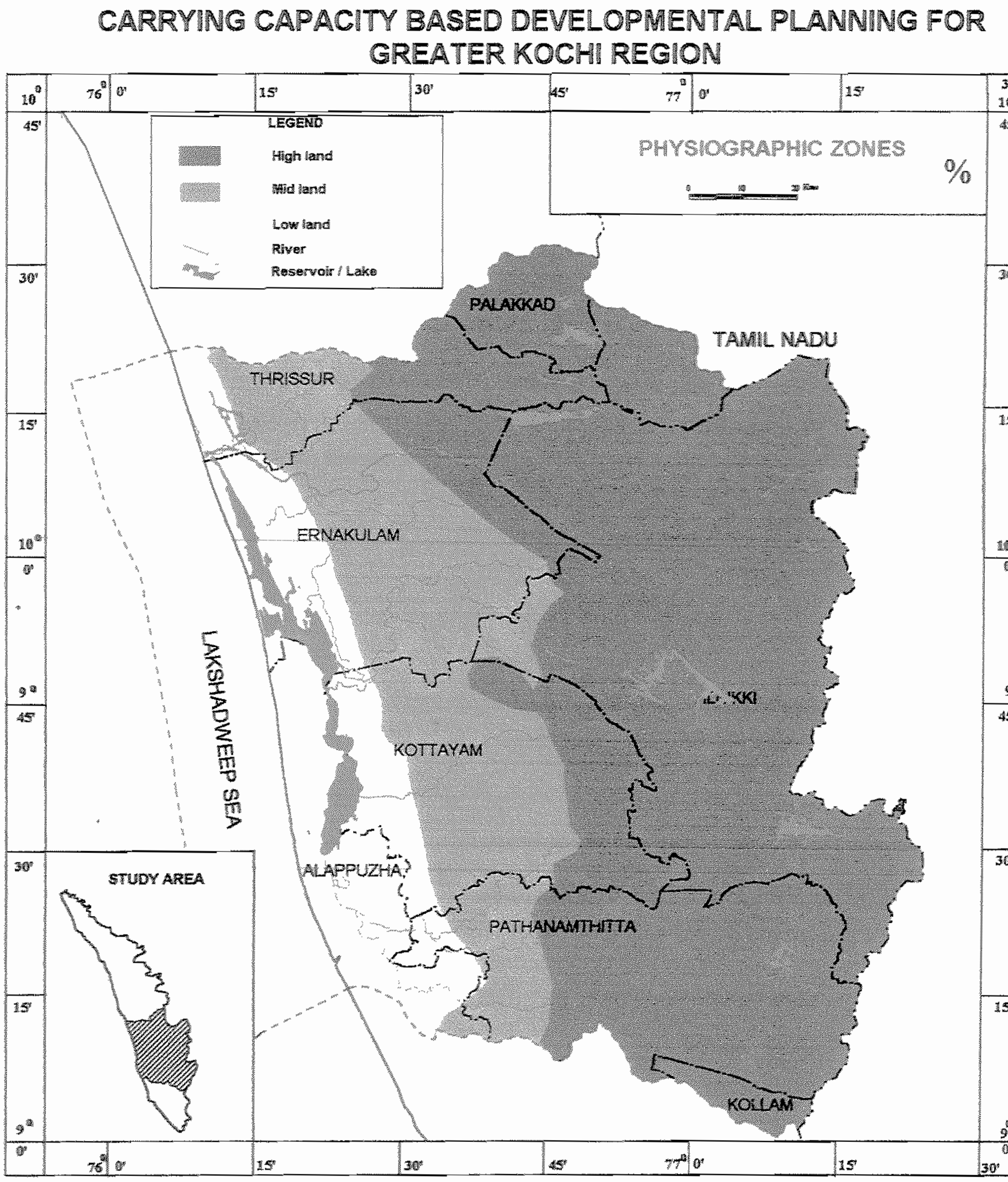
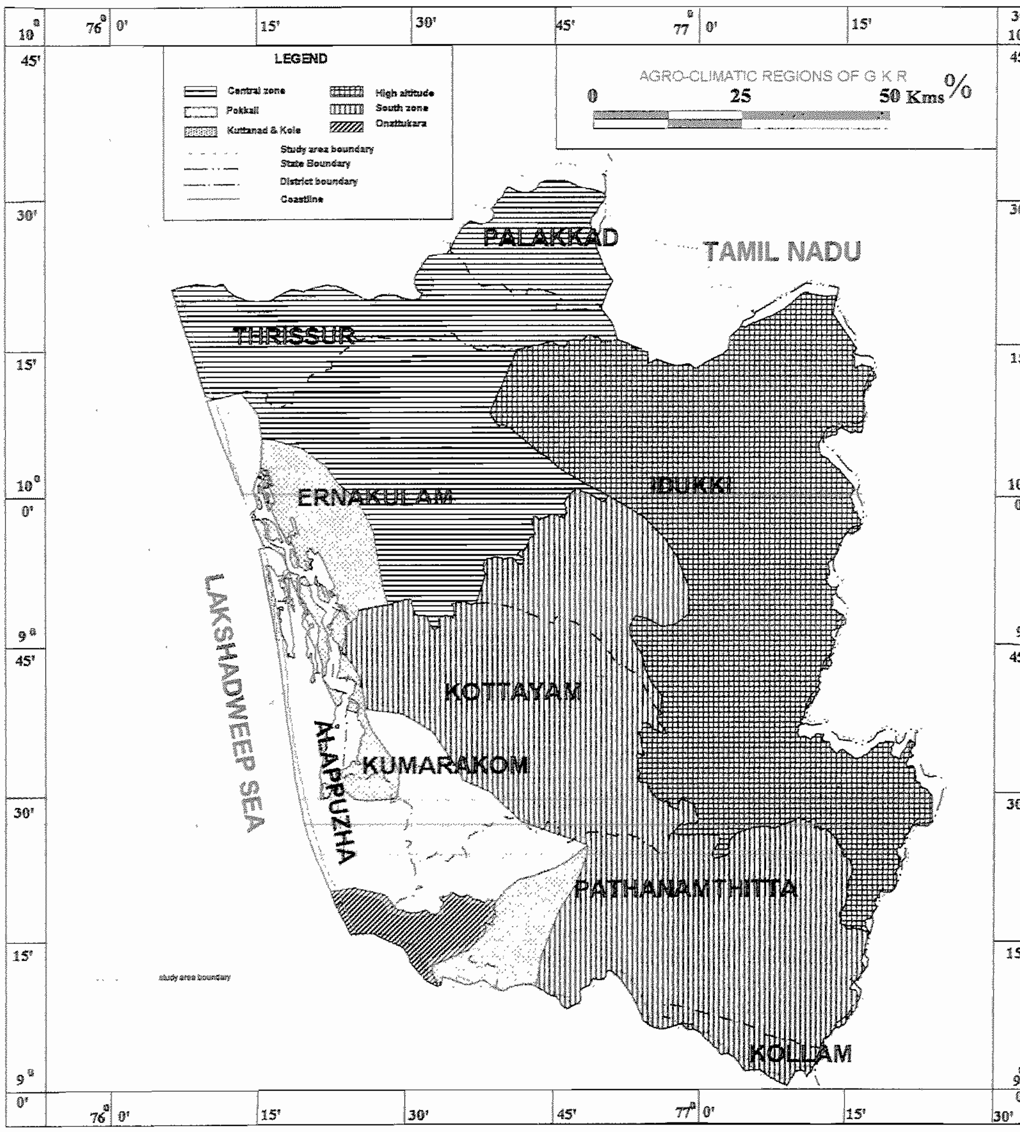


Fig. 2.1.2 : Physiographic Zones of GKR

CARRYING CAPACITY BASED DEVELOPMENTAL PLANNING FOR
GREATER KOCHI REGION



Source: Agro-climatic Zone Specific Research, ICAR, 1991

Fig. 2.1.3 : Agro-climatic Regions of GKR

CARRYING CAPACITY BASED DEVELOPMENTAL PLANNING FOR GREATER KOCHI REGION

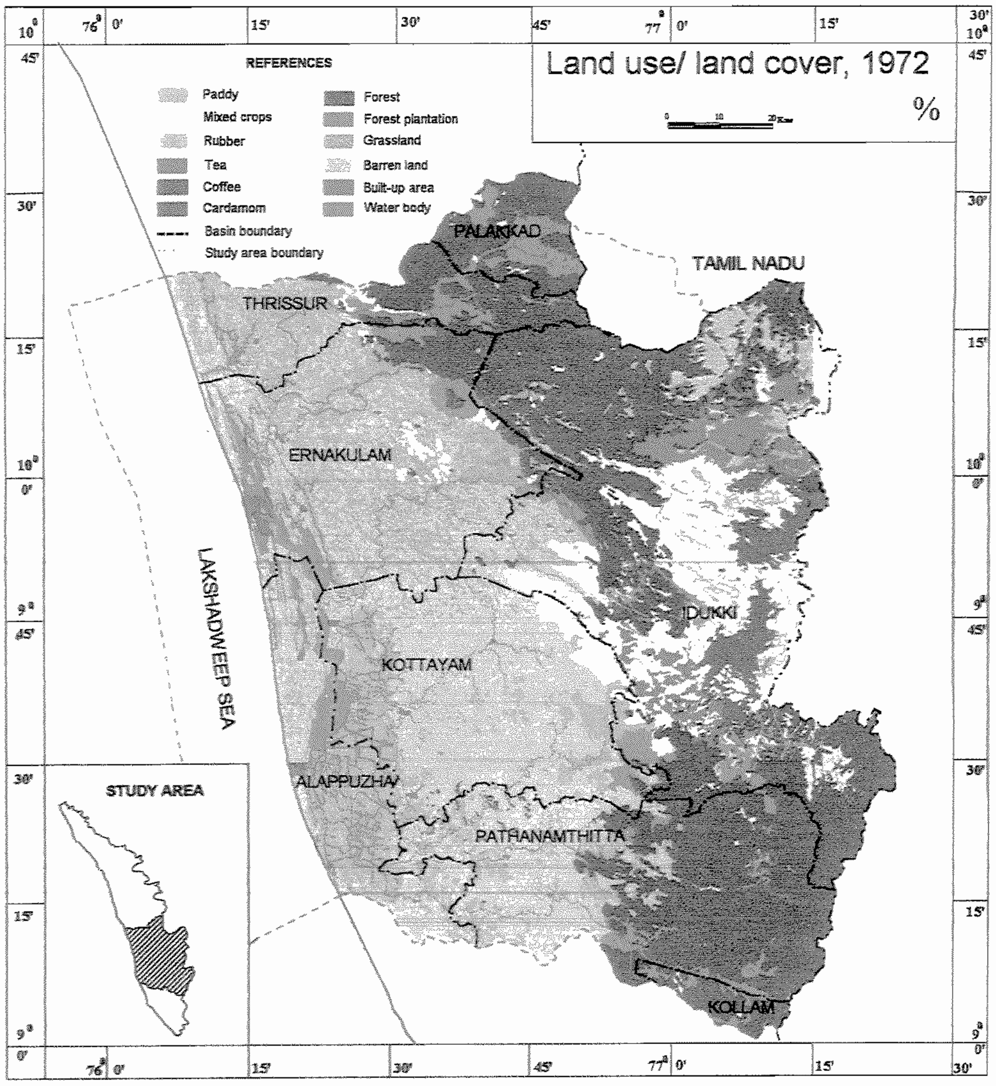


Fig. 2.1.4 : Land use/ Land Cover Categories of GKR 1968-72

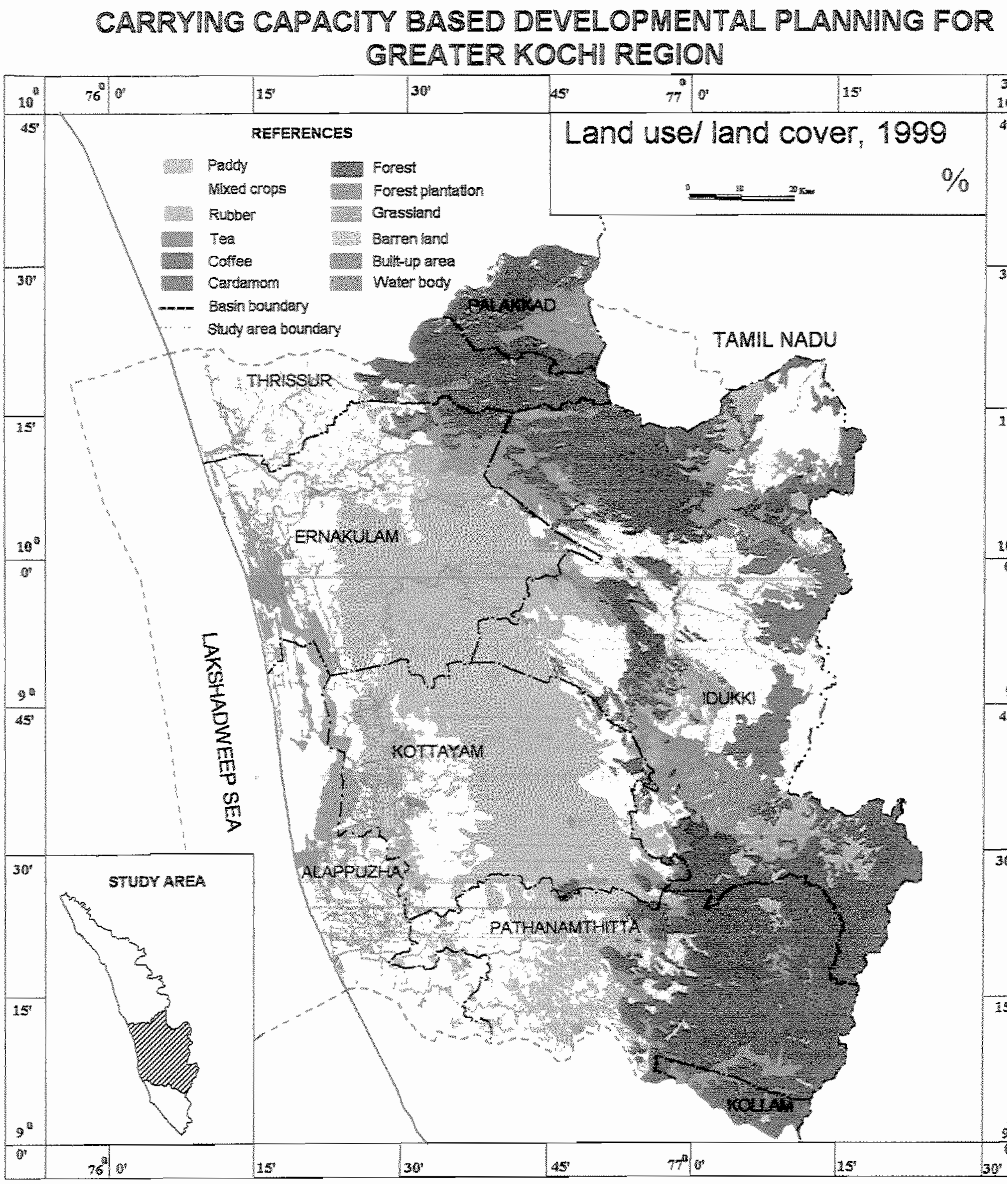


Fig. 2.1.5 : Land use/ Land Cover Categories of the GKR- 1999

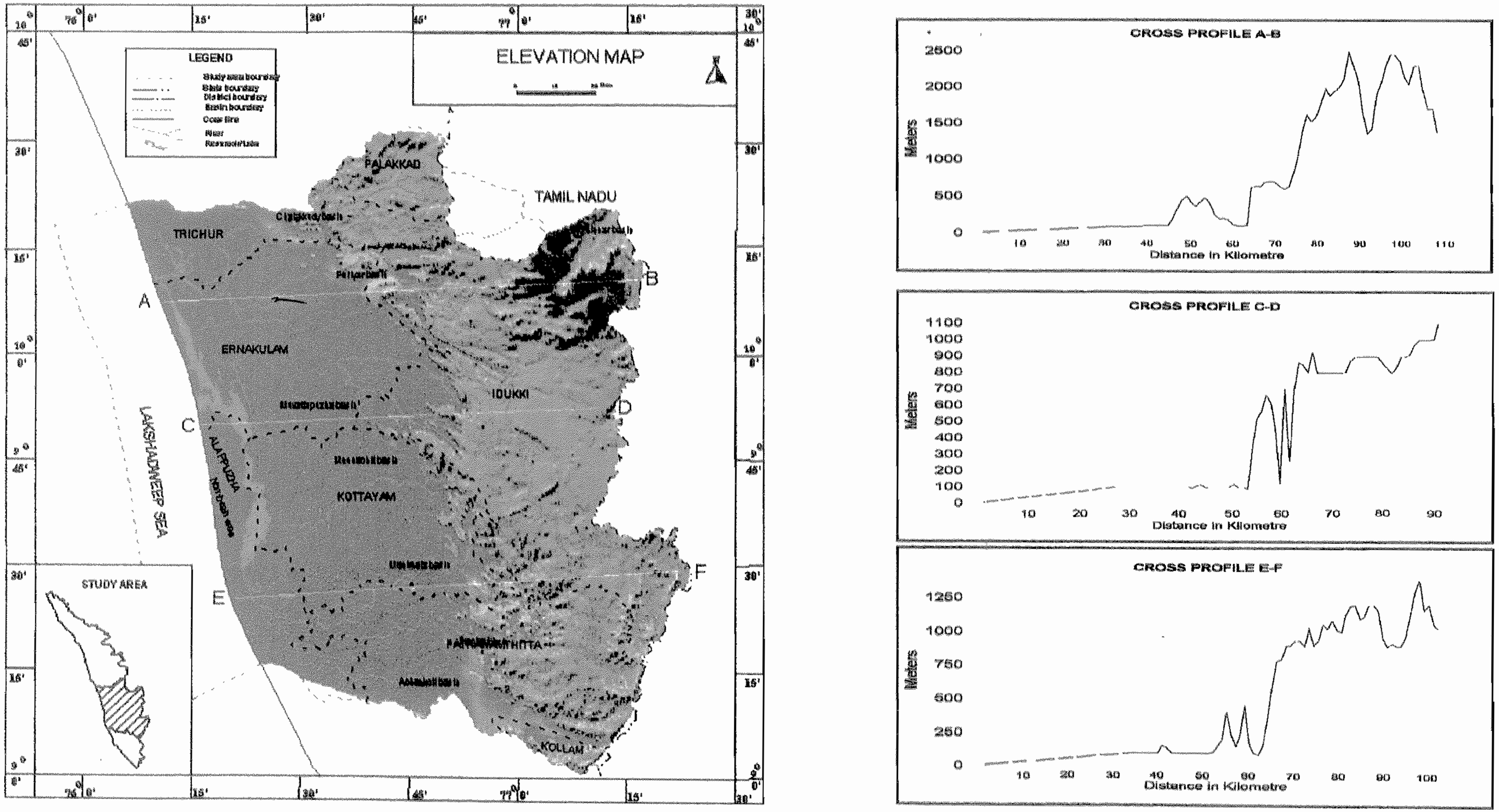
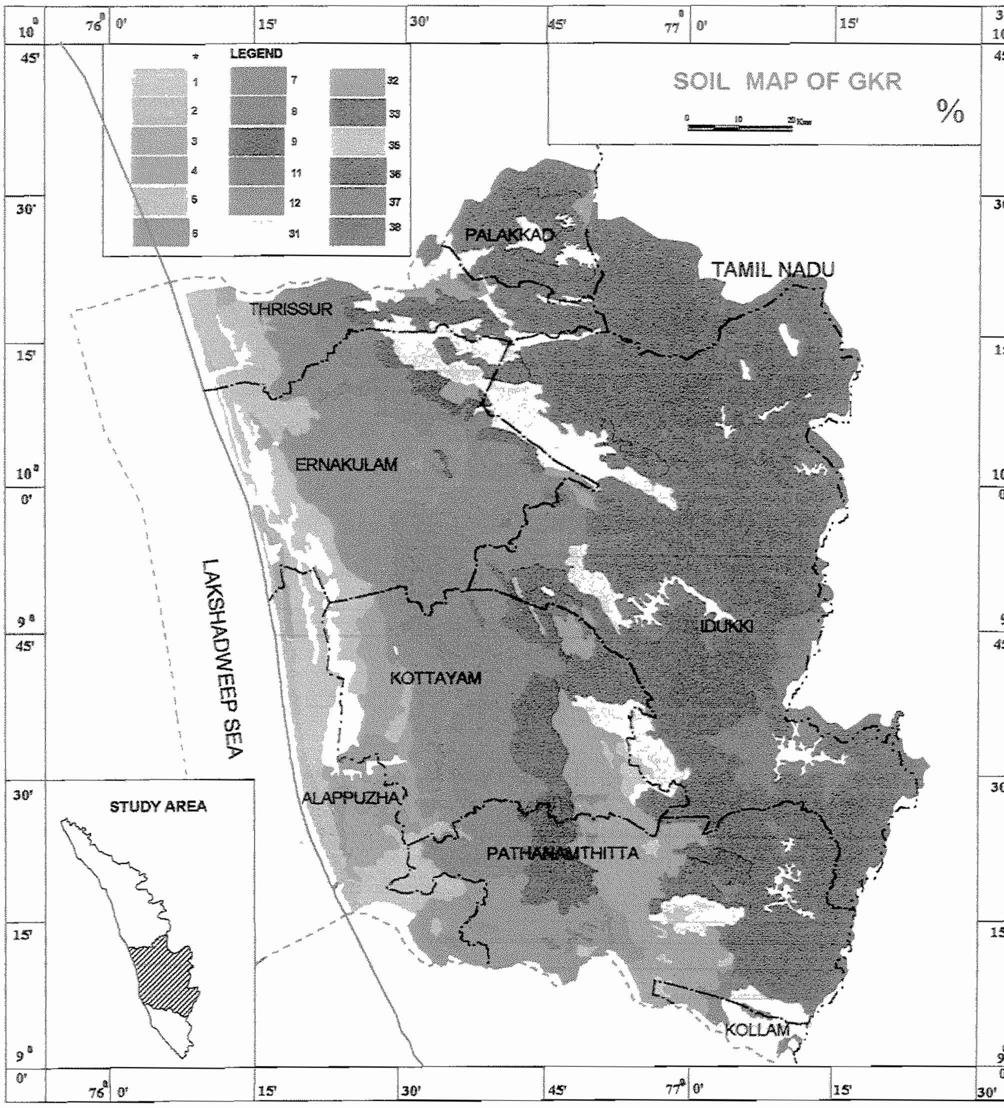


Fig. 2.1.6 : Elevation Map of GKR and East-West Profile

CARRYING CAPACITY BASED DEVELOPMENTAL PLANNING FOR GREATER KOCHI REGION



* The number which follows the legend represents the soil type referred to in the text on soil

Fig. 2.1.7 : Soil Map of GKR

2.2 Water Resources

2.2.1 Surface Water

Water is a prime natural resource, a basic human need and a precious national asset. The Planning and management of this resource and its optimal, economical and equitable use are important and urgent. The available quantity is limited, but the demand on water keeps on increasing to satisfy the needs of the ever-increasing population and to produce more food, fibre and the required industrial products. The total quantum of water available may be enough to meet all our demands, but it is not available where, when and in the quantities we want. This calls for scientific long-term planning for equitable and efficient utilization of the available water at the local, state, regional, national and some times at international levels, both in time and space.

Despite its well-endowed location in a high rainfall region in the country receiving an annual rainfall of more than twice the national average, Kerala State is facing acute water scarcity for nearly six months every year (State Planning Board, 1997). The narrow width of the State, steep slopes, porous substrata, deforestation tendencies in the high ranges, lack of multicrop system in large areas, extreme variance in the regional distribution of rainfall, absence of snow in the Western Ghats, high population density and relatively high rate of water use for domestic purposes, etc are the major factors which contribute to this situation. Eventhough Kerala State is endowed with 44 rivers within such a narrow strip of land, most of them remain dry from December to May. On the other hand, the setting of Kerala with its unique cropping pattern with predominance of perennial crops, high cropping intensity, high density of human and cattle population, low-lying coastal strip facing salt water intrusion etc are all highly water demanding. Development of water resources and its rational utilization consistent with the overall interests of the State from a long term perspective, is therefore, critical in sustaining the life supporting systems of Kerala.

Watersheds and River Basins

Fig. 2.2.1.1 shows the location map of the study area, which includes seven river basins, namely; Chalakudy, Periyar, Muvattupuzha, Meenachil, Manimala, Pamba and Achencoil. All these seven rivers originate from the Western Ghats and drain into the Vembanad Wetland System, except a portion of Chalakudy-Periyar river. The general features of the rivers and their drainage basins are given in **Table 2.2.1.1**.

The drainage maps of the rivers are shown in **Figs. 2.2.1.2 to 2.2.1.8.** These maps also indicate the rainfall patterns and river discharges of the respective basins.

2.2.1.1 Rainfall and Climatological Features

Based on physiography, Kerala can be divided into three zones: **(Fig. 2.2.1.9)** eastern highland (>75 m), western lowland (<8 m) and the central midland (8 m-75 m). Forty-four rivers with length more than 15 km originate from the Western Ghats, out of which 41 flows towards the west and join the Lakshadweep Sea. The remaining three rivers flow towards the east to the neighbouring States and join the Cauvery system and drain into the Bay of Bengal. The average annual rainfall of the State is estimated as 3000 mm. However, the spatial and temporal distribution pattern **(Fig. 2.2.1.10)** is mainly responsible for the frequent floods and droughts in Kerala. The average annual rainfall in the lowland of Kerala ranges from 900 mm in the south to 3500 mm in the north. In the midland, annual rainfall ranges from 1400 in the south to 4000 mm in the north. In the highlands, it varies from 2500 mm in the south to 6000 mm in the north.

There are certain areas in Attappady valley and Chinnar in Idukki district with only around 600 mm annual average rainfall whereas some areas in Silent Valley region like Poochippara and Walakkad receive an annual average rainfall as high as 9000 mm. About 60% of the annual rainfall in the State is received during the southwest monsoon (June-August), 25% during northeast monsoon (September – November) and the remaining during the summer months.

Details of information on rainfall and climatology collected are furnished in **Tables 2.2.1.2** and **2.2.1.3**.

To give an insight into the spatial and temporal distribution of rainfall, the average number of rainy days and the percentage of rainfall density during the southwest and northeast monsoons in the study region, detailed studies have been carried out. **Table 2.2.1.4** furnishes the details of the river basins of Chalakkudy, Periyar, Muvattupuzha, Meenachil, Manimala, Pamba and Achencoil in different physiographic zones.

2.2.1.2 Surface Water Availability - Quantity in River Basins and Watersheds

Streamflow

Details of information on river discharge collected are furnished in **Table 2.2.1.5.** As a part of the preliminary analysis of data, the monthly flows in different physiographic zones of the seven river basins have been worked out. **Table 2.2.1.6** gives the annual discharge in different physiographic zones of the river basins.

Using these stream flow data from different river basins, drainage area, total annual discharge at various locations for different physiographic zones are given in **Table 2.2.1.6.** There is a considerable drop in the flows with the cessation of northeast monsoon in November. This is mainly because all these rivers are monsoon fed. Another unique aspect is the physical feature influenced by the narrow width between the Western Ghats and the sea (35 – 120 km) with steep gradients and undulations. The longitudinal profile of the rivers in the study area is shown in **Fig. 2.2.1.11**. Though the rainfall in the State is higher than the national average at 3000 mm per year, the steep topography, unevenness of the rainfall in time and space, short length of rivers, the unique physiography geology, soil, vegetation and the very high population density have resulted in low availability for utilisation. The tailrace from the hydroelectric projects is reflected in the values of Chalakkudy, Muvattupuzha and Pamba.

Flow duration curves with monthly flows for different gauging stations in the river basins are given in **Figs. 2.2.1.12** to **2.2.1.15.** It can be observed that flows at all stations in the summer, except at the station in Muvattupuzha (due to tailrace of Idukki), are very low or nil. The curves give an idea about the spatial and temporal distribution of flows in summer months. The curve will be useful in deciding about the future interventions for meeting the minimum requirements of the basins.

The Utilizable surface water potential for the river basins of the study area is given in **Table 2.2.1.7.** It is important to understand that not all runoff (or annual yield) is utilizable. In the coastal belt of the State where it is thickly populated, storage space is not available, and in summer, salinity intrusion makes the estuarine water unusable. The entire runoff below the 8 m contour may be considered unutilisable. In the midlands between 8 m and 75 m contour, experience has shown that about 50% of the runoff may be considered utilizable directly or through storage, whereas most of the runoff in the highlands (above 75 m contour) will be utilizable except for about 15% lost by evaporation, spillage etc.

This estimate of utilizable yield may be on the higher side for several reasons:

- the present trend is against large storage reservoirs due to environmental controversies and time and cost over-runs,
- the scale of storage envisaged in a series of checkdams is of much lower order of magnitude,
- water quality deterioration is another factor and
- Complete and actual attainment of the utilizable yield is only imaginative. It is well to remember that monsoon flows contribute to almost 90% of the annual yield, leaving only about 10% during leanflow period. Only large storage can fill the gap.

2.2.2 Ground Water Resources

2.2.2.1 Hydrogeology

Though the physiographic divisions of Kerala is mainly based on the average heights from mean sea level, geomorphologically, coastal belt mainly consists of sandy alluvium and tertiary deposits while midlands consist of thick laterites and tertiary sediments. Highlands are made of hard rocks, occasionally with lateritic cover. Though the coastal belt constitutes only around 10% of the total landmass, it supports more than 25% of State's population. This obviously puts a very heavy pressure on the limited water resources available on this small narrow stretch of land of the State. Details of the hydrogeology of the region are shown in **Fig. 2.2.2.1**.

2.2.2.2 Geomorphology

The definitions of geomorphic aspects considered are given in **Table 2.2.2.1**. The linear, areal and relief aspects of the sub-basins/basins are given in **Tables 2.2.2.2** and **2.2.2.3.** The study shows that most of the laws formulated with reference to the quantitative geomorphologic analysis of drainage basins are of importance to studies on runoff and other hydrological processes.

The drainage density is an important indicator of the linear scale of landform elements in stream-eroded topography. Low drainage density is favoured in regions of highly resistant or highly permeable subsoil materials under dense vegetative cover and where relief is low. High drainage density is favoured in regions of weak or impermeable subsurface materials, and mountainous relief. Drainage density of the sub-basins is between 0.37 and 3.62. In almost all sub-basins, the circularity ratio decreases with increasing size of the basin. The circularity ratios of the sub-basins of the seven river basins range from 0.04 to 1.53 and elongation ratios range from 0.16 to 0.98. Thus, it may be presumed that smaller basins tend to be more circular or less elongate than larger ones. If the elongation ratio shows a value 1.0, it means that the drainage basin is having a circular shape and lower elongation ratio means that the drainage basins are more elongated. These aspects are very important in flood studies, where a hydrograph will have a sudden peak in circular basins in comparison to elongated basins.

2.2.2.3 Groundwater Availability

The annual groundwater recharges of the seven river basins, as worked out by CGWB are given in **Fig. 2.2.2.2**. Of the total recharge, it is estimated that only 50% is utilizable; a similar figure has been arrived at by the State Groundwater Department in their study for the entire State. This value of utilizable groundwater has been assumed considering the various hydrological and environmental factors of this humid tropic State. The investigations of CWRDM in the coastal shallow aquifer zone indicate that the present utilization in this zone varies from 30 to 33%. In the light of this information and data available for other regions, it is estimated that 20% of the recharge is already being utilized in the river basins. The density of dug wells in the study area is given in **Fig. 2.2.2.3.**

2.2.2.4 Groundwater Scenario in the Coastal Belt

Alappuzha coast is 42 km long and it stretches from Aroor in the north to Puthupally in the south covering an area of 260 km^2 including the backwater area. Kayamkulam, Ambalapuzha, Alappuzha and Chertala are some of the important towns in this coastal tract.

The major portion of groundwater along the coastal belt of the Alappuzha district is being tapped from the top unconfined sandy aquifer, whose thickness varies from 3 m to 15 m depending on the locations. Groundwater is mainly extracted from the aquifer through large number of existing open wells. The variation of diameters and depths of these open dug wells in different taluks along the coastal belt are as follows:

Taluk	Average diameter (m)	Average depth (m)
Cherthala	1.05	2.70
Ambalapuzha	1.75	2.68
Kuttanadu	2.40	3.00
Karthikapally	2.05	2.73
Mavelikara	2.40	3.00

The density of wells in the Alappuzha coast is around 185/km^2. A study by CWRDM shows that the total groundwater availability in the top unconfined aquifer along the entire Alappuzha coast comes out to 39.60 Mm^3 and average utilization is of the order of 42% through an estimated 39,400 wells scattered all along the coastal stretch of the district.

Seawater intrusion along the coastal belt of Alappuzha region shows the qualitative response of change of depth-to-water table to the change in water quality parameters (TDS and chlorides) in the coastal unconfined aquifer. An exponential decrease of QDI (Quality Depth Index) with well distance (from the seashore) is observed. The coastal aquifer of Alappuzha can be divided into sensitive and insensitive. The QDI variation is between 21 ppm and 540 ppm and the TDS in 40 ppm and 900 ppm for chloride. The estimated width of sensitive zone in Alappuzha coast extends upto 150 m from the shore. This zone should be avoided while drilling very deep tube wells along the coast. Identification of this sensitive zone is extremely important because much care has to be taken to maintain minimum possible depth for groundwater table. This can be achieved by combination of restricted groundwater withdrawal and appropriate recharging in this zone.

Ernakulam coast is 45 km long and it stretches from Chellanam in the south to Munambam in the north. North Parur, Ernakulam, Fort Kochi and Mattancherry are some of the important towns in the coastal tract. A sizeable portion of groundwater along the coastal belt of the Ernakulam district is being tapped from the top unconfined sandy aquifer whose thickness varies from 2 to 4 meters. The variation of diameters and depth of these open dug wells in different taluks along the coastal belt are as follows:

Taluk	Average Diameter (m)	Average Depth (m)
Parur	1.47	3.44
Kanayannur	1.43	3.18
Cochin	1.19	1.83

The average well density in the Ernakulam coastal belt is around 159/km^2. The average withdrawal from these open wells was observed to be 1600 litres/day/well. The total groundwater availability in the top unconfined aquifer along this coast comes out to 82 Mm^3 and the average utilization is of the order of 33% through an estimated 56000 open dug wells in this coastal stretch.

Lowering of groundwater table (especially in summer) is associated with an increase in salinity. Field observations indicate that depending on location within the coastal belt of the district, every centimeter drop of groundwater table is met with an increase of 20 ppm to 1140 ppm of TDS and an increase of 23 ppm to 3850 ppm of chloride. Sea water has an effect upto 100 m from the shore which means, during summer, groundwater use by the well owners have to be restricted to minimise the fall of the lowering water table with specific reference to this 100 m zone. As a long-term measure, recharging the coastal aquifers to maintain the optimum groundwater level in summer has to be planned.

Thrissur coast is 58 km long stretching from Kottappuram in the south to Andathode in the north near Ponnani. Kodungallur, Vadanapally, Chavakad and Guruvayur are some of the important towns in this coastal tract. The major part of the groundwater along the coastal belt of the Thrissur district is being drawn from the top unconfined sandy aquifer whose thickness varies from 3 to 27 meters depending on the location. Groundwater is mainly extracted from the aquifer through a large number of existing open dug wells, filter point wells and ponds. The variation in diameters and depths of these open dug wells in different taluks along the coastal belt are as follows:

Taluk	Average Diameter (m)	Average Depth (m)
Chavakad	1.85	4.38
Trichur	1.05	6.22
Kodungallur	2.17	3.45
Mukundapuram	2.25	3.20

The average density of wells is around 153/km^2. There are around 69 ponds/km^2 in the area. The average withdrawal from these wells was observed to be 2500 liters/day/well. The total groundwater availability in the top unconfined aquifer along the entire Thrissur coast works out to 127 Mm^3 and average utilization is of the order of 37.4% through an estimated 52000 wells.

Experimental areas show the Quality Depth Index variation between 1967 ppm/m to 23 ppm/m for total dissolved solids and 3400 ppm/m to 45 ppm/m for chloride. Studies on the coastal wells of Thrissur district reveal that sea water has an effect upto 200 m from the shore, which means, during summer, groundwater use by well owners have to be restricted to minimise the fall of the lowering water table with specific reference to this 200 m zone.

2.2.2.5 Tanks and Ponds in the Study Area

Field exploration and inspection of important tanks and ponds of Kerala were carried out during the summer months of March-April, 1989 by CWRDM. The summer months were identified for inspection works to ascertain the water availability during the worst months of the year as well as to have a clear idea regarding the utilization of these water bodies when water is scarce in the State. The tanks/ponds with summer storage capacity more than 1500 m^3 were only inspected. The information collected from the field includes the following:

- Location details – name of village/town, taluk, district, river basin and frame of reference (latitude, longitude and altitude);
- Important physical features – length and breadth/diameter, total depth and summer water level, quality and water transportation problem, etc;
- Details such as number of streams/springs draining into the tank/pond, lining and protection works, and pumping facilities;
- Information pertaining to ownership, year of construction, landuse and population in the area, and general geological features; and
- Details on present use and suggestions on possible rejuvenation and future development.

Location of these tanks and ponds in the study area are shown in **Fig. 2.2.2.4**. The storage capacity and the summer storage of these tanks/ponds for different districts are shown in **Table 2.2.2.4**.

About 77% of these water bodies are used for irrigation, though in most of the cases this is not done in a systematic manner. Though not on a commercial scale, 90% of the tanks/ponds inspected are used for fishing. The field investigations revealed a great potential for utilising these water bodies for organised pisciculture activities. Water from only 4% of the tanks are used for drinking. It may be noted that 98% of the tanks and ponds are used for washing and bathing which considerably affect the quality of water, though the quality of most of these water bodies is satisfactory otherwise. Only 0.08% of tanks/ponds inspected are not utilized for any purpose. Most of the tanks in Thrissur district are used for washing and bathing only. The percentages of these tanks fitted with pumps in Thrissur, Ernakulam and Kottayam districts are 17, 19 and 15 respectively. District-wise present utilization of these tanks/ponds is shown in **Table 2.2.2.5**.

2.2.2.6 Springs in the Study Region

A detailed survey of the springs in Kerala was carried out by CWRDM during February -March, 1988 with the following objectives:

- To identify the perennial springs with reference to latitude, longitude and altitude distributed in different districts/revenue boundaries and river basins of Kerala;
- To ascertain the geological, geo-morphological and landuse characteristics of the sites where the springs are located and from where they originate;
- To measure and compute the discharge (spring-flow) during the summer season (February-March);

* To estimate the quality of water contributed by these springs; and
* To ascertain the present utilization of the springs as well as to recommend ways and means to optimally utilize these springs in future.

This period was chosen since the flow in the streams and springs of Kerala would be minimum during the summer months. Hence the discharges reported are basically summer flow and the average daily discharge of these springs over the years will be much higher than what they are reported here. The prominent springs that are identified in the study area are shown in **Fig. 2.2.2.5.** The details of these 41 numbers of springs identified in the study area like location, place, nearest town, approximate height from MSL, landuse around, perenniality, discharge (in lpm), water quality, number of beneficiaries, type of use, storage facility, future possibility of development etc are also studied.

2.2.3 Estuarine water : Cochin Backwater System

2.2.3.1 River Discharges

The Cochin backwater receives freshwater discharges from six rivers; Periyar, Muvattupuzha, Meenachil, Pamba, Manimala and Achencoil **(Table 2.2.3.1)**. The river discharge depends mainly on the rainfall in the drainage area of the backwater between the estuary and the Western Ghats. Most of the rainfall occurs during May to August and thereafter the precipitation decreases. Average annual runoff ranges from 5180 Mm^3 in river Periyar to 1190 Mm^3 in river Meenachil.

The discharge rate of all rivers except Muvattupuzha is insignificant during January to May. In the river Muvattupuzha almost constant flow is maintained during non monsoon months through the discharge of tailrace water from the Idukki hydroelectric power station. The discharges from all the rivers in the region are maximum during the months of June, July and August, which represent the monsoon season. Thereafter the rate of discharge shows a gradual decrease and becomes insignificant by the end of the year. The recent data, however, shows a sharp decrease during the month of September. The fresh water discharge during the period 1990-95 represents two maximas, the major maxima during monsoon and secondary maxima during the post monsoon (October).

2.2.3.2 Tides

The tides of Cochin backwaters are mixed and semidiurnal in character and have a maximum range of 1m. The difference in height between the observed and predicted tides ranges up to 15-25 cm and a time lag of 15-20 minutes have been noted. The average duration of spring flood and ebb tides is longer than that of neap tide days. Flood currents are faster than ebb currents. Because of the geographical complexity of Kochi backwater systems, tidal distortion is generally noticed.

2.2.3.3 Distribution of Currents

The flow pattern of this backwater system is more related to the tidal rhythm. The current speed ranges from few cm/s to 195 cm/s and is also related to river discharge. High current speeds are observed in all seasons at station 6 with a maximum of 195 cm/s observed during May at the surface. Current velocity is higher in Ernakulam channel compared to that of the Mattancherry channel.

2.2.3.4 Volume Transport Across Cochin Inlet

The volume transport at Cochin inlet was computed for different phases of the tide during spring and neap tides of various seasons (monsoon, post monsoon and pre monsoon). The cross-sectional area of Cochin inlet was 4805 m^2 during 1985-1986 and cross-sectional area during 1993-1994 is found to be 4234.28 m^2, both below the chart datum. However, no much significant variation was observed in the cross-sectional area during 1998-1999 when compared with the value recorded in 1993-1994. But this variation in cross-sectional area from 1985-1986 period is due to sedimentation at the banks and the scouring effect in response to variation in spring or neap cycles. The changes in channel morphology in rapid time scales can be due to response to variations in discharge due to storms or spring-neap cycle with inlet cross-sectional area fluctuating by 10-15%. Cross sectional configuration of Cochin inlet from first Cochin bank to Vypeen bank is projected in **Fig. 2.2.3.1.** Seasonal and Annual Variation in Volume transport at Cochin tidal inlet is given in **Table 2.2.3.2.**

During spring flood in March 1993-94, volume transport was higher than that of the one recorded in 1985-86 and 1999. Spring flood volume transport during March was high (76.63 Mm^3) compared with the year 1985-86 (44.41 Mm^3) and the least in March 1999 (21.75 Mm^3). Eventhough the effect of higher duration and range was found to be insignificant during 1993-94, the higher velocity during this period is responsible for higher volume transport. In January (1993-94), during neap flood the volume transport is less (7.42 Mm^3) when compared to that of 1985-86 (19.26 Mm^3). This variation in volume transport during neap flood (August, January) of both periods was due to the variation in current velocity at the inlet mouth and the tidal distortion in the channels. The volume transport during pre-monsoon season in May at the phase of neap ebb was almost equal (10.54 Mm^3 and 10.38 Mm^3) for tides of almost equal duration and range in 1985-86 and 1993-94 periods, while comparatively higher volume transport during spring flood in May during 1999 is attributed to the increased flood velocity.

Earlier studies have documented that the tidal prism in the pre-monsoon season was found to be 31.5 Mm^3 and during the other seasons, the value ranges between 9.5 Mm^3 and 132 Mm^3. In 1993-94, the increased volume transport in March spring flood is due to the increased velocity in March, whereas decreased volume transport in September 1998-99 spring flood is observed due to the decreased velocity in September by the opposing effect of river discharge against flood currents.

The volume transport in all spring flood conditions for the different periods 1985-86, 1993-94 and 1998-99 is invariably greater than the volume transport during the neap flood and neap ebb in almost all seasons under investigation. The spring flood dominance at this inlet causes the increased volume transport. This clearly shows that more volume of water is being transported into the estuarine region during spring flood to preserve continuity, which also carries suspended sediments into the bay, thus enhancing higher sedimentation. This effect of flow asymmetry was due to the tidal distortion caused by bay geometry, which in turn affects tidal flows near the inlet mouth. However, the channel cross-sectional area is maintained by the flow itself. It is explained that the effect of asymmetry between ebb and flood currents, which contributes to the maintenance of deep self-sustaining drainage channels even in the presence of large sediment input from surrounding coastal waters.

Earlier studies indicated the silt wedge and the development of turbidity maxima at this inlet during flood period. In general, the volume transport during neap flood of 1993-94 and 1998-99 is comparatively less than that of 1985-86 and the least in May at neap. The range and duration of the flood tide is greater than that of ebb in all the months during the period 1985-86 and further substantiated the fact that there is no direct relationship between tidal range and duration such that higher tidal range may not be related to the higher duration. But during the period of observations in 1993-94, and 1998-99 it was observed that the flood tide duration was less than that of the ebb tide duration, which correlates with the change over of this estuary inlet system from ebb dominance to flood dominance.

This mechanism creates more transport of suspended sediments into the bay region to settle than to flush out into the near shore regions. Earlier studies on the non-linear growth of tidal distortion in shallow estuaries due to bay geometry and identified that the long term fate of estuaries is partly a function of net import or export of sediments in an inlet/bay system. The role of geometry of cross-section in generating flood dominance in shallow estuaries have a tendency to be filled up more quickly with sediments than those otherwise.

2.2.3.5 Dilution and Flushing Characteristics

The dilution and flushing characteristics of estuaries are mainly dependent on the fresh water discharge and the volume transport into/out of the estuary through tidal inlets. This mechanisms will influence the salinity distribution as well as flushing of effluents within/from the estuary since the fresh water discharges into the estuary vary seasonally and sometime quite drastically. The dilution and flushing characteristics of Cochin estuarine-inlet system studied under present investigations was found to be highly susceptible to river management approaches and hence, the variation in estuarine characteristics could be mainly attributed to the recent developmental activities and freshwater diversion at the upstream regions.

Table 2.2.3.3 presents Seasonal and Annual Variation in the freshwater fraction (F) and dilution factor (R) for different seasons at Cochin inlet. It was observed that the average freshwater content was minimum (0.22) in March and maximum (0.67) in August during the period 1985-86, whereas the minimum and maximum freshwater content during 1993-94 were 0.16 and 0.6 respectively, while a very high value of (3.05) and (12.78) was observed in August and September respectively during 1998-99. However least value of (0.32) was observed in January 1999. Hence, it is concluded that the freshwater discharge during the southwest monsoon period has a high influence on the freshwater content in the estuary during these periods. Higher values of dilution factor in 1985-86 was observed in March (4.55) and lower values in August (1.49), whereas in 1993-94, the average dilution factor was observed to be high in May (6.17) and the least in August (1.67). But, during 1998-99 the dilution factor was observed to be higher in January (3.13) and March (2.94) with the lowest in September (0.08).

From these observations, it is found that higher values recorded during January and March of 1998-99 was due to negligible freshwater flow and hence resulted in more saline water intrusion. The fluctuations in freshwater fraction corresponding to dilution factor in different seasons clearly indicate the influence of fresh water discharges into the estuary and its gradual decrease during the pre-monsoon season and also the effect of peak fresh water content, as monsoon turns active. The freshwater content in 1998-99 showed a steady increase from January (0.32) to September (12.78) while in 1993-94 it increased from May (0.16) to August (0.60) and thereafter it decreased to March (0.17). Higher values of dilution factor were observed during pre-monsoon season and post-monsoon season when the freshwater flow was negligible in all the above different years.

Table 2.2.3.4 shows the time lag and the distance from the Barmouth for the tide to reach different stations during the period 1998-99 and the flushing time required for the estuary during different months for mean river flow based on freshwater fraction method. It is observed that the flushing time required to replace the existing freshwater in the estuary at a rate equal to the river discharge is higher in January and May and the least in August and September **(Table 2.2.3.5).**

The flushing of pollutants in Cochin estuary explained based on dilution factors indicates that the pollution in Cochin estuary - inlet system is mainly dependent on the availability of freshwater in the estuarine reaches. The commissioning of Muvattupuzha river valley project for multi purpose objectives like irrigation of 178 km^2 of lands, supply of 19.92 m^3/s of water to Hindustan News Print Limited and 1.84 cumecs to Greater Cochin water supply scheme and generation of 6 MW electricity etc. would definitely affect the Cochin estuarine characteristics. If the scarcity of freshwater flow continues, the abatement of estuarine pollution would become more cumbersome which in turn would adversely affect the ecosystem of this tropical estuary in future.

2.2.3.6 Stratification and Circulation Features

The action of gravity upon the density difference between seawater and freshwater tends to cause vertical salinity stratification and, a characteristic convective flow will follow in estuarine circulation. It has been identified that the circulation features influence the problems of sedimentation and pollution through waste disposal. The Seasonal and Annual variations of stratification - circulation parameters are given in **Table 2.2.3.6.**

Cochin estuarine features vary from month to month. Generally, higher values of stratification and circulation parameters were observed during monsoon months in 1985-86. Similarly, higher values of stratification parameters were also observed in monsoon month of August (2.21) during 1993-94. Likewise, May (0.23) and August (0.31) of 1998-99 also showed higher values. But, higher values of circulation parameters were observed in March (3.35) and May (3.37) of 1993-94. The least values of stratification parameters were observed in April (0.08) and January (0.11) of 1985-86. In the case of circulation parameters, in 1993-94 the least value was observed in the month of January (2.32). But during the year 1998-99, very high values of circulation parameters were observed in the month of April and May. Highest values of stratification (1.46) were observed in August of 1985-86. Similarly in 1998-99, the monsoon month of August also recorded high value (0.31) of stratification features. This evidently shows a decreasing stratification tendency during post-monsoon season and higher values in monsoon seasons. The circulation parameter is invariably higher in almost all seasons of the year 1998-99, when compared to the one recorded in 1985-86 and 1998-99. However, in the present study, it is observed that salt wedge to highly stratified conditions prevail in this estuary during monsoon months while a partially mixed to moderately stratified conditions exist during post-monsoon months. This estuary behaves as a partially to well-mixed type during pre-monsoon months as the freshwater fraction drops down.

2.2.4 Coastal Waters

The coastal water study area covered by NIO comprises an area along a stretch of about 120 km from Thottappally in the south to Kodungallur in the north along the coast and 20 km towards offshore from the coast. The study area falls mainly off the coastline of Alappuzha and Ernakulam districts. The environmental setting of the study region with reference to coastal zone is presented here.

2.2.4.1 Openings to the Sea

There are four major openings along the coastline of the study area where the backwaters join the sea. These are at Thottappally, Andakaranazhi, Kochi and Azhikode. At Thottappally, a spillway exists at about 500m landward ride of the opening. This spillway was constructed for preventing salt-water intrusion in order to facilitate agricultural activity especially paddy culture throughout the year. The mouth is closed by sand bar formation for most part of the year and opens only during southwest monsoon season when the sluice gates of the spillway are opened for releasing the floodwater. In some of the years, the sand bar has to be cut open for releasing floodwater. The opening at Andakaranazhi also opens only seasonally when the floodwater accumulates in the backwater system. The major opening existing at Kochi is open throughout the year and exchange of water between the Kochi backwaters and sea occurs here

At Azhikode (Munambam) also, the barmouth is open throughout the year. These two openings are important in the water exchange between the backwaters and the sea that affects the ecology and controls the environmental quality of the backwaters. Apart from these, there are several small openings (pozhi) along the coast where the drainage canals open into the sea during flood season only. All these canals are closed by sand deposition during fair weather season. In the recent past, most of these openings were to be manually cut open for relieving the floodwater during southwest monsoon.

A major port exists at Kochi where navigation is facilitated through the Kochi opening (Kochi bar mouth). A minor port exists at Alapuzha where shipping activities used to take place earlier. Now this port is inactive and the pier constructed on the open coast for facilitating shipping activity is in a dilapidated condition. There are two fishery harbors in the study area, one at Thoppumpady in the Kochi backwaters and another at Munambam.

2.2.4.2 Shoreline

The coastline undergoes seasonal erosion and accretion and sea wall or sea wall-groin assembly to protect the coasts covers major part of the shoreline. At some places net erosion takes place leading to land loss and some places experience accretionary tendency. In several localities, the coastal protection methods fail and erosion takes place.

2.2.4.3 Influence of Kochi backwaters

The coastal waters of Kochi receive about 11×10^9 m^3 of fresh water annually through the Kochi backwaters. The major industries of Kerala are situated upstream of the backwater system. The effluents from various industries and the sewage discharge from the urban area amount to 1.4×10^6 m^3 per day. Industrial wastes, domestic sewage, waste from fish processing plants, coconut husk retting, etc. contribute the pollution load. All these effluents are discharged into the backwater system and no industry is directly dumping waste into the sea. However, part of the effluents discharged into the backwater system is expected to reach the coastal waters as the final destination after undergoing the physical, chemical and biological processes occuring in the backwater system. Another important activity, which affects the region, is the dredging of the harbours area, including the maintenance dredging of the navigational channel and the dredge spoil dumping in the coastal region. In addition to this, reclamation also takes place in the backwater area for various urban developmental activities. These are some of the factors, which can directly or indirectly affect the water quality and ecology of the coastal waters.

2.2.4.4 Mud Banks

A unique phenomena occurring in the near shore area of the study region is the formation of mud banks during the southwest monsoon season (**Fig. 2.2.4.1**). This phenomenon is very important in respect of the fisheries of the region. Appearance of mud banks is a boon for fisheries.

Mud banks get activated during the southwest monsoon season. The process of activation includes stirring up of consolidated mud from the bottom because of forceful wave action and the formation of thick colloidal suspension of fine clay particles in which the waves get continuously damped. When the force of the waves begins to decline, the suspended mud settles to the bottom and the mud banks become passive. The mud banks are roughly semi-circular in appearance and have offshore distance of 6 km and alongshore distance of 4 km. Its dimensions, however, vary from year to year. The calm, turbid and viscous waters demarcate the mud banks. The sediment of the mud banks consists largely of fine clay particles with some silt and practically no sand. Kaolinite is the major mineral found in the mud of the mud bank. The fine sediment is rich in phosphorus. Organic carbon is high in the fine mud. Chlorophyll content is extremely low and phaeophytin values are somewhat higher. Carbohydrate contents are low.

There are almost twenty places along the Kerala coast, where according to available records, mud banks have occurred sometime or other in the past. Of the twenty, the Njarakkal mud bank (north of Kochi) and the Purakkad mud bank (south of Alappuzha) are most famous and well marked. These two mud banks have appeared almost every year during the Southwest monsoon period.

2.2.4.5 Activities in the Coastal Zone

The major activities in the coastal zone are:

- Intense fishing
- Navigation
- Dredging of approach channels of Kochi Port
- Dumping of dredge spoils off Kochi
- Recreation
- Extraction of sand from beaches for filling and construction
- Coastal protection work

Table 2.2.1.1

General Features of the Rivers and their Drainage Basins

River	Length (km)	Drainage area (km^2)	Origin (Place)	Altitude above MSL (m)
Chalakkudy	130	1704	Annamalai Hills	1250
Periyar	244	5398	Sivagiri Hills	1830
Muvattupuzha	121	1554	Taragamkanam Hills	1094
Meenachil	78	1272	Pazhavattimudi	1097
Manimala	90	847	Tatamala	1156
Pamba	176	2235	Pullichimalai	1650
Achencoil	128	1484	Pasukidametu	700

Table 2.2.1.2

Details of Daily Rainfall Data Available

Basin	Station	Period	Data Availability (Years)
Chalakkudy	Sholayar PH, Vettilapara, Karappara,, Parambikulam, Peruvaripalam, Sholayar Dam, Thunakadavu, Poringalkuth, Thumburmuzhi, Chalakudy, Mattathur, Potta	1979-96	12-18
Periyar	Planchode, Odakkali, Grahamsland, Gundumally, Ranicoil, Perumbavoor, Alwaye, Manjumalai Estate,Neriamangalam, Cochin NAS, Cochin INS, Mundirimedu, Kodungallur, Iruttukanam, Shellercoil, Manakudy, Kamakshy Estate, Vazhavara, Irattayar, Peerumedu, Shengulam PH, Willington Island, Perinjankutty Upper, Rajakkad, Panamkutty, Vytila, Devikolam, Murinjapuzha	1966-99	6-28
Muvattupuzha	Malankara, Areekuzha, Cherthala, Piravam, Puthencruz, Thodupuzha, Vaikom, Velloor	1963-99	5-32
Meenachil	Erattupetta, Kozha DAF, Kottayam, Kottayam RRI, Kottayam B &R, Teekoy Estate, Kottayam R H, Kumarakam, Thanneermukkam	1970-99	3-20
Manimala	Thiruvalla, Changanasseri, Mancompu, Mundakkayam, Mundakayam RH, MDS Kanjirappally	1964-99	4-36
Pamba	Perumthenaruvi, Maniyar, Pamba, Alappuzha, Anathodu, Pullad State Seed Farm, Vallathumuzhi, Chittar	1978-99	2-13
Achencoil	Konni Estate, Achencoil, Kayamkulam CPCRI, Pathiyoor, Harippad, KayamkulamRRS, KonniSCRS, Kumpazha, Konni, Adoor, Chamravattom, Sadanandapuram, Mavelikara	1964-99	2-27

Table 2.2.1.3

Details of Daily Climatological Data Available

River Basin	Station	Period	Data Availability (Years)
Chalakkudy	Kannankuzhi, Karappara, Thellickal	1978-95	12-16
Periyar	Kochi (IMD), Perinjankutty, Upper Perinjankutty, Rajakkad, Panamkutty, Karimanal, Kunjithanni, Mankulam, Pindimedu, Pettimudi, Munnar, Sengulam, Iruttukanam, Idukki, Kulamavu, Kattappana, Kadamankuzhi, Meenmutty, Ayyappan Coil, Thattathikkudy, Idamalayar, Udumpanchola, Murinjapuzha	1978-99	6-16
Muvattupuzha	Areekuzha	1994-99	6
Meenachil	Kottayam (IMD), Kozha	1980-99	6-17
Manimala	Kanjirapally	1994-99	6
Pampa	Angamoozhi, Vallathumoozhi, Triveni, Pullad	1978-99	6-16
Achencoil	Chittarmoozhy, Punnamedu, Karuppanthodu, Kayamkulam RRS	1984-99	6-11

Table 2.2.1.4

Annual Rainfall over River Basins in the Study Region

River Basin	Physiographic Zone	Total Rainfall (mm)	No. of Rainy Days	% of Rainfall Density		
				SW-M	NE-M	Others
Chalakkudy	High land	3016	118	66	22	12
	Mid land	3258	130	64	25	11
	Low land	2734	119	67	24	9
Periyar	High land	2444	120	60	26	14
	Mid land	2701	109	62	24	14
	Low land	3075	117	64	24	12
Muvattupuzha	High land	2020	132	57	28	15
	Mid land	3127	130	57	28	15
	Low land	2439	123	63	25	12
Meenachil	High land	4081	162	57	25	18
	Mid land	3806	145	58	27	15
	Low land	3107	133	53	28	19
Manimala	High land	3760	155	48	31	21
	Mid land	2465	109	58	28	14
	Low land	2240	129	58	27	15
Pamba	High land	3762	164	53	29	18
	Mid land	3225	114	45	31	24
	Low land	329833	131	50	30	20
Achencoil	High land	2857	142	46	31	23
	Mid land	2640	112	46	34	20
	Low land	2107	114	53	28	19

SW-M : South West Monsoon (June, July, Aug)
NE-M : North East Monsoon (Sep, Oct, Nov)
Source : Secondary data collected by CWRDM

Table 2.2.1.5

Details of Daily River Discharge Data Available

River Basin	Station	Period	Data Availability (Years)
Chalakkudy	Arangali, Kuriarkutty, Karapara, Ambalakadavu	1974-96	13-22
Periyar	Neeleeswaram, Bhoothathankettu, Chemmanar, Upper Idamalayar, Iruttukanam, Kalady, Kallar, Kunjithanny, Marthandavarma, Mudirapuzha, Panniar, Perinjankutty, Rajakkad, Thuvalar, Mangalapuzha, Planchodu	1963-96	11-34
Muvattupuzha	Ramamangalam, Muvattupuzha, Kalampur, Kakkadassery, Malankara, Thodupuzha	1972-95	11-24
Meenachil	Kidangoor, Peroor, Pala, Teekoy, Cheripad	1970-96	11-27
Manimala	Kallooppara, Thondara, Mundakayam, Manimala	1964-95	11-29
Pamba	Malakkara, Kurudamannil, Erapuzha	1964-95	11-31
Achencoil	Thumbamon, Kollakadavu, Konny, Pandalam, Kalleli	1964-96	11-33

Table 2.2.1.6

Annual Discharge of River Basins

River Basin	Physio-graphic Zone	Location	Drainage Area (Km^2)	Total Discharge (Mm^3)	% of Total Discharge during	
					Monsoon Period	Lean Period
Chalakudy	Highland	Karapara	86	143	97	3
		Kuriyarkutty	129		95	5
	Midland	Ambalakadavu	1331	1820	86	14
		Arangali	1342		92	8
Periyar	Highland	Thuvalar	41	6938	91	9
		Iruttukanam	26		89	11
		Panniar	58		60	40
		Chemmanar	10		84	16
		Rajakkad	639		91	9
	Midland	Neeleswaram				
		Kalady	4234		91	9
		Mudirapuzha	4773		90	10
		Upper	43		89	11
		Idamalayar	696		86	14
		Kunhithanny		7240		
		Perinjankutty	38		91	9
		DS	392		89	11
Muvattupuzha	Midland	Kalampoor	366	3793	96	4
		CWC	208		87	13
		Kakkadassery	476		75	25
		Thodupuzha	1057		53	47
		Malankara	1194		78	22
		Ramamangalam	1038		81	19
		Muvattupuzha				
Meenachil	Highland	Teekoy	57	639	75	25
		Cherippad	147		93	7
		Kidangoor	615		93	7
	Midland	Palai	438	1075	95	5
	Lowland	Peroor	768	1196	87	13
Manimala	Highland	Mundakkayam	110	274	94	6
	Midland	Kallooppaara	731	1055	95	5
		Manimala	510		94	6
	Lowland	Thondara	780	1305	90	10
Pamba	Midland	Kurudamanil	1523	3868	86	14
		Malakara	1713		90	10
	Lowland	Erapuzha	1685	4056	82	18
Achencoil	Highland	Kalleli	560	658	92	8
		Konny	419		95	5
	Midland	Pandalam	834	1425	89	11
		Thumbamon	810		94	6
	Lowland	Kollakadavu	960	1743	87	13

Source : Secondary data collected by CWRDM

Table 2.2.1.7

Basin wise Annual Utilisable Surface Water Potential

River basin	Utilizable Surface Water Potential (Mm^3)
Chalakkudy	1493
Periyar	6305
Muvattupuzha	1859
Meenachil	1056
Manimala	888
Pamba	3297
Achencoil	1343
Total	**16241**

Table 2.2.2.1

Definitions of Geomorphic Aspects Considered

Factor	Mathematical Expression	Parameters	Reference
Drainage density, D	$D = \frac{\sum_{i=1}^{K} \sum_{i=1}^{N} Lu}{Au}$	Lu = length of stream (km) Au = basin area (km^2) K = highest order of stream N = number of streams u = order	Strahter 1952 Horton 1945
Stream frequency. F	$F = \frac{\sum_{i=1}^{K} Nu}{Au}$		Horton 1945
Form factor, RF	$Rf = Au / L_b^2$	Lb = maximum basin length. km	Miller 1953
Circularity ratio. Rc	$Rc = Au / A_p$	Ap = area of a circle with same basin parameter. km^2	Schumn 1956
Elongation ratio, Re	$Re = D / L_b$		Schumn 1956
Constant of channel maintenance. C	$C = I / D$		Schumn 1956
Relief ratio. Rh	$Rh = H / L$	H = elevation difference between reference points,m L = horizontal distance, m	Morisawa 1959
Discharge. Q	$Q = JA^m$	Q = discharge. m^3/s J, m = regression coefficients	Morisawa 1959

Table 2.2.2.2

Linear Aspects of River Basins in the Study Area

River basin Sub basin Perimeter	Order U	No of Streams Nu	Stream Length Lu (km)	Bifurcation Ratio Rb	Mean Length Lu (km)	Length Ratio	Max. Basin Length Lb (km)
Chalakkudy	1	195	126	0.00	0.65	--	
Karappara	2	40	43	4.88	1.09	1.67	
58.85 km	3	9	315	4.44	1.65	1.52	21.1
	4	1	16	9.00	16.50	10.00	
	Total	**245**	**201**				
Chalakkudy	1	264	188	0.00	0.71	--	
Kuriarkutty	2	56	61	4.71	1.10	1.54	
54.45 km	3	11	25	5.09	2.25	2.05	18.6
	4	3	32	3.67	10.82	4.81	
	5	1	4	3.00	3.85	0.36	
	Total	**335**	**310**				
Periyar	1	112	69	0.00	0.61	--	
Thuvallar	2	16	26	7.00	1.62	2.63	
32.45 km	3	5	9	3.20	1.87	1.16	10.6
	4	1	9	5.00	9.35	5.00	
	Total	**134**	**113**				
Periyar	1	1337	879	0.00	0.66	--	
Upper	2	247	225	5.41	0.91	1.39	
Idamalayar	3	46	97	5.37	2.12	2.32	
137 5 km	4	12	54	3.83	4.54	2.14	40.7
	5	2	21	6.00	10.45	2.30	
	6	1	22	2.00	22.00	2.11	
	Total	**1644**	**1300**				
Periyar	1	1251	772	0.00	0.62	--	
erinjankutty	2	233	254	5.37	1.09	1.77	
Upper	3	17	51	13.71	2.98	2.73	
139.15 km	4	13	47	1.31	3.60	1.21	34.6
	5	2	37	6.50	18.70	5.20	
	6	1	16	2.00	15.95	0.85	
	Total	**1517**	**1177**				
Muvattupuzha	1	336	150	--	0.45	--	
Kalampur	2	65	50	5.16	0.76	1.70	
93 km	3	15	30	4 33	2.03	2.67	
	4	3	36	5.00	11.67	5.75	31.3
	5	1	20	3.00	20.50	1.76	
	Total	**420**	**286**				
Muvattupuzha	1	1824	386	--	0.21	--	
Kakkadasseri	2	387	162	4.71	0.42	1.98	
116 km	3	83	91	4.66	1.09	2.60	
	4	20	45	4.15	2.25	2.06	72 8
	5	6	32	3.33	5.42	2.41	
	6	1	36	6.00	36.00	6.64	
	Total	**2321**	**753**				

Contd....

Table 2.2.2.2 Contd...

River basin Sub basin Perimeter	Order U	No of Streams Nu	Stream Length Lu (km)	Bifurcation Ratio Rb	Mean Length Lu (km)	Length Ratio	Max. Basin Length Lb (km)
Muvattupuzha	1	244	502	--	0.40	--	
Thodupuzha	2	387	168	3.21	0.44	1.08	
111 km	3	78	90	4.96	1.15	2 64	
	4	12	74	6.50	6.17	5.37	78.5
	5	2	19	6.00	9.50	1.54	
	6	1	22	2.00	22.50	2.37	
	Total	**1724**	**876**				
Muvattupuzha	1	3450	1076	--	0.31	--	
Malankara	2	847	423	4.07	0.50	0.25	
185.50 km	3	178	225	4.76	1.26	0.39	
	4	35	154	5.09	4.40	0.29	96.8
	5	9	73	3.88	8.11	0.54	
	6	2	77	4.50	38.50	0.21	
	7	1	4	2.00	4.00	9.63	
	Total	**4522**	**2032**				
Muvattupuzha	1	3447	1072	--	0.31	--	
Muvattupuzha	2	846	422	4.07	0.50	0.62	
180 km	3	178	225	4.75	1.26	0.40	
	4	35	154	5.09	4.40	0.29	97.5
	5	9	73	3.89	8.11	0.54	
	6	2	77	4.50	38.50	0.21	
	7	1	6	2.00	0.50	77.00	
	Total	**4518**	**2024**				
Meenachil	1	174	58	--	0.34	--	
Teekoy	2	37	23	4.70	0.62	1.85	
50 km	3	10	13	3.70	1.35	2.17	12.5
	4	3	5	3.33	1.83	1.36	
	5	1	4	3.00	4.50	2.56	
	Total	**225**	**105**				
Meenachil	1	432	169	--	0.39	--	
Cherippad	2	90	66	4.80	0.74	1.89	
96 km	3	25	29	3.60	1.16	1.57	
	4	7	12	3.57	1.71	1.48	18.5
	5	3	19	2.33	6.33	3.70	
	6	1	3	3.00	3.00	0.47	
	Total	558	299				
Muvattupuzha	1	3535	1136	--	0.32	--	
Ramamangalam	2	867	458	4.08	0.53	0.60	
199 km	3	183	243	4.74	1.33	0.39	
	4	36	155	5.08	4.29	0.3[illegible]	103
	5	9	73	4.00	8.11	0.53	
	6	2	77	4.50	38.50	0.21	
	7	1	19	2.00	19.00	2.03	
	Total	4633	**2160**				

Contd....

Table 2.2.2.2 Contd...

River basin Sub basin Perimeter	Order U	No of Streams Nu	Stream Length Lu (km)	Bifurcation Ratio Rb	Mean Length Lu (km)	Length Ratio	Max. Basin Length Lb (km)
Manimala	1	399	190	--	0.48	--	
Mundakkayam	2	78	58	5.12	0.74	1.56	
52 km	3	19	33	4.11	1.74	2.34	14
	4	5	16	3.80	3.20	1.85	
	5	1	18	5.00	18.00	5.63	
	Total	502	315				
Manimala	1	1416	686	--	0.48	--	
Manimala	2	322	241	4.49	0.75	1.55	
Bridge Site	3	71	147	4.54	2.07	2 77	
116 km	4	18	78	3.94	4.33	2.09	
	5	5	27	3.60	5.40	1.25	26
	6	1	30	5.00	30.00	5.56	
	Total	1833	1209				
Meenachil	1	1538	683	--	0.44	--	
Peroor	2	338	291	4.55	0.86	1.94	
183 km	3	83	150	4.07	1.81	2.10	
	4	24	80	3.46	3.31	1.83	53
	5	9	63	2.67	7.00	2.11	
	6	1	38	9.00	38.00	5.42	
	Total	1993	1304				
Pamba	1	7556	2642	--	0.35	--	
Kurudamannil	2	1380	838	5.48	0.61	1 73	
248 km	3	312	388	4.42	1.24	2.04	
	4	72	223	4.33	3.09	2.49	
	5	17	76	4.24	4.47	1.45	61.5
	6	5	120	3.40	60.00	13.42	
	7	1	53	5.00	53.00	0.88	
	Total	9343	4340				
Pamba	1	7690	2755	--	0.36	--	
Erappuzha	2	1412	880	5.45	0.62	1.72	
303.50 km	3	319	420	4.43	1.32	2.13	
	4	73	228	4.37	3.13	2.37	
	5	17	76	4.29	4.47	1.43	75.8
	6	5	120	3.40	24.00	5.37	
	7	1	76	5.00	76.00	3.17	
	Total	9517	4555				
Manimala	1	1801	917	--	0.51	--	
Thondara	2	407	335	4.43	0.82	1 62	
150 km	3	93	199	4.38	2.14	2.60	
	4	23	98	4.04	4.26	1 99	49
	5	5	27	4.6	5.40	2.27	
	6	1	66	5	66.00	12.22	
	Total	2330	1642				

Contd....

Table 2.2.2.2 Contd...

River basin Sub basin Perimeter	Order U	No of Streams Nu	Stream Length Lu (km)	Bifurcation Ratio Rb	Mean Length Lu (km)	Length Ratio	Max. Basin Length Lb (km)
Achencoil	1	830	404	--	0.49	--	
Kalleli	2	209	197	3.90	0.94	1.94	
92 km	3	55	82	3.80	1.49	1.58	
	4	10	44	5.50	4.40	2.95	36.8
	5	2	35.50	5.00	17.75	4.03	
	6	1	10.50	2.00	10.50	0.59	
	Total	**1107**	**773**				
Achencoil	1	1410	652	--	0.46	--	
Konni	2	355	296	3.97	0.83	1.80	
127 km	3	90	142	3.94	1.58	1.90	
	4	18	70	5.00	3.89	2.46	52.8
	5	4	41	4.50	10.25	2.64	
	6	1	28	4.00	28.50	2.78	
	Total	**1878**	**1230**				
Achencoil	1	1645	780	--	0.47	--	
Pandalam	2	411	879	4.00	0.92	1.97	
173 km	3	103	180	3.99	1.74	1.89	
	4	23	83	4.48	3.52	2.02	67.8
	5	4	41	5.75	10.25	2.91	
	6	1	53	4.00	53.50	5.22	
	Total	**2187**	**1504**				
Achencoil	1	1708	817	--	0.48	--	
Kollakadavu	2	432	407	3.95	0.94	1.97	
960 km	3	107	184	4.04	1.72	1.83	84.5
	4	24	85	4.46	3.54	2.06	
	5	4	41	6.00	10.25	2.90	
	6	1	76	4.00	76.00	7.42	
	Total	**2276**	**1610**				

Rb = NU/(Nu+1)

Source: Secondary data collected by CWRDM/CUSAT

Table 2.2.2.3

Aerial and Relief Aspects of the River Basins in the Study Area

River Basin / Sub basin	Drainage Area Au (km^2)	Form Factor (Rf)	Shape Factor (Rs)	Circularity Ratio (Rc)	Elongation Ratio (Re)	Drainage Density (per km)	Constant of Channel Maintenance	Stream Frequency	Relief Ratio (R)
Chalakkudy									
Karapara	86	0.1925	1.789	0.312	0.495	2.338	0.428	2.8455	0.0282
Kuriarkutty	129	0.3717	1.351	0.548	0.6879	2.401	0.410	2.5909	0.0946
Periyar									
Upper Idamalayar	369	0.2224	2.018	0.245	0.53212	3.5193	0.2841	4.4545	0.0826
Thuvalar	38	0.3355	1.48	0.454	0.6536	2.978	0.3358	3.5217	0.0885
Perinjankutty Upper	398	0.3314	1.968	0.258	0.6496	2.958	0.3381	3.8125	0.0347
Muvattupuzha									
Kakkadasseri	208	0.0392	2.270	0.194	0.224	3.62	0.276	11.158	0.031
Kalampur	366	0.3732	1.372	0.531	0.689	0.782	1.279	1.1490	0.032
Thodupuzha	476	0.773	1.435	1.525	0.314	1.839	0.544	3.6190	0.036
Muvattupuzha	1038	0.1092	1.577	0.039	0.373	1.95	0.513	4.3540	0.030
Malankara	1057	0.1128	1.610	0.386	0.379	1.923	0.520	4.2990	0.028
Ramamangalam/ Muvattupuzha	1194	0.1126	1.625	0.379	0.379	1.809	0.553	3.880	0.022

Contd....

Table 2.2.2.3 Contd...

River Basin/Sub basin	Drainage Area Au (km^2)	Form Factor (Rf)	Shape Factor (Rs)	Circularity Ratio (Rc)	Elongation Ratio (Re)	Drainage Density (per km)	Constant of Channel Maintenance	Stream Frequency	Relief Ratio (R)
Meenachil									
Teekoy	57.00	0.870	1.040	0.280	0.510	1.40	0.714	1.580	0.084
Cheripad	147.00	0.920	1.100	0.140	0.340	2.10	0.476	1.960	0.003
Palai	438.00	0.797	1.263	0.234	0.456	1.417	0.701	1.442	0.021
Meenachil	1272.00	0.677	1.480	0.135	0.432	1.428	0.7003	1.475	0.0079
Manimala									
Mundakkayam	110.00	0.556	1.766	0.516	0.8571	2.83	0.340	4.523	0.0922
Manimala Bridge	510.00	0.754	1.325	0.476	0.980	0.375	0.318	3.594	0.0273
Thondara/Manimala	780.00	0.350	3.078	0.3583	0.647	2.105	0.643	2.987	0.0532
Pamba									
Kurudamannil	1523	0.4027	1.793	0.311	0.716	2.850	0.351	6.135	0.027
Erapuzha/Pamba	1685	0.2937	2.086	0.229	0.612	2.703	0.370	5.648	0.210
Achencoil									
Kalleli	419	0.050	1.268	0.622	0.251	1.845	0.542	2.642	0.061
Konni	560	0.035	1.514	0.436	0.210	2.196	0.455	3.354	0.038
Pandalam	834	0.0279	1.690	0.350	0.188	1.803	0.555	2.622	0.028
Kollakkadavu/Achencoil	960	0.0207	1.958	0.260	0.163	1.677	0.596	2.370	0.022

Source : Secondary data collected by CWRDM

Table 2.2.2.4

District wise Number of Tanks/Ponds in the Study Region

District	Storage Capacity (1000 m^3)					Summer Storage Capacity (1000 m^3)				
	5-10	10-25	25-50	50-100	>100	1.5-5	5-10	10-20	20-50	>50
Alappuzha	9	28	7	2	-	14	22	7	2	1
Ernakulam	2	27	15	2	1	14	18	7	6	2
Idukki	4	2	1	-	-	2	3	1	1	-
Kottayam	2	11	6	-	-	5	9	4	1	-
Pathanam-thitta	6	1	1	-	-	5	1	1	1	-
Thrissur	4	45	15	15	1	22	27	17	13	5

Source : Secondary data collected by CWRDM

Table 2.2.2.5

District wise Utilization of Tanks/Ponds

District	Utilization of Tanks/Ponds (Numbers)			
	Irrigation	Washing/Bathing	Drinking	Fisheries
Alappuzha	17	48	-	2
Ernakulam	18	47	2	-
Idukki	4	7	-	-
Kottayam	1	20	1	-
Pathanamthitta	7	7	-	-
Thrissur	38	62	2	2

Table 2.2.3.1

Discharge Rate of Various Rivers into the Vembanad Lake

Unit : m^3/s

Month	1980-1990		1990-1995	
	Range	Average	Range	Average
Periyar				
January	6.0-73.3	29.1	37.4-50.2	43.3
February	5.5-59.7	23.8	37.8-65.5	51.3
March	7.0-59.5	25.0	40.8-58.2	48.3
April	5.1-78.6	38.5	45.8-77.2	61.4
May	10.4-137.9	59.4	50.6-180.3	89.2
June	168.0-906.1	395.9	268.4-721.6	502.4
July	270.8-1045.1	558.9	505.9-912.2	720.6
August	306.3-793.5	531.7	490.5-748.1	576 1
September	95.4-755.7	322.3	141.9-398.9	285.4
October	74.1-347.3	232.8	192.1-391.7	307.2
November	91.4-230.6	150.1	153.8-372.4	236.0
December	17.4-134.2	55.7	66.6-81.8	67.0
Muvattupuzha				
January	41.4-73.2	59.5	62.3-84.3	73.9
February	28.4-69.2	57.0	63-6-86.6	77.5
March	37.0-77.3	56.7	69.1-84.8	75.6
April	30.0-84.5	57.9	67.7-90.0	79.9
May	38.0-104.6	70.0	81.7-188.9	109.5
June	77.0-497.0	267.0	24.9-405.7	307.0
July	200.2-491.1	346.1	316.0-492.1	412.6
August	197.0-384.3	290.7	271.3-329.5	301.0
September	104.0-332.9	187.7	91.8-276.0	163.0
October	91.5-272.8	173.2	118.9-276.7	207.4
November	74.6-218.5	154.5	114.9-181.3	146.2
December	55.4-103.6	72.9	79.9-89.4	85.4
Manimala				
January	0.5-3.0	1.8	0.5-4.9	1.8
February	0.0-1.2	0.3	0.0-15.3	3.3
March	0.0-5.2	1.1	0.0-1.7	0.8
April	0-12.8	3.9	1.8-8.5	4.9
May	4.9-17.9	11.6	1.8-8.5	32.9
June	72.8-181.1	109.0	121.9-247.5	164.4
July	41.2-187.7	111.4	141.0-227.6	186.1
August	63.6-133.5	100.1	75.4-147.4	110.8
September	34.3-138.8	77.8	10.0-121.0	49.6
October	31.3-120.4	74.0	68.6-140.5	104.7

Contd...

Table 2.2.3.1 Contd...

Month	1980-1990		1990-1995	
	Range	Average	Range	Average
November	48.6-90.9	67.9	51.9-95.4	69.7
December	3.9-36.0	14.3	4.2-13.7	7.1
Meenachil				
January	0.5-3.6	1.7	0.3-5.1	1.6
February	0.0-1.2	0.4	0.0-5.9	1.3
March	0.0-6.7	1.5	0.0-0.8	0.4
April	0.0-24.4	6.7	0.9-15.7	4.5
May	11.0-25.5	18.5	1.9-107.4	29.8
June	69.5-156.0	101.5	118.1-250.2	157.6
July	58.5-162.5	112.8	142.8-219.4	181.7
August	83.6-127.4	99.1	77.4-149.1	111.8
September	30.1-126.6	72.0	11.8-96.0	43.4
October	26.7-103.4	69.6	50.4-138.4	94.2
November	31.5-96.5	61.4	49.5-83.2	59.3
December	3.0-25.2	12.4	3.6-9.3	5.7
Pamba				
January	19.8-25.0	21.5	17.4-33.0	23.4
February	9.2-17.4	13.7	8.1-30.5	14.7
March	13.6-26.8	18.7	7.9-26.3	15.5
April	12.1-37.2	22.1	10.0-39.6	23.0
May	25.3-41.4	34.2	26.2-187.6	68.5
June	98.8-280.2	183.5	217.9-518.8	322.0
July	100.3-451.0	272.9	288.1-463.9	375.8
August	170.2-336.2	238.4	199.5-354.2	258.5
September	100.0-342.2	194.5	50-271.1	131.3
October	67.0-226.9	159.8	115.0-353.2	218.2
November	84.3-192.9	133.4	111.8-231.5	158.0
December	20.6-72.0	37.7	31.0-45.3	38.2
Achencoil				
January	1.2-10.3	3.4	1.0-4.9	2.8
February	0.3-3.9	1.3	0.5-4.3	1.8
March	0.0-5.8	1.4	0.9-2.1	1.4
April	0.0-21.1	4.5	0.9-7.0	3.4
May	0.3-10.9	6.5	3.1-73.2	21.5
June	6.0-154.3	63.1	60.9-252.4	114.2
July	25.3-131.1	81.6	70.8-147.0	119.2
August	28.0-118.9	67.4	48.6-130.8	77.8
September	9.8-200.2	82.2	7.1-84.4	34.3
October	20.4-95.7	54.4	41.6-146.3	83.9
November	19.9-76.9	56.9	36.5-149.0	71.8
December	4.0-33.3	11.1	4.5-11.7	8.3

Source : Secondary data collected by CWRDM / CUSAT

Table 2.2.3.2

Seasonal and Annual Variations in Volume Transport at Cochin Tidal Inlet

Season/ Month	Year	Tidal Phase	Tide Levels (cm)	Duration (hr)	Avg.Cross-sectional area (m^2)	Volume Transport ($x10^6$) (m^3)
Monsoon						
August	1985-86	Neap Flood	018-090	0755-1520	5026	43.08
	1993-94	Neap Flood	021-086	0700-1330	4481	39.95
	1998-99	Neap Flood	039-111	0530-1330	4486	34.88
September	1985-86	Spring Flood	028-092	0718-1335	5051	51.83
	1993-94	Spring Flood	---	---	---	---
	1998-99	Spring Flood	066-108	0700-1330	4633	16.26
Post-Monsoon						
January	1985-86	Neap Flood	036-075	0950-1510	5034	19.26
	1993-94	Neap Flood	058-091	1100-1530	4578	07.42
	1998-99	Neap Ebb	106-028	0554-1348	4541	30.99
March	1985-86	Spring Flood	034-100	0800-1420	5079	44.41
	1993-94	Spring Flood	062-087	0530-1030	4578	76.63
	1998-99	Spring Flood	021-092	0420-1148	4495	21.75
Pre-Monsoon						
April	1985-86	Neap Ebb	081-049	1156-1604	5071	20.56
	1993-94	Neap Ebb	---	---	---	---
	1998-99	Spring Flood	000-090	0730-1600	4440	36.68
May	1985-86	Neap Ebb	073-054	0715-1150	5063	10.54
	1993-94	Neap Ebb	085-064	1200-1630	4578	10.38
	1998-99	Spring Flood	021-092	0420-1148	4495	21.75

Source : Secondary and Primary data collected by CUSAT

Table 2.2.3.3

Seasonal and Annual Variations in Fresh Water Fraction and Dilution Factor at Cochin Inlet

Season/ Month	Freshwater Fraction (Avg. F)			Dilution Factor (Avg. R)		
	1985-86	1993-94	1998-99	1985-86	1993-94	1998-99
Monsoon						
August	0.67	0.60	3.05	1.49	1.67	0.33
September	0.29	--	12.78	3.45	---	0.08
Post-Monsoon						
January	0.25	0.25	0.32	4.00	4.08	3.13
March	0.22	0.17	0.34	4.55	5.81	2.94
Pre-Monsoon						
April	0.25	---	0.72	4.00	----	1.38
May	0.24	0.16	0.79	4.17	6.17	1.26

Source : Secondary and Primary data collected by CUSAT

Table 2.2.3.4

Time Lag and the Distance from the Barmouth

Station No.	Name	Distance from Barmouth (m)	Time lag for Tide (hr)
1	Thannirmukkom South	42875	2.40
2	Thannirmukkom North	42000	2.35
3	Ittipuzha river mouth	29500	1.65
4	Murinjapuzha mouth	24500	1.37
5	Kumbalam- Perumbalam	17500	0.98
6	Thevara	10000	0.56
7	Marine Science Jetty	6875	0.38
8	Fisheries Harbour	4375	0.24
9	Barmouth	Nil	Same phase
10	Bolghatti	3125	0.17
11	Vaduthala Jetty	6875	0.38
12	Varapuzha Cheranallur	11875	0.66
13	Eloor (FACT)	15625	0.87
14	Pathalam Bridge	17425	0.98

Source : Secondary and Primary data collected by CUSAT

Table 2.2.3.5

Seasonal Variations in Flushing Time for the Cochin Estuary

Season/ Month	Mean River Discharge (m^3/s)	Flushing Time (days)
Monsoon		
August	1327.8	0.23
September	936.5	0.14
Post-monsoon		
January	116.9	0.76
March	104.3	0.27
Pre-monsoon		
April	133.5	0.27
May	197.1	0.69

Source : Secondary and Primary data collected by CUSAT

Table 2.2.3.6

Seasonal and Annual Variations of Stratification and Circulation Parameter Values at Cochin Inlet

Season / Month	Stratification Parameter			Circulation Parameter		
	1985-86	1993-94	1998-99	1985-86	1993-94	1998-99
Monsoon						
August	1.46	2.21	0.31	1.66	2.89	5.89
September	0.39	---	0.03	1.04	---	0.67
Post-Monsoon						
January	0.11	0.18	0.19	1.14	2.32	0.33
March	---	0.15	0.06	---	3.35	0.53
Pre-Monsoon						
April	0.08	---	0.06	1.14	----	52.0
May	----	0.27	0.23	---	3.37	17 5

Source : Secondary and Primary data collected by CUSAT

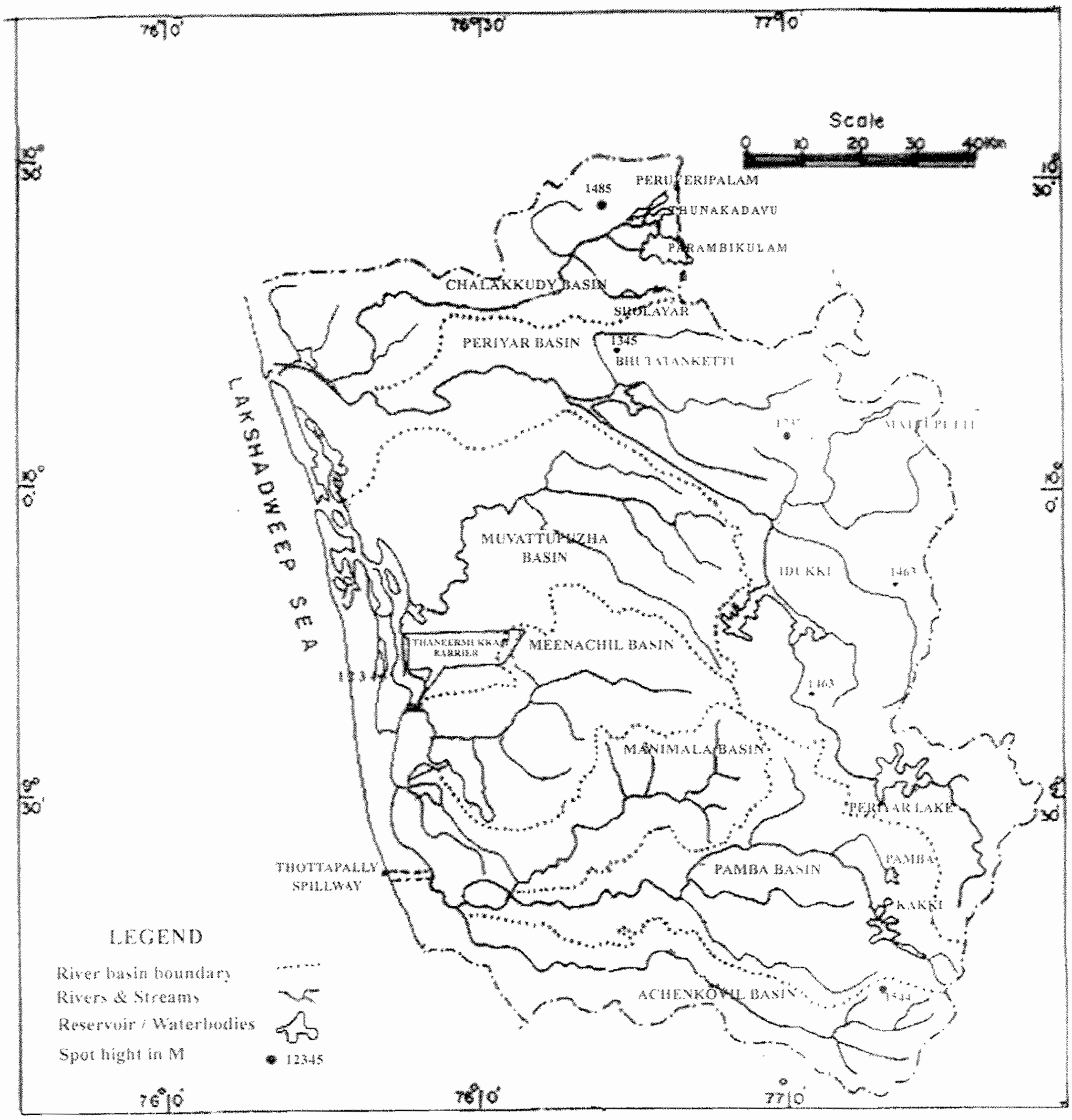


Fig. 2.2.1.1 : Location Map of the Study Area with River Basins

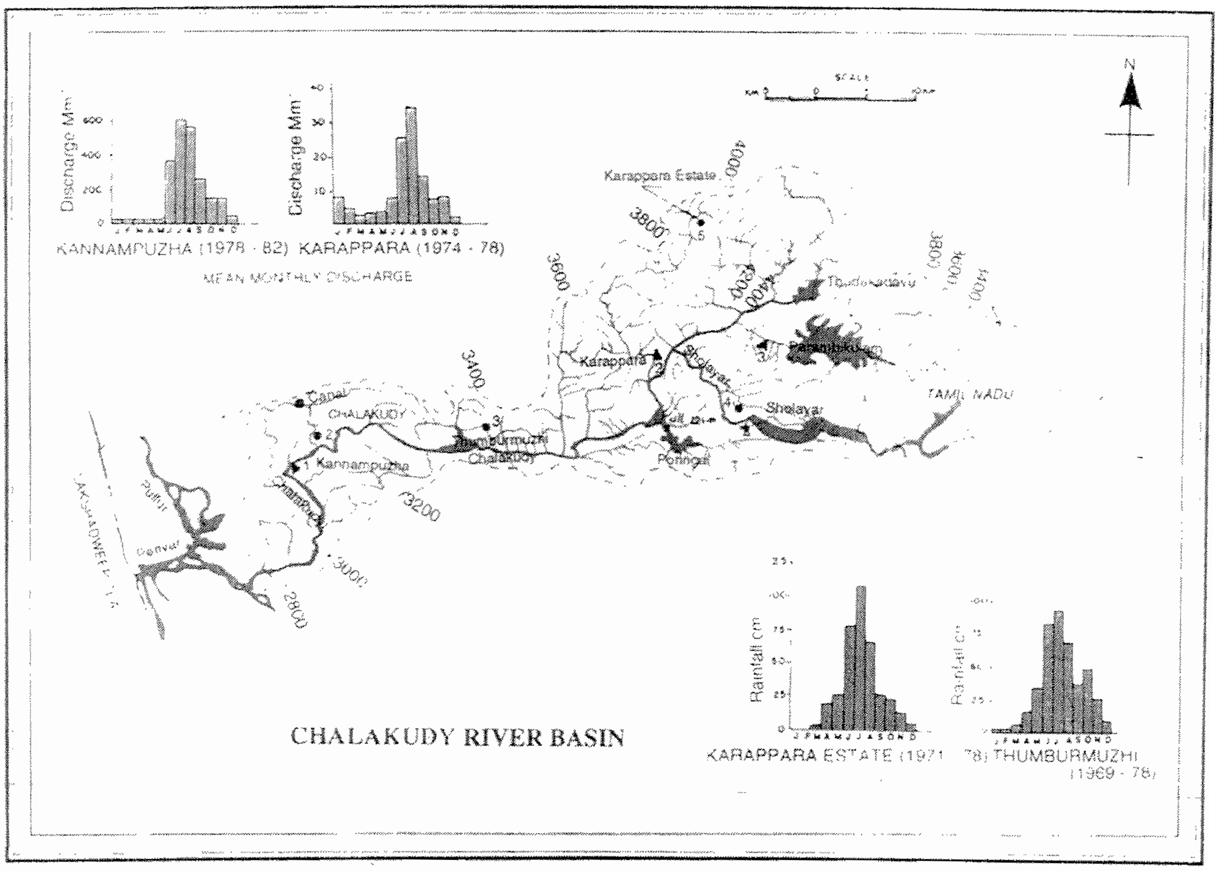


Fig. 2.2.1.2 : Drainage Map of Chalakudy River Basin

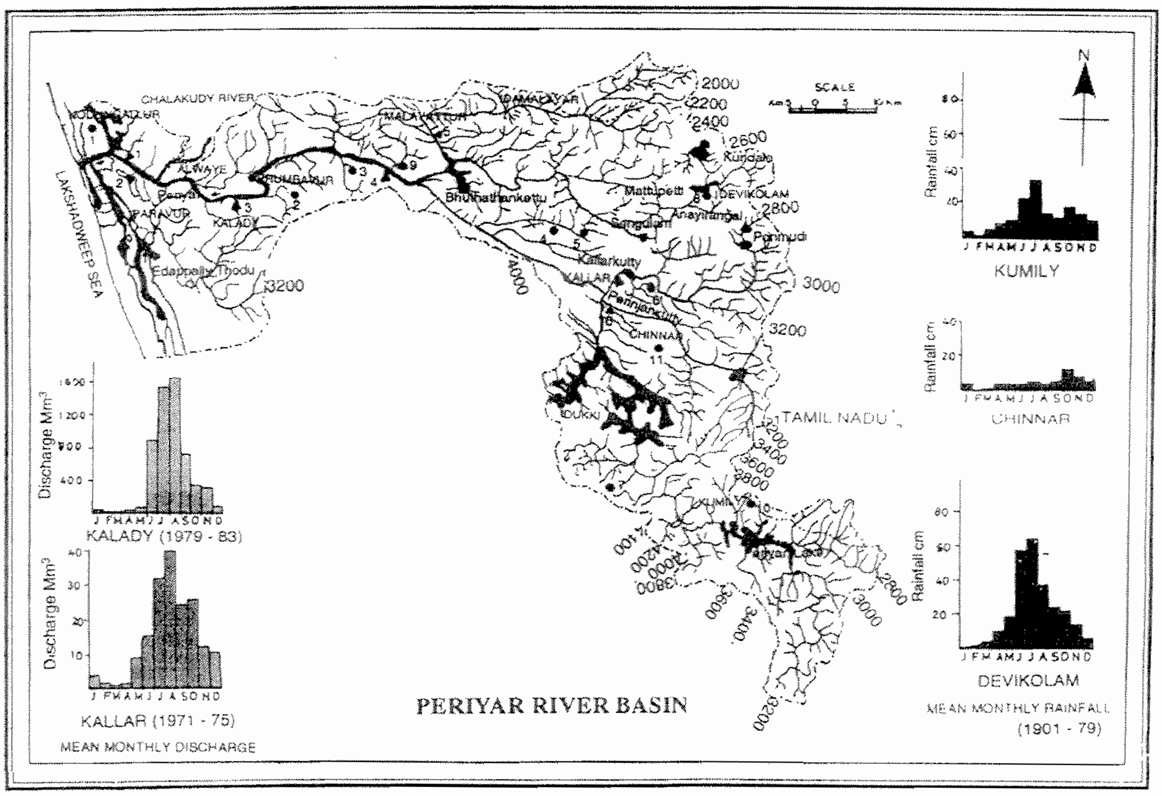


Fig. 2.2.1.3 : Drainage Map of Periyar River Basin

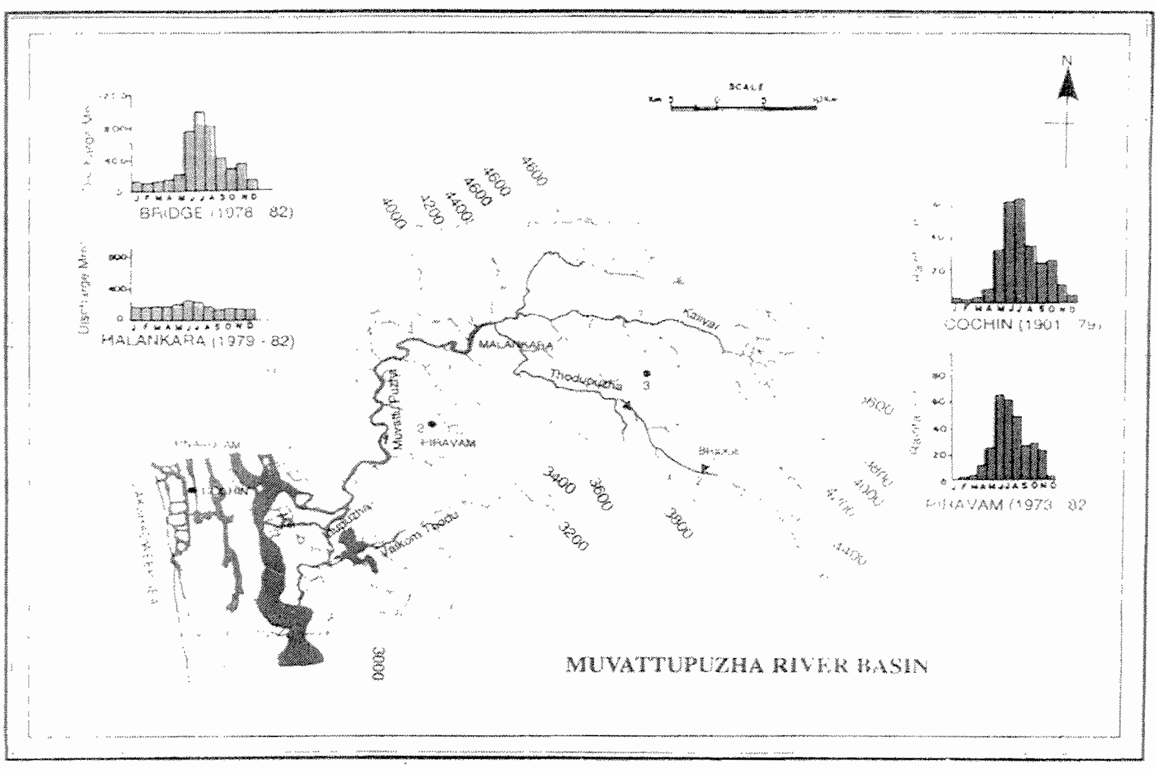


Fig. 2.2.1.4 : Drainage Map of Muvattupuzha River Basin

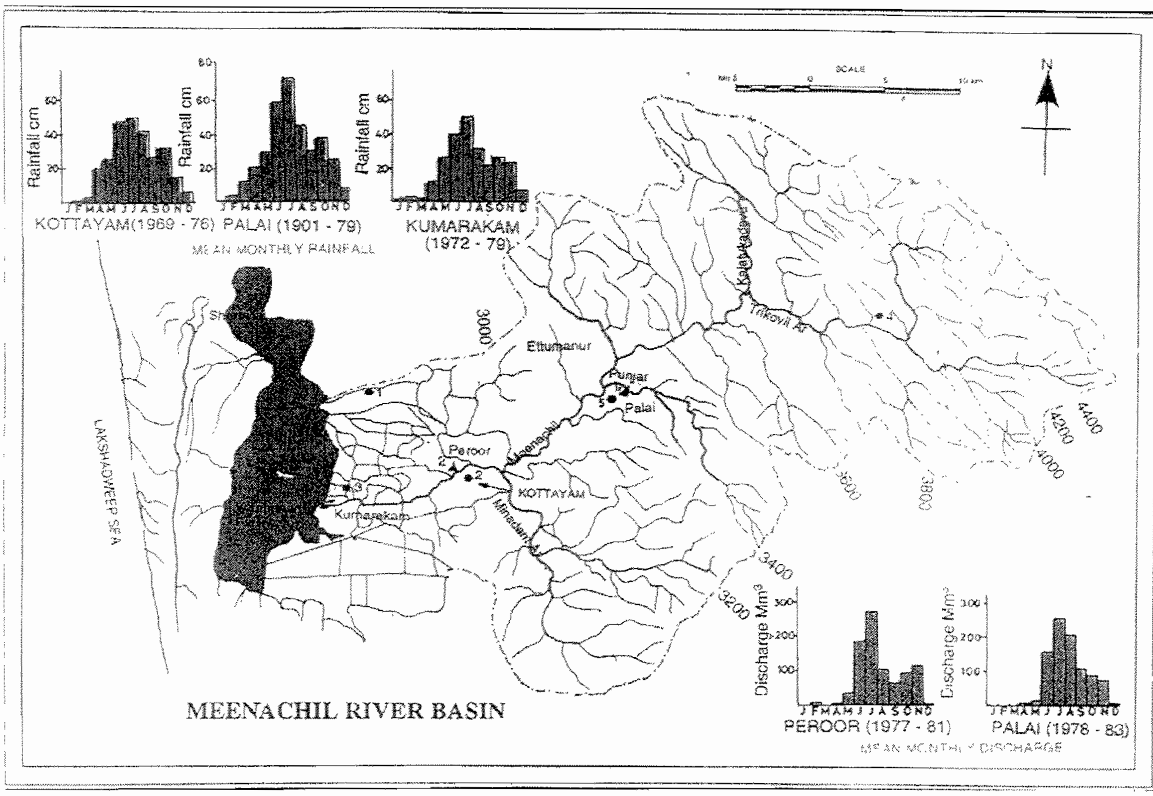


Fig. 2.2.1.5 : Drainage Map of Meenachil River Basin

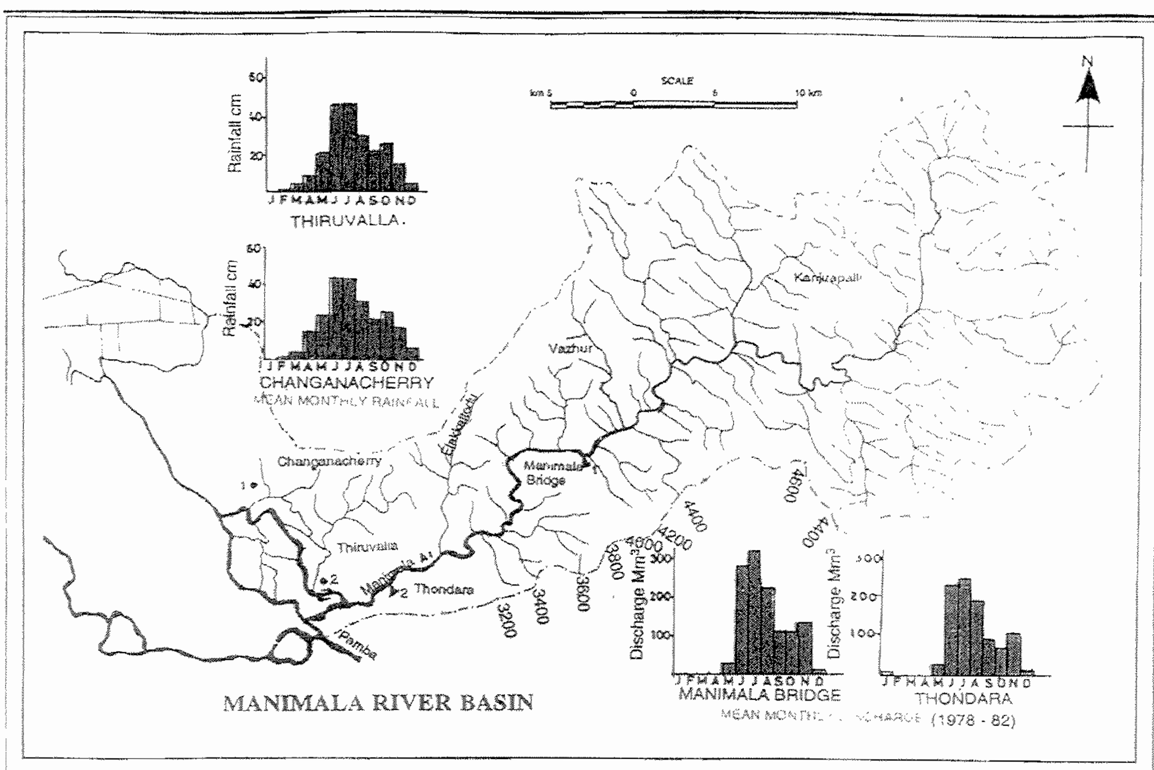


Fig. 2.2.1.6 : Drainage Map of Manimala River Basin

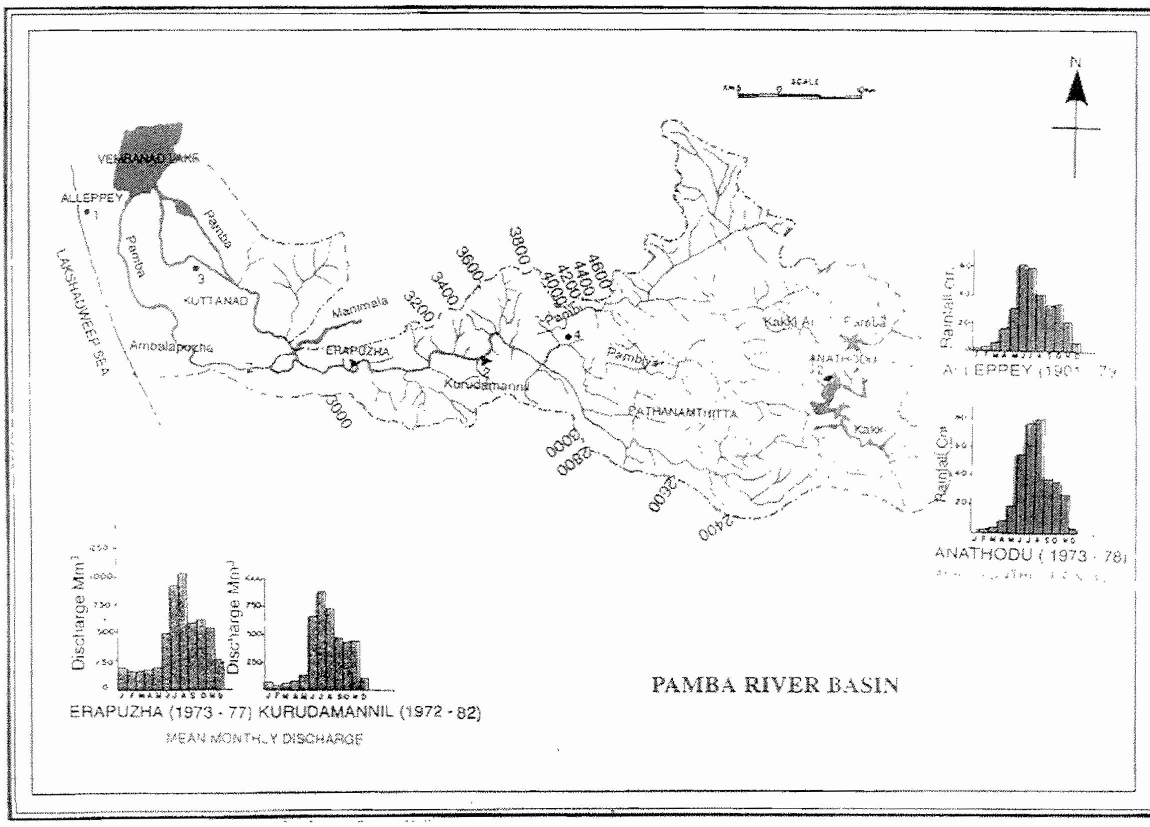


Fig. 2.2.1.7 : Drainage Map of Pamba River Basin

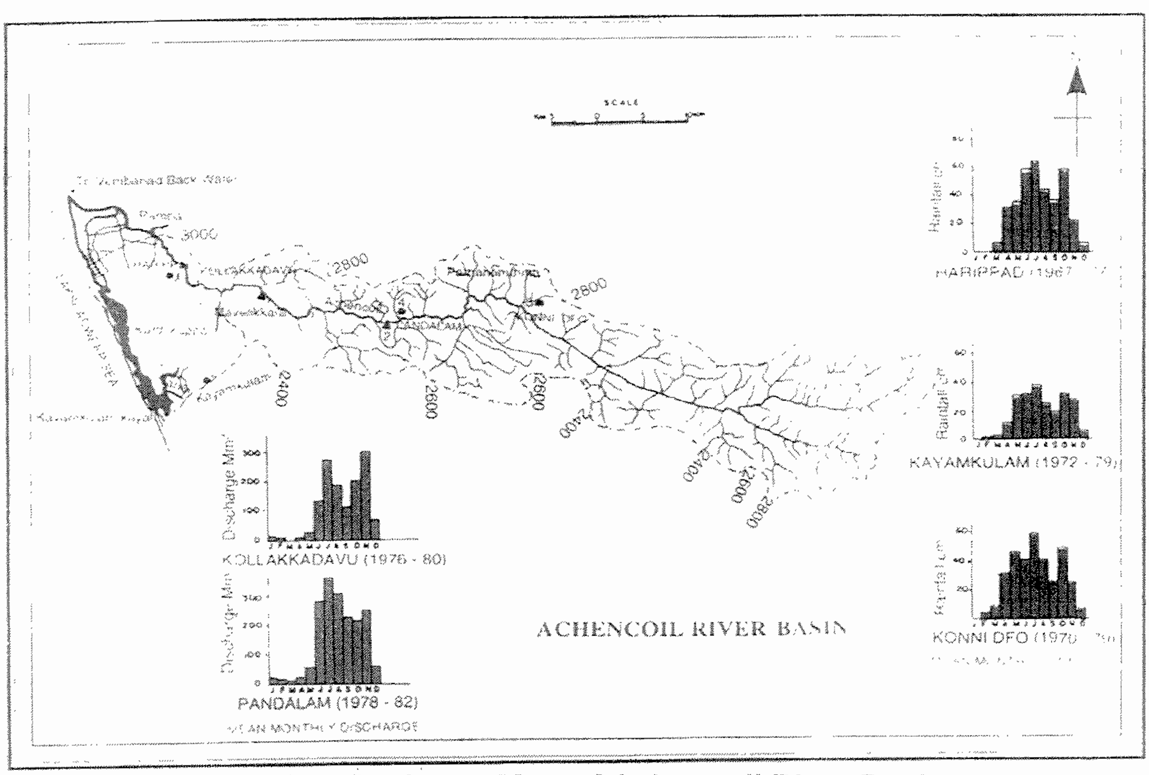


Fig. 2.2.1.8 : Drainage Map of Achencoil River Basin

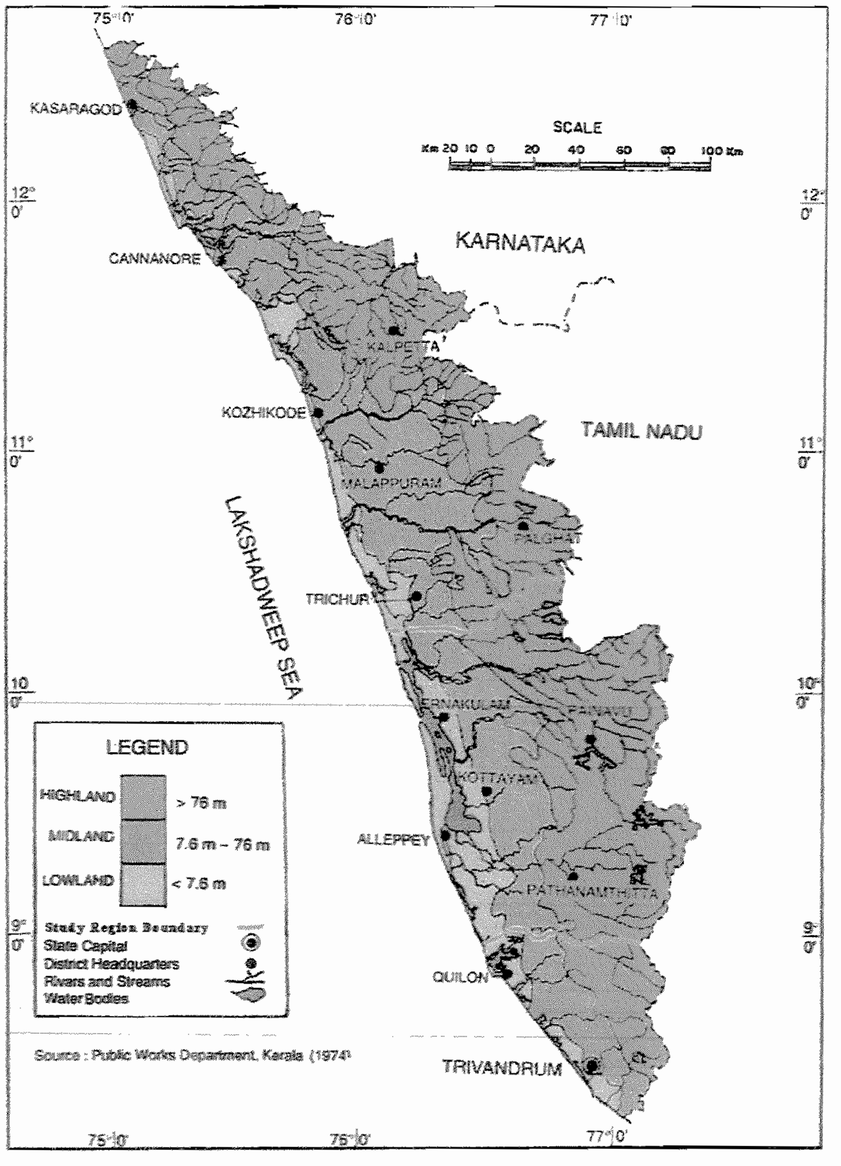


Fig. 2.2.1.9 : Physiographical Divisions of the Study Region

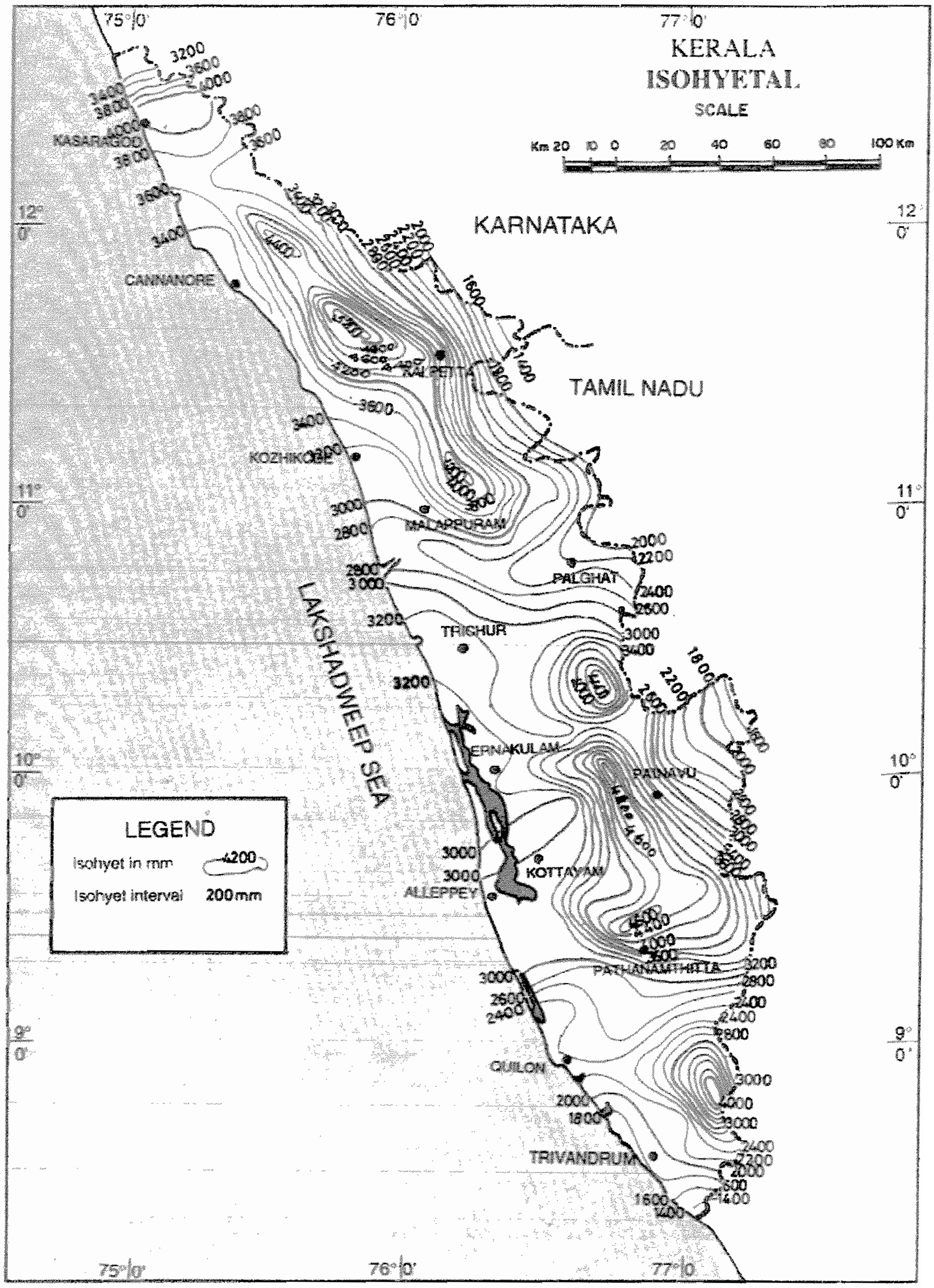


Fig. 2.2.1.10 : Isohyetal Map of Kerala

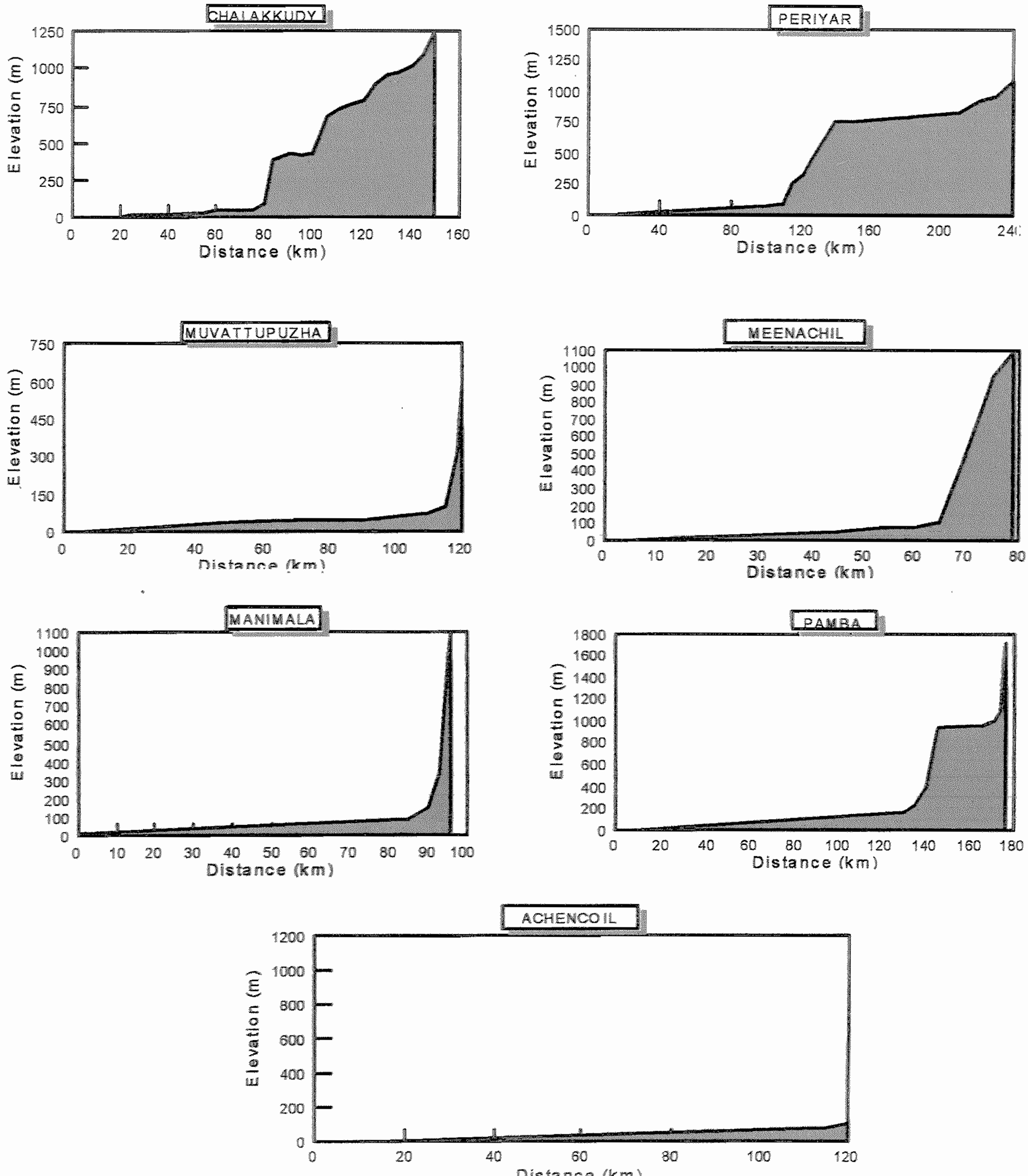


Fig. 2.2.1.11 : Longitudinal Profile of Rivers in the Study Area

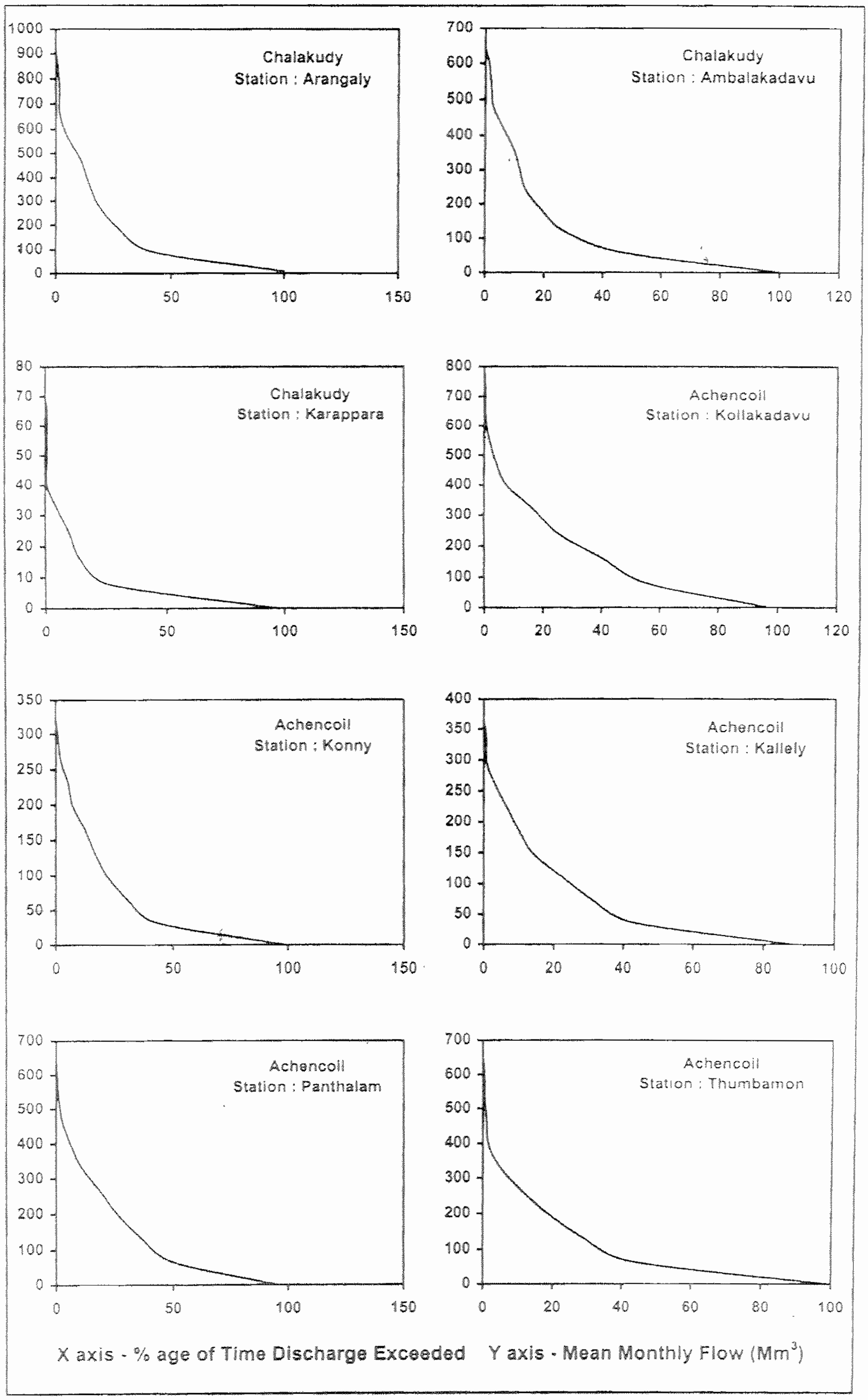


Fig. 2.2.1.12 : Flow Duration Curves – Chalakkudy and Achencoil Basins

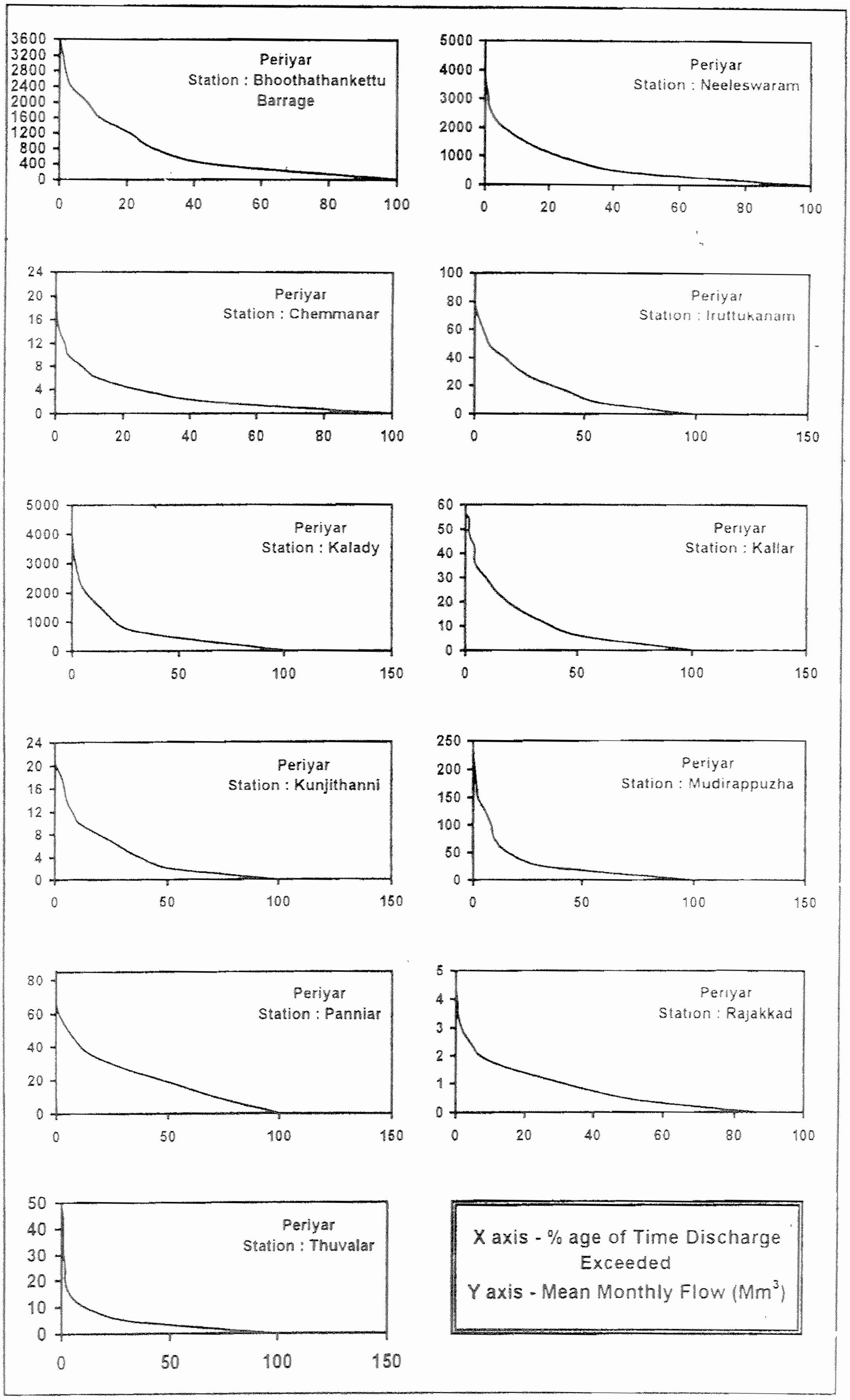


Fig. 2.2.1.13 : Flow Duration Curves – Periyar Basin

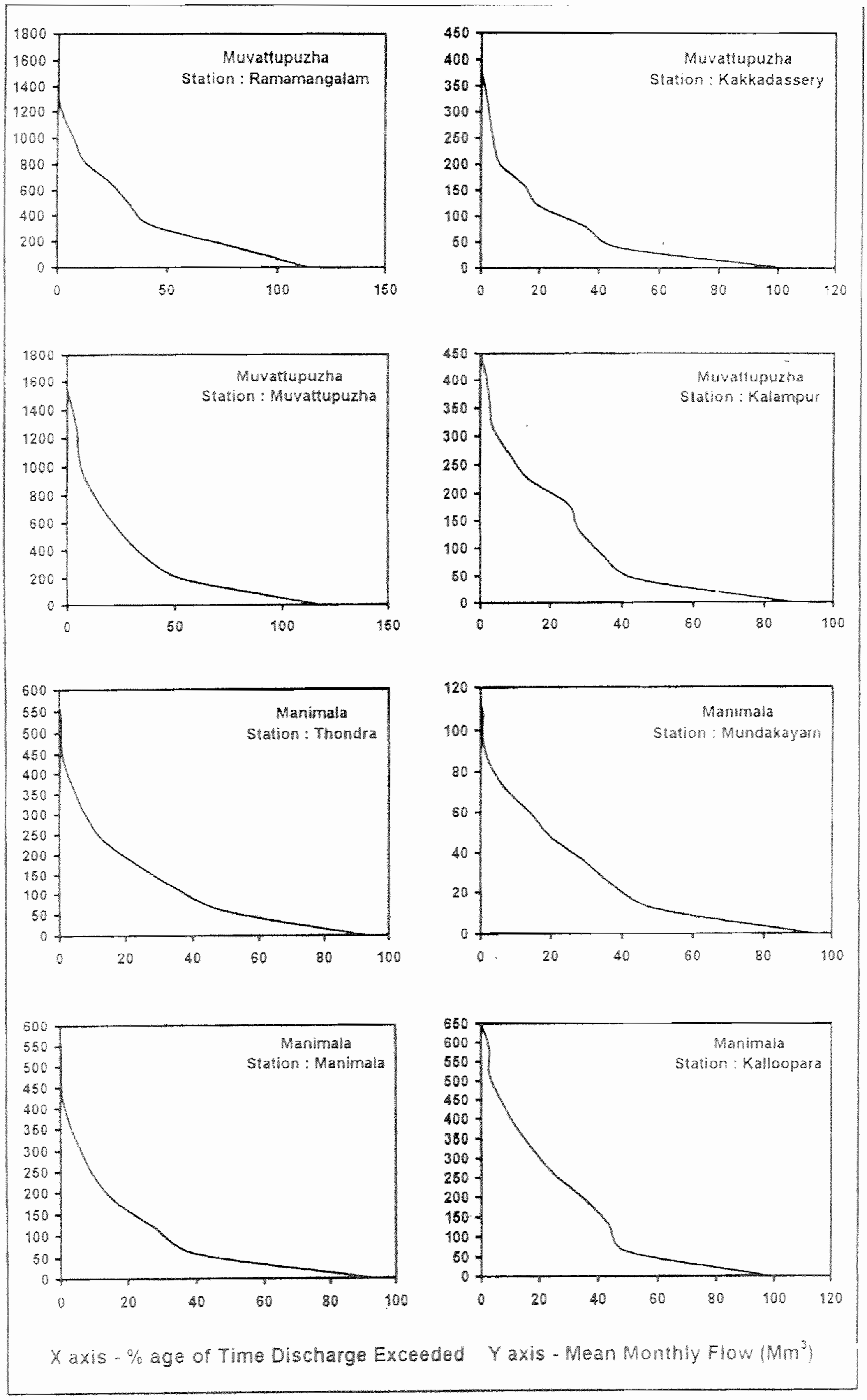
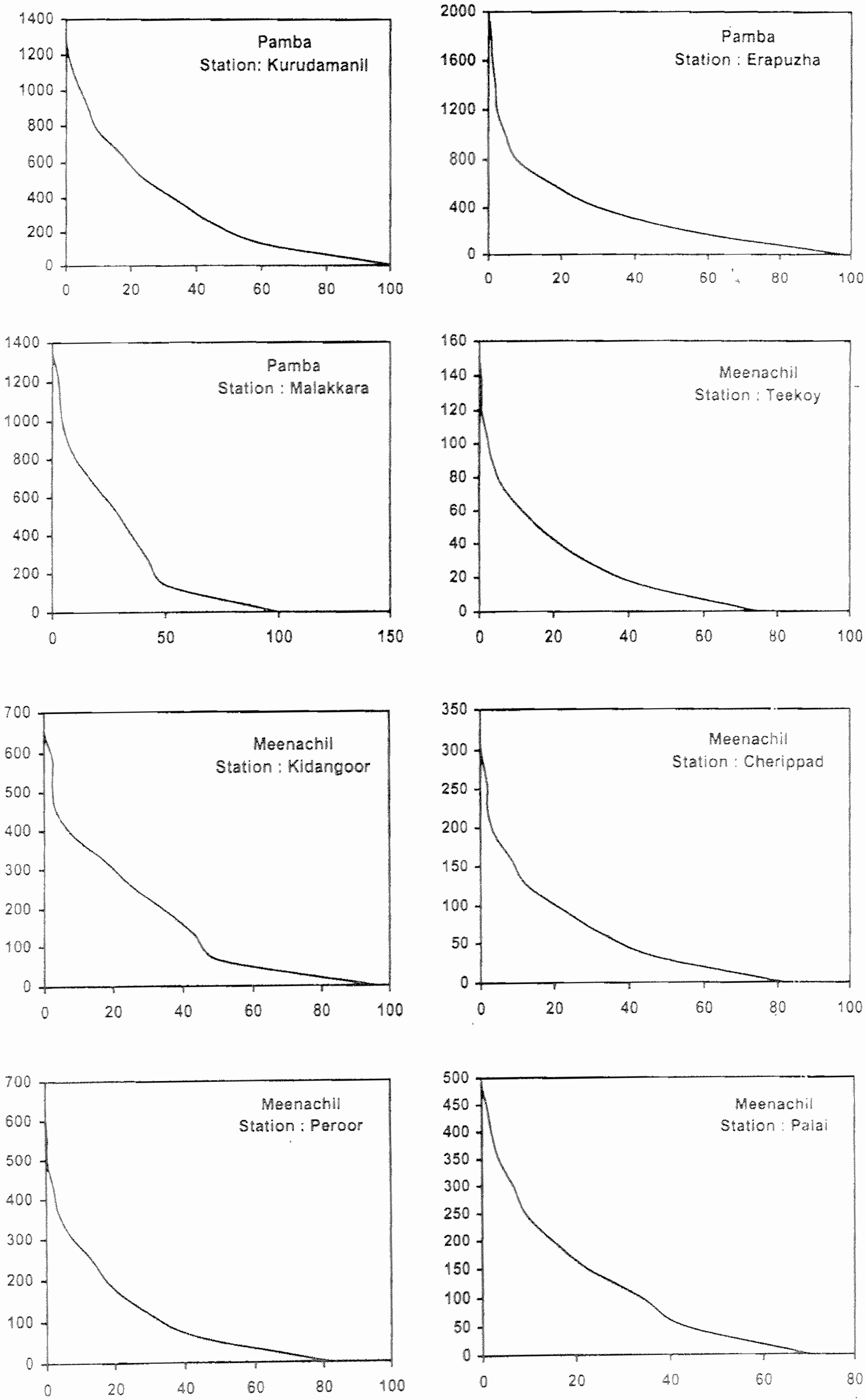


Fig. 2.2.1.14 : Flow Duration Curves – Muvattupuzha and Manimala Basins



X axis - % age of Time Discharge Exceeded   Y axis - Mean Monthly Flow (Mm^3)

Fig. 2.2.1.15 : Flow Duration Curves – Pamba and Meenachil Basins

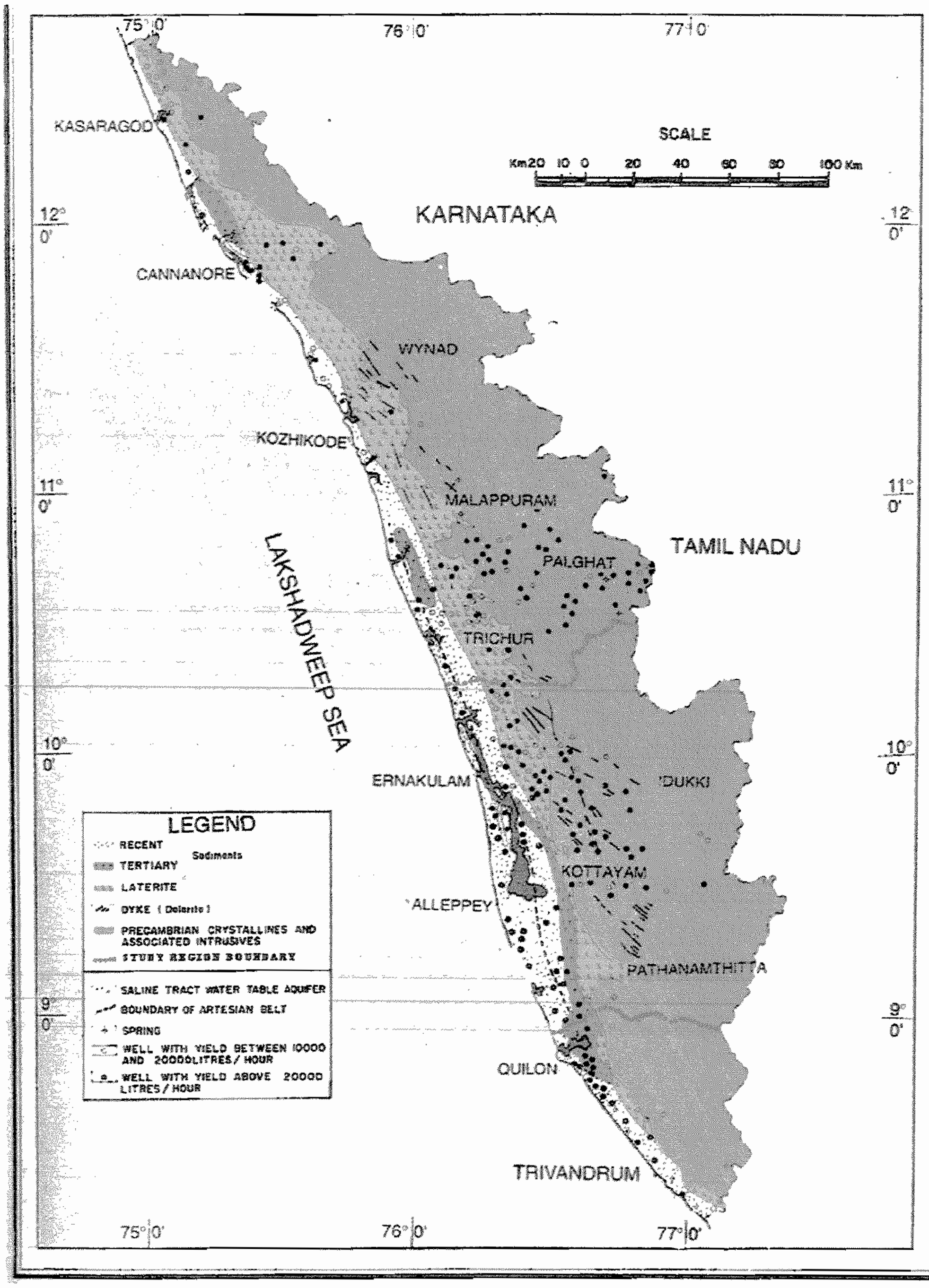


Fig. 2.2.2.1 : Hydrogeology of Kerala

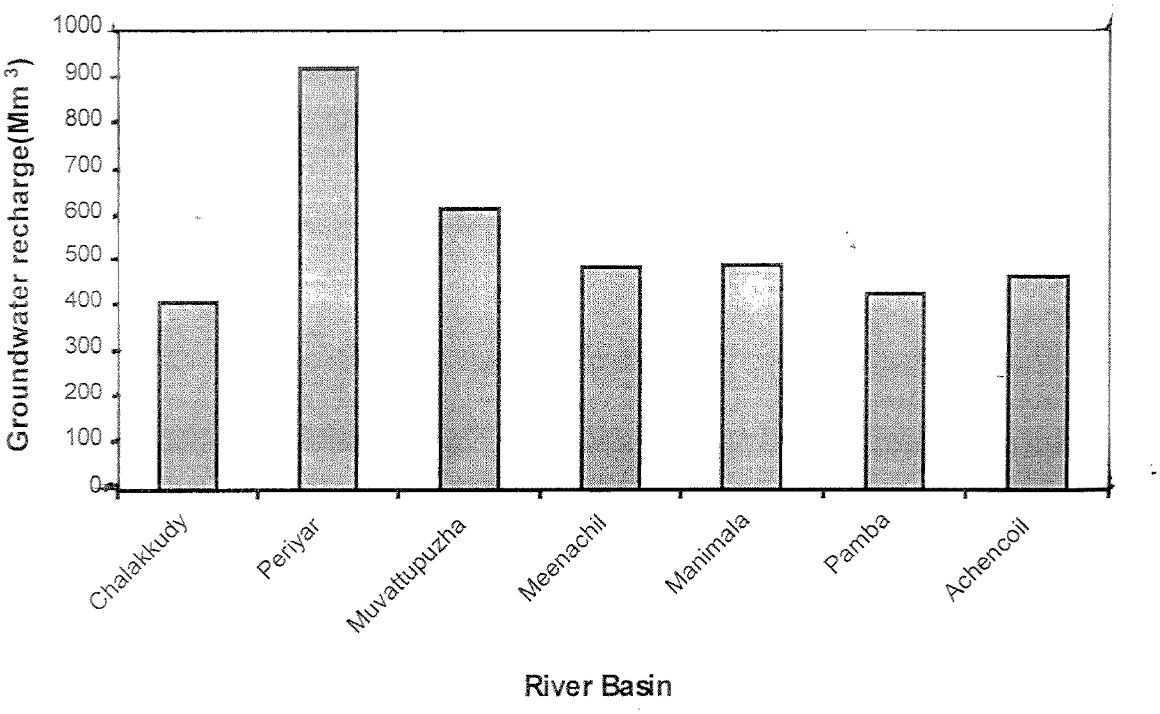


Fig. 2.2.2.2 : Groundwater Potential of River Basins

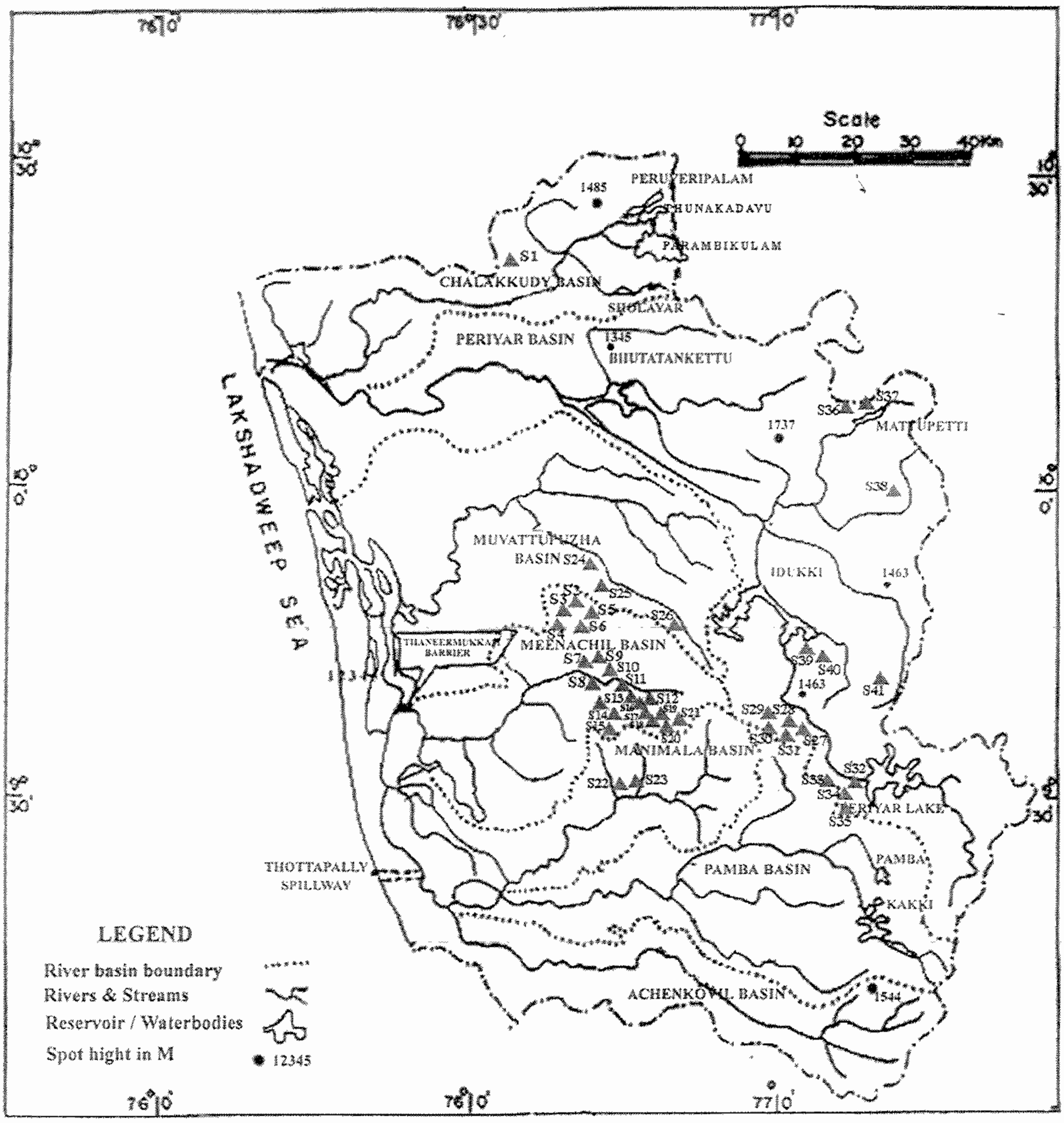


Fig. 2.2.2.5 : Location of Springs in the Study Area

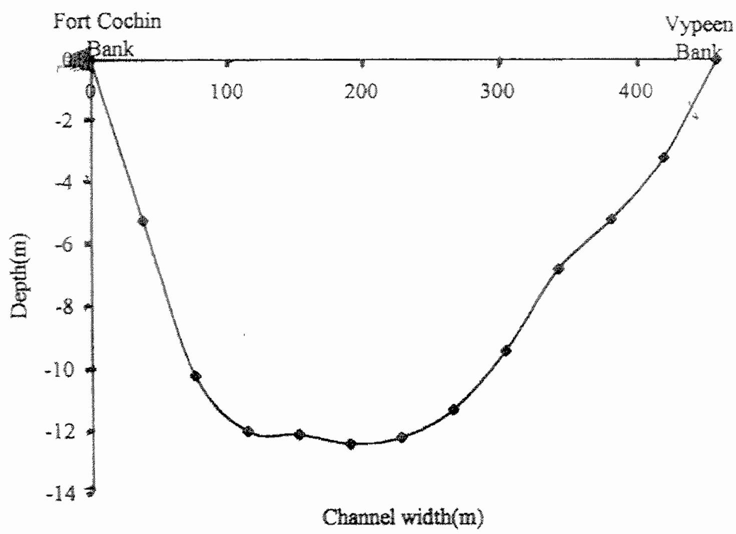


Fig. 2.2.3.1 : Cross-sectional Configuration of Kochi Inlet

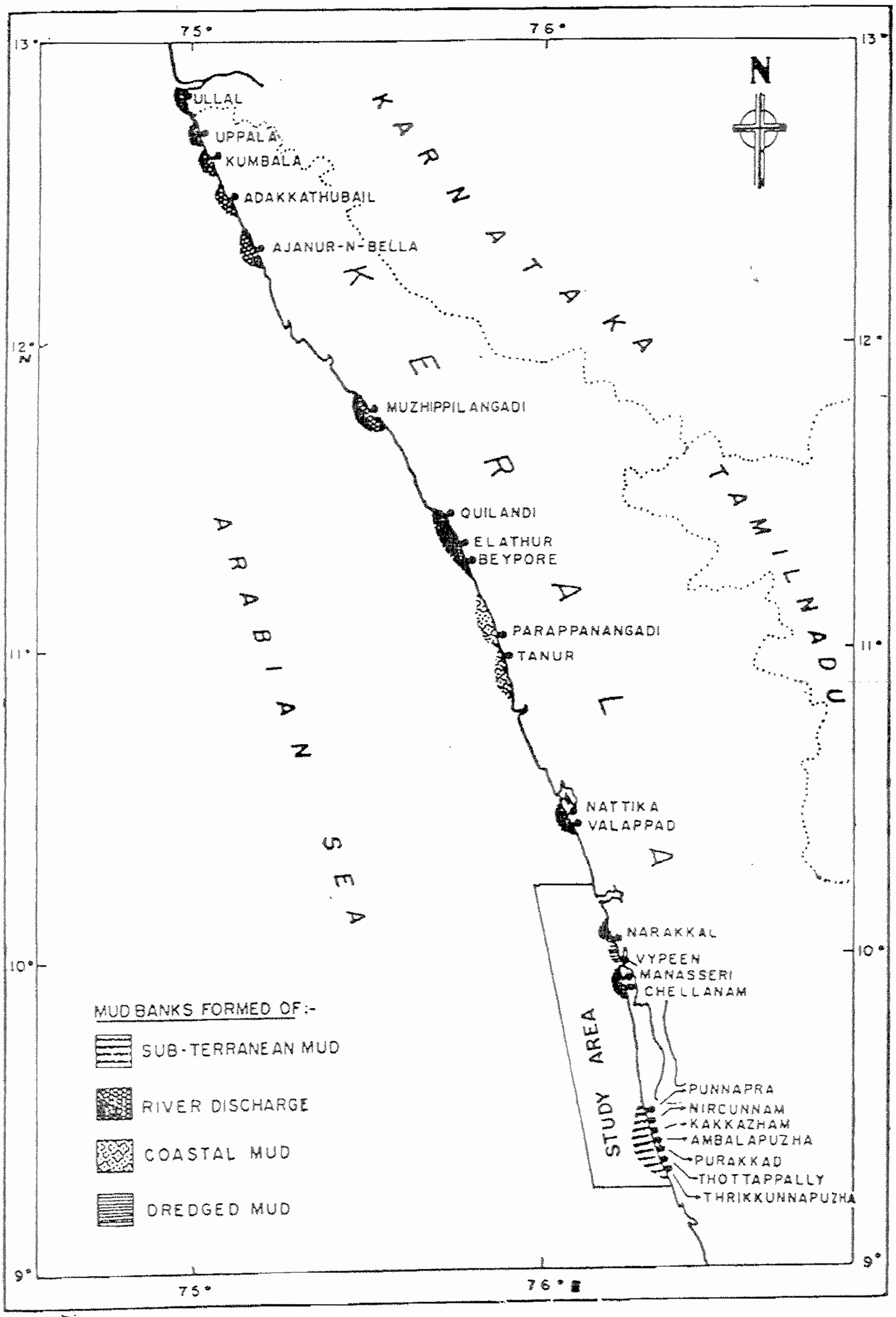


Fig. 2.2.4.1 : Areas of Mudbank Formation and the Various Types of Mudbanks along the Kerala-Karnataka Coast

2.3 Terrestrial Biological Resources

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 off maintaining desired environmental quality levels in the study area) is the major goal of the proposed study.

It has been undoubtedly established that the tropical evergreen ecosystem is the most complex and diverse ecosystem of the planet earth. Moreover the ecological functions and processes are integral parts and requirements for 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. 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 2.3.1)**. 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.

Forests also serve as livelihood support systems of forest dwellers. Hence, conservation of forest ecosystems plays 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 i.e. timber and Non Wood Forest Produce (NWFPs) as detailed in **Table 2.3.2**. The major categories of timber such as industrial wood, plywood, match wood, bobbin wood etc, are raw materials for various industries and provide an array of end products and employment to thousands of people.

Non Wood Forest Produce (NWFPs) includes all goods of biological origin derived from forests excluding wood (in all its form). This includes fuelwood, fodder, green manure, litter, grass etc, edible products like fruits, nuts, roots, tubers, honey, meat etc, industrial raw materials 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 agro-ecosystems.

2.3.1 Evaluation of Forest Sector in the Study Region

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

2.3.1.1 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 scale and superimposed over the base map, which was collected from CESS. This map was scanned and ~~subse~~quently 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% crown density and as degraded with less than 40% **(Fig. 2.3.1)**.

The forest cover of the study region is estimated to be 4168.94 Km^2. This accounts for 29.7% of landuse in the study region. Areas with forest cover in the region are included under forest divisions. The major chunk of the forest divisions of Periyar Tiger Reserve (PTR), Ranni, Malayattoor and Munnar, contribute to 55% of the total forest, cover in the region. The contiguous forest patch of Ranni, PTR and Achencoil contribute to 38% of the forest cover **(Fig. 2.3.2)**.

2.3.1.2 Vegetation Type and Status

Area under forests in the study region comprise of the following dominant vegetation types; Evergreen (EG), semievergreen (SEG), moist deciduous (MOF), montane subtropical (MST) and temperate forests (TF) etc and forest plantations. Most dominant vegetation is of evergreen and semievergreen types, which constitute 65% of the forest cover. Of the above, 59% are under dense forests and 41% are degraded. A major portion of the most fragile, biodiversity rich evergreen forests of the State (68%) is also located in this region.

Moist deciduous forests occupy 16.9% of the study area. Of this, 76% are degraded. Dense forests under this category constitute only 24%. Montane subtropical and temperate forests constitute 0.1% of which 55 % are classified as dense forests. Grasslands constitute 1.93% and forest plantations constitute 16.29%. Area wise estimate of the vegetation types and categories in each forest division is given in **Table 2.3.3** and distribution of major forest types is given in **Fig. 2.3.3**. Dense montane subtropical and temperate forests are confined to the forests of Mankulam and Eravikulam divisions. Grasslands forms the major vegetation type in Eravikulam constitutes 67% of the total grasslands in the study area.

2.3.1.3 Growing Stock

Total growing stock in the region is 499.18 LM^3. Lion's 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 2.3.4)**.

2.3.1.4 Forest Degradation

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

2.3.1.5 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, and multiple use management and finally to biodiversity conservation, ever since the Forest Conservation Act, 1980 regulated forestland 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. About 80% of the timber harvest can be attributed teak.

2.3.1.5.1 Forest Plantations

Forest plantations in Kerala are government owned and Forest Department manages 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 assume great importance. But unfortunately plantations in Kerala are of low productivity. This is reflected in the Mean Annual Increments (MAI) and the site quality class categories. The MAI of the standing crop of the State at 60 years is 2.423 m^3/ha in comparison to the potential MAI of 4.968 m^3/ha under site quality class 1 with full stocking as reported in the All India yield table for teak. Site quality is also an important factor. 86% of teak plantation in the state falls 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. The age class distribution of teak plantations reveals that most of the plantations are over 30 years of age and was planted after 1960. The five-year plan targets with over 50,000 ha. Of teak plantations on an average and annual planting target of 1700 ha has made the Department to go for large scale conversion of natural forests to low productive plantations through unscientific management practices.

Large land area 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 1963-1993 to show the trend from the published sources of Kerala Forest Department (**Fig. 2.3.4**).

2.3.1.5.2 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 2.3.5 and 2.3.6**. 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 accounting for 80% of the total revenue. Other sources are fuel wood and charcoal, livestock, etc.. 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 a hike in the expenditure for the various activities since 1980s, which has stabilised since 1993. Expenditure on the establishment was the highest followed by the maintenance of existing reserved forests.

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 2.3.7)**. There has been considerable increase in the turn over since 1993. It has almost reached 100 crore mark in the year 1996.

2.3.2 Resource Extraction

2.3.2.1 Extraction of Timber

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

Major sources of pulpwood are bamboo, eucalyptus and reed. Data on extraction of bamboo, eucalyptus and reed were collected **(Table 2.3.8)**. 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).

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.

2.3.2.2 Extraction of Non Wood Forest Produce

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 effective tools in forest management has been widely recognised and many workers have identified the stress on the need for its conservation. 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. The extraction of these resources can provide tangible benefits to the local people simultaneously conserving the biological resources of standing forests, which in turn enhance 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) has 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.

Scientists from tropics repeatedly argue NWFP as the most potential source of income and highlight 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. High value of medicinal plant sales in Belize and NWFP extraction in Ecuadorian Amazonia 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.

Kosady (4 MT) were the other procurement centres listed in the descending order in terms of quantity of forest products collected.

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 sinuata*, *Cardamom* and Pathripoovu are the selected five products. Quantity of resin collected from the study site during the year 1993 was 54.3 MT and showed an increasing trend in collection till the year 1995 and a declining trend thereafter **(Fig. 2.3.9)**. Mean quantity collected annually was estimated to be 72.7 MT. 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. Total quantity of items collected during the past five years and mean annual quantities collected are presented in **Table 2.3.9**.

Major share of all the selected products were collected through the society located in Sholayar. Quantity procured by other societies in the study area is given in **Fig. 2.3.10**.

2.3.2.2.1 Forest Products as Source of Income Generation

Besides fuel wood, 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 varieties 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 41.4 lakh rupees (mean annual income) is annually extracted from the study area. This estimate is based on the accounts compiled from the societies 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. 2.3.11)**.

Mean seasonal income generated indicates highest income accrued during the month of March and lowest during the month of July **(Fig. 2.3.12)**. Income generated during the past 5 years and average income accrued in each month are presented in **Fig. 2.3.13** and **Table 2.3.10**.

Income generated through selected NWFPs is presented in **Table 2.3.11**. Resin was found to be the single item, which contributed majority of the income. Mean annual income accrued is estimated to be 11.14 lakh Rs. Honey is the second largest individual product contributing mean annual income of 8.34 lakh Rs. followed by Shikkakai (3.2 lakh Rs.), Cardamom (3.68 lakh Rs.) and

Pathripoovu (2.18 lakh Rs.). The fluctuations in income accrued through these selected products during the past five years is shown in **Fig. 2.3.14**.

Forest dwellers at Sholayar received the highest returns through selling the products. Mean annual average is estimated to be 14 lakh Rs. Annual fluctuation in income is shown in **Fig. 2.3.15**. The other successful foragers of forest products were from Palappilly (6 lakh Rs.), Kuttampuzha (5.7 lakh Rs.) and Devikulam (5.6 lakh Rs.) as given in **Table 2.3.12**.

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. Collection and sales of Shikakai is the major source of income for people at Nelliyampathy and Kosady. Area wise income generated through extraction of selected NWFPs is given in **Fig. 2.3.16**.

Price fluctuation in procurement of selected products (resin, honey, shikakai, cardamom and pathripovu) during the past 5 years is shown in **Fig. 2.3.17**. An exhaustive list of the products, its quantity and income accrued is given in **Table 2.3.13**.

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

2.3.3 Soils in the Forest Division

The quality of soils under different forest divisions within GKR was assessed. In all, 35 soil samples were collected from 6 forest divisions, viz., Konni (20 nos.), Kottayam (4 nos.), Kothmangalam (1 no.), Munnar (3 nos.), Malayattor (5 nos.), and Vazhachal (2 nos.). At each sites, samples were collected at 3 depth levels; 0 – 20 cm; 20 – 40 cm and 40 – 60 cm. Physical properties like type of soil, color, composition and its nature etc. are summarized in **Table 2.3.14**. Other physico-chemical properties like gravel, sand, silt & clay content and organic carbon, pH, acidic / basic content of soils are summarized in **Table 2.3.15**.

Table 2.3.1

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	Eco-tourism 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 yet at undiscovered which cannot be valued on present society's knowledge, skills, needs, technology and uses

Table 2.3.2

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 • Resins • Charcoal • Others	• Livelihood of forest dependent communities • Raw materials for Ayurvedic medicines cosmetics, industry, etc. • Employment generation • Energy input to agro ecosystems	• Indigenous communities • Farmers • Industrialists • Merchants • Ayurvedic drug manufacturers • End users • Others

Table 2.3.3

Area under Various Vegetation Types

Unit : Km^2

Division	Forest Plantation	EG/ SEG (Dense)	EG/ SEG (Degraded)	MDF (Dense)	MDF (Degraded)	MST/ TF (Dense)	MST/ TF (Degraded)	Grass Land	Total Area
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**	**2.52**	**--**	**80.62**	**4168.94**

EG: Evergreen, SEG: Semi-Evergreen; MDF: Moist Deciduous Forest; MST: Mountain Subtropical; TF: Temperate Forests

Source : Primary data collected by KFRI

Table 2.3.4

Growing Stock of Wood in Each Vegetation Type

Unit : **Lakh m^3**

Sr. No.	Forest Division	Plantations	Evergreen	Moist Deciduous Forest
1.	Ranni	1.96	99.33	6.88
2.	Periyar Tiger Reserve	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.	Achencoil	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**

Source : Secondary data collected by KFRI

Table 2.3.5

Revenue from Timber and other Forest Products

(Rs in Lakhs)

Sr. No.	Item	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94
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
	Total	**3401.89**	**4280.54**	**4862.12**	**4014.53**	**3379.00**	**3225.37**	**3742.62**	**5578.31**	**7888.11**	**10319.21**
6.	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 2.3.6

Sector wise Expenditure on Forests

(Rs in Lakhs)

Year	Maintenance of Existing Reserve Forests	Regene-ration	Social Forestry	Wild-life	Establi-shment	Others	Total
1980-81	387.93	139.64	7.34	16.08	385 60	83.83	1220.50
1981-82	729.82	142.26	8.36	47.53	487.09	108.65	1523.71
1982-83	543.46	123.93	15.43	18.27	510.15	100.47	1311.71
1983-84	546.83	44.92	238.59	19.05	584.64	166.94	1600.97
1984-85	549.79	20.24	231.09	23.04	660.28	153 64	1692.08
1985-86	593.43	6.04	667.93	172.75	695.66	427.14	2562.95
1986-87	762.12	5.44	672.10	152.75	877.57	173.63	2843.61
1987-88	566.62	3.86	945.22	118.34	950.72	107.33	2692.09
1988-89	408.35	9.11	931.93	126.62	1050.49	167.61	2694.11
1989-90	1217.88	67.55	705.53	209.50	1213.74	520.55	2893.65
1990-91	494.58	120.66	616.88	233.84	1511.69	463.29	3440.94
1991-92	215.69	125.72	1033.62	454.36	1600.51	861.84	4291.74
1992-93	260.97	139.05	1139.68	474.72	1787.77	2233.54	6035.73
1993-94	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 2.3.7

Annual Turn Over from Forestry Operations

(Rs. in Crores)

Year	Gross Revenue	Expenditure	% 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

Source : Secondary data collected by KFRI

Table 2.3.8

Extraction of Timber and Major Pulpwood Species from the Study Area

Unit 1000 m^3

Year	Timber				Pulpwood		
	Teak	Rose wood	Anjili	Others	Bamboo	Reed	Eucaly-ptus
1973	3.5	0.98	0.95	0.48	-	-	-
1976	15.5	1.58	1.55	0.80	70	-	-
1977	10.5	1.61	1.62*	0.95	800	15000	-
1978	11.0	0.96	0.9	2.49	450	14000	-
1980	13.5	1.55	1.50	0.30	100	13000	-
1981	9.0	1.22+	1.21	0.80+	50	-	-
1982	7.8+	1 08+	1.05	0.29+	-	38000	-
1983	18.0+	0.79+	0.78+	1.05+	800	4000	-
1986	5.8*	0.76*	0.75	0.49	150	50000	-
1987	7.5*	1 41	1.41	0.94	6100	22000	1.50
1988	14.2	0.80	0.8*	0.30	4100	105000	-
1989	2.8	0.25	0.25*	0.20	-	40000	5.10
1990	9.9	0.22	0.24*	0.19	-	75000	8.20
1991	5.7	0.26*	0.27	0.30	150	50000	43.0
1992	9.6	0.32	0.31	0.24	200	39000	28.5
1993	12.0	0.42	0.42	0.19	100	38000	3.0

+ Only Selection Fell, * Clear Fell, Rest- No fell (extracted)
Source : Secondary data collected by KFRI

Table 2.3.9

Flow of selected NWFPs (MT)

Product	1993	1994	1995	1996	1997	Total	Average
Resin	54.3	69.1	109.6	66.3	64.0	363.4	72.7
Honey	18.6	11.8	23.3	32.6	2.0	88.3	17.7
Shikkakai	51.0	28.4	73.1	32.1	106.6	291.2	58.2
Cardomom	3.1	1.6	6.8	5.4	1.4	18.3	3.7
Pathripoovu	3.7	6.9	3.3	1.7	5.6	21 2	4.2

Table 2.3.10

Seasonal Fluctuations of Income Generated through Extraction of NWFPs (Rs. in Lakhs)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1993	1.94	2.9	2.37	2.51	1.69	1.51	2.52	1.05	1.91	1.74	2.23	3.86	26.23
1994	3.95	1.38	4.89	4.34	2.72	3.38	1.03	0.17	0.52	3.39	5.55	4.53	35.85
1995	6.11	3.39	11.07	3.72	6.13	3.24	2.06	5.28	10.76	1.93	1.55	3.37	58.61
1996	9.87	7.62	9.12	3.45	3.76	1.65	1.50	2.01	1.34	2.41	3.84	2.40	48.97
1997	5.69	9.82	6.64	4.59	3.34	2.22	1.40	0.97	1.93	1.83	1.19	1.73	41.35
Average	**5.512**	**5.022**	**6.818**	**3.722**	**3.528**	**2.4**	**1.702**	**1.896**	**3.292**	**2.26**	**2.872**	**3.178**	--

Table 2.3.11

Income Generated through Extraction of Selected NWFPs (Rs. in Lakhs)

Product	1993	1994	1995	1996	1997	Total	Average
Resin	8.86	9.77	16.73	9.38	10.98	55.72	11.144
Honey	4.58	3.34	12.04	14.22	7.51	41.69	8.338
Shikkakai	0.39	2.40	0.95	4.05	8.22	16.01	3.202
Cardomom	1.81	3.06	12.92	0.41	0.22	18.42	3.684
Pathripoovu	1.42	3.39	1.36	0.76	3.96	10.89	2.178
Total	17.06	21.96	44.00	28.82	30.89	142.73	--

Table 2.3.12

Income Generated Areawise through NWFPs Extraction (Rs. in Lakhs)

Zone	1993	1994	1995	1996	1997	Total	Average
Adimaly	2.34	6.75	5.85	4.08	2.11	21.13	4.226
Palappilly	4.15	3.86	5.03	7.50	10.07	30.61	6.122
Sholayar	12.64	15.97	13.52	11.90	16.09	70.12	14.024
Nelliyampathy	2.12	1.85	1.10	2.54	1.54	9.15	1.83
Devikulam	0.66	4.99	7.69	8.53	6.21	28.08	5.616
Kuttampuzha	2.75	3.37	10.86	8.58	2.93	28.49	5.698
Vazhathope	1.85	2.37	1.41	1.71	2.16	9.50	1.90
Kosady	0.021	0.11	0.17	0.90	1.53	2.73	0.5462
Total	**26.53**	**39.27**	**45.63**	**45.74**	**42.64**	**199.81**	--

Table 2.3.13

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.)
Mezhuku (I)	*Apies sps.*	70	17784	660	4097	947	35034	361	53292	1193	51035	4832	181242
Mezhuku (II)	*Apies sps.*	30	802	--	--	-	--	4	154	--	--	34	956
Marotti (seed)	*Hydnocarpus pentendra*	729	4365	3236	2048	163	1287	137	43361	1985	44093	9159	113587
Urinchikai	*Sapindus laurifolius*	3264	25634	4274	20464	513	2107	829	3743	13777	153734	22656	205683
Kurunthotti (dry)	*Sida rhombifolia (ssp. Retusa)*	1373	8088	2800	18033	416	4777	430	2860	199	1527	5217	35285
Kurunthotti (fresh)	*Sida rhombhifolia (ssp. Retusa)*	260	780	--	--	--	--	1	5	--	--	261	785
Kattukurumulaku	*Piper nigrum*	4	46	165	9784	28	691	14	365	582	2394	792	13280
Kudampuli	*Garcinia gummigutta*	698	13998	73	1679	27	618	300	16	406	16482	1504	48316
Karinkurinji (fresh)	*Strobilanthes ciliatus*	134	6432	273	1356	--	--	84	335	27	128	2518	8251
Karinkurinji (dry)	*Strobilanthes ciliatus*	--	--	17025	2131	962	104	58	20365	--	--	23737	92881
Paali kuru	*Palaquium ellipticum*	97	3122	41116	69559	--	--	--	--	--	--	41413	72681
Vazhana (flower)	*Cinnamomum verum*	--	--	1	20	4	12	--	--	--	--	6	32
Patchotti (skin)	*Symplocos cochin chinensis*	2329	6619	2194	9853	3249	17481	2656	15160	12432	56864	22858	105977
Pattincha	*Acacia caesia*	--	--	4247	23137	1429	9355	14518	128533	25893	192976	46088	354001
Kattupadavalam	*Trichosanthes cucumerina*	4146	31367	28198	340763	9404	131656	19754	592133	6901	1202465	68421	2298383
Makkumkaya	*Entada rheedii*	71517	1105	876	1442	986	2301	1946	13545	152	450	75495	18843
Kolinchi	*Alpinta galanga*	210	968	--	--	24	133	700	6804	--	--	934	7905
Payyaniveru	*Oroxylulm indicum*	--	--	--	--	--	--	67	207	--	--	67	207
Kattuthippali veru	*Piper longum*	982	1380	876	5076	895	5722	1076	22773	903	7041	4733	41991
Palamuthukku kezhengu	*Ipomoea mauritiam*	36	72	--	--	--	--	3942	10339	401	1001	4379	11411
Edampiri valampiri	*Helicteres isora*	6	7	8	10	16	16	3	9	727		33	42
Neerottikuru	*Croton tiglium*	.	..	.			-	998	7201	147	7124	1725	14325
Kandankoova	*Curcuma sps*	2711	9638	347	8512	221	2362	2184	28711	--	1395	5610	50617
Vella koova	*Curcuma sps*		-	--	--	20	46	100	655	108	--	120	701
Kaanjiram (seed)	*Strychnos nuxvomica*	-	--	453	2594	-	--	--	--	--	332	560	2926
Padakizhangu	*Cyclea peltata*	10	42	--	--	--	--	6	35		--	51	77
Putheri chunda (fresh)	*Solanum indicum*	--	--	--	--	--	--	--	--	547	2246	547	2246
Orila	*Desmodium velutinum*	94	465	627	4629	--	--	3960	36571	3463	31151	8143	728117
Orila (fresh) (ii)	*Desmodium velutinum*	--	--	--	--	--	--	254	1763	267	2054	50011	3817
Manjal	*Curcuma aromatica*	--	--	--	--	49	249	--	--	--	--	49	249

Contd...

Table 2.3.13 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.)
Pulinkuru	*Tamarindus indica*	-	--	5546	8319	-			--	--	--	5546	8319
Kattu inchi	*Zingiber zerumbet*	--	--	20	90	--	--	--	--	--	--	20	90
Adapathian	*Holostemma addkodian*		--	4	30	--			--	--		4	30
Kalpasam	*Parmelia dilatata*	-	--	--	--	3000	9000	--	--	--	--	3000	9000
Adalodakam	*Adathoda zeylanica*	--	--	--	--	252	766	--	--	--	--	252	766
Eenthapanakkai	*Cycas sps*	--	--	--	--	5	45	74	612	--	--	78	657
Kumizhu veru	*Gmelia arborea*	--	--	--	--	92	368	2020	7297	--	--	2112	7665
Vayampu	*Acorus calamus*	--	--	--	--	--	--	347	3407	--	--	347	3407
Thumba veru	*Leucas sps.*	--	--	--	--	--	--	332	7250	--	--	332	7250
Kashurimanjal	*Curcuma aromatica*	25908	205392	30359	350511	22611	212593	27727	296276	10863	87386	117467	1152158
Thelli (I)	*Canarium strictum*	30315	533779	28378	478020	67072	1072768	34869	551222	42851	846567	203544	3514017
Thelli (II)	"	23844	320322	30608	401246	24046	496581	26556	32384	14520	216151	119572	1466684
Thelli (III)	"	0	6	5	150	345	8265	910	9904	168	4216	927	22341
Thellivella	"	--	--	--	--	26	557	--	--	42	1024	68	1580
Thaen	*Apies sps*	18558	458221	117446	335959	23284	1204311	32599	1421426	20127	689585	136818	4110002
Cheruthaen	"	731	44834	108	7123	1388	82499	1915	124325	871	76534	5013	335316
Cheevakai (dry)	*Acacia concinna*	51037	386707	23802	235738	73062	938752	33853	404982	93657	837612	275411	2803789
Pathripoovu	*Sterospermum colais*	3676	142450	6938	339498	3276	136464	1685	75710	5574	396354	21146	1090475
Kunkillyam	*Boswellia serrata*	585	9900	758	66025	329	48209	515	18333	524	44259	2711	177816
Maramanjal	*Coscinium fenestratum*	2153	8510	24317	96371	2654	13541	6794	40103	1800	12515	37717	171041
Naruneendi	*Hemidesmus indicus*	5	54	--	--	2	9	--	--	--	--	7	63
Moovila	*Pseudodarthrea viscida*	5	40	243	243	--	--	--	--	--	--	29	283
Manjakkova	*Curcuma angustifolia*	63	757	4623	4623	12	158	251	3240	200	3552	908	12331
Kattupayar	*Vigna trilobata*	--	--	60	60	--	--	--	--	--	--	13	60
Odakkuru	*Sarcostigma cleinii*	--	--	20	20	174	4211	--	--	--	--	176	4231
Painupoovu		--	--	--	--	15	236	8	554	32	2512	55	3302
Arattha	*Ruta graveolens*	--	--	--	--	--	--	182	1998	--	--	182	1998
Malainchi		--	--	--		--	--	16	112	--	--	16	112
Kazhanji kuru	*Caesalpinia bonduc*	2	17	--	--	--	--	13	240	3	240	18	497
Kopuvella	*Vareria indica*	1720	20645	1022	12277	131	15759	1236	15921	1122	15858	6409	80460
Pulthylum	*Cymbopogon flexuosus*	34	1692	2211	446842	10	1917	--	--	--	--	2255	454951
Putheri chunda	*Solanum indicum*	466	1398	-				3100	16250	5361	18691	8927	36339
Padavala samoolam	*Trichosanthes curumerina*	90	1350	-	-	-	-		--	--	-	90	14
Thanikka	*Terminalia bellirica*	25	25 00	--	--	--	--	--	--	--		25	25
Pollakkaya (fresh)	*Anamirta cocculus*	50	100	--	--	--	--	-	--	--		50	100
Pollakkaya (dry)	"	100	200	--	--	--	--	--	--	--	--	100	200
Nellikkai (fresh)	*Phyllanthus emblica*	8188	123012	429	1871	1087	2919	--	--	--	--	9704	127802
Nellikkai (dry)	*Phyllanthus emblica*	24	96	--		--	--	78	780	--	--	102	876

Contd...

Table 2.3.13 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.)
Kattukodi	*Piper sps*	2716	9662	1947	7711	--	--	2	4	2588	10552	11917	27929
Chittaratha	*Alpinia calcarata*	163	996	6	30	36	268	338	2313	--	--	543	3606
Kolincha	*Acacia sps.*	--	--	22	397	--	-	--	--	--	--	22	397
Amalpori	*Rauvolfia serpentina*	7	209	--	--	--	--	47	3802	--	--	54	4010
Sathavari	*Asparagus racemosus*	0	2	--	--	10588	28283	1038	37073	5600	22080	26571	87438
Cheruthekku	*Callicarpa tomentosa*	438	812	--	--	--	--	83	498	14618	32337	15139	33646
Chittamruthu	*Tinospora cardifolia*	-	--	--	--	--	-	200	600	21	63	221	663
Kadukka	*Terminalia chebula*	-	--	15626	391	--	-	--	--	4835	16923	20461	55988
Plassu	*Butea monosperma*	--	--	--		--	-	2103	2590	1206	3998	3309	10588
Cheevakkai (fresh)	*Acacia sinuate*	-	--	4585	4585	-	--	-	--	185	43972	23078	48557
Cheevakkai (fresh)	*Acacta simata*	51037	386707	23802	235738	730062	938752	33853	404982	93657	837612	275411	2803789
Peenari	*Nothapodytes nimmoniana*	--	--	765	1261	1000	2000	2271	687	582	2394	4618	11742

Source : Secondary data collected by KFRI

Table 2.3.14

Physical Properties of Soil in Different Forest Divisions of GKR

Sr. No.	Forest Division / Sample Location	Depth (cm)	Physical Property of Soil
A	Konni Forest Division, Kollam		
1.	**Perinthomoozhi, Naduvathumoozhi Range** 1884 teak, level, well drained	0 – 20	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
2.	**Perinthomoozhi, Naduvathumoozhi Range** 1963 teak (II), level, well drained	0 – 20	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
3.	**Mannarappara, Naduvathumoozhi Range** 1932 teak, 90 masl, rolling, pit on upper slope, well drained, plentiful undergrowth. Plot 1 of 500 m transect	0 – 20	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
4.	**Mannarappara, Naduvathumoozhi Range** 1932 teak, 75 masl, rolling, pit on upperslope, well drained, abundant undergrowth. Plot 2 of 500 m transect	0 – 20	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
5.	**Mannarappara, Naduvathumoozhi Range** 1932 teak, 70 masl, rolling, pit on midslope, well drained, abundant undergrowth. Plot 3 of 500 m transect	0 – 20	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
6.	**Mannarappara, Naduvathumoozhi Range** 1932 teak, 60 masl, rolling, pit on midslope, well drained, abundant undergrowth. Plot 4 of 500 m transect	0 – 20	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

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Table 2.3.14 Contd...

Sr. No.	Forest Division / Sample Location	Depth (cm)	Physical Property of Soil
7.	**Mannarappara, Naduvathumoozhi Range** 1932 teak, 45 masl, pit on level, well-imperfectly drained, plentiful undergrowth. Plot 5 of 500 m transect	0 – 20	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
8.	**Kummannoor, Konni Range** 1910 teak, 60 masl, hilly, pit on midslope, well drained	0 – 20	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
9.	**Adichanpara, Konni Range** 1976 teak, 60 masl, hilly, pit on midslope, well drained	0 – 20	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
10.	**Uliyanad, Naduvathumoozhi Range** 1914 teak, 50 masl,l hilly, pit on lower slope, well drained	0 – 20	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
11.	**Ulliyanad, Naduvathumoozhi Range** 1971 teak (II), 50 masl, hilly, pit on midslope, well drained	0 – 20	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
12	**Pichandikkulam, Naduvathumoozhi Range** 1964 teak, 50 masl, hilly, pit on lower slope, well drained	0 – 20	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

Contd...

Table 2.3.14 Contd...

Sr. No.	Forest Division / Sample Location	Depth (cm)	Physical Property of Soil
13	**Pothupara, Naduvathumoozhi Range** 1962 teak, 75 masl, hilly, pit on midslope, well drained	0 – 20	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
14	**Adukeera, Naduvathumoozhi Range** 1937 teak plantation, 50 masl, hilly, pit on midslope, well drained	0 – 20	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
15	**Kaikunnam, Mannarappara Range** 1963 teak, 50 masl, hilly, pit on midslope, well drained	0 – 20	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
16	**Anchukal (Kummannur), Konni Range** Moist deciduous forest, undisturbed, hilly, pit on upper slope, well drained	0 – 20	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
17	**Anchukal (Kumnannur), Konni Range** 1910 teak, hilly, pit on midslope, well drained	0 – 20	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
18	Pothupara, Konni Range 1947 teak (II), level-undulating, pit on level, well drained	0 – 20	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

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Table 2.3.14 Contd...

Sr. No.	Forest Division / Sample Location	Depth (cm)	Physical Property of Soil
19	**Kokkathode, Naduvathumoozhi Range** Moist deciduous forest, undisturbed, level-undulating, pit on level, well drained	0 – 20	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
20	**Kokkathode, Naduvathumoozhi Range** 1937 teak (II), level-undulating, pit on level, well drained	0 – 20	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 – 60	Red (2.5 YR 4/6), clay loam, massive, firm, plentiful roots, strongly acid
B	**Kottayam Forest Division, Idukki**		
21	**Kodamurutty, Nagarampara Range** Semi evergreen forest, undisturbed, 875 masl, hilly, pit on midslope, poorly drained	0 – 20	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
22.	**Anchammile, Nagarampara Range** Moist deciduous forest, undisturbed, 850 masl, hilly, pit on midslope, poorly drained	0 – 20	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
23	**Kodamurutty, Nagarampara Range** Grassland, undisturbed, 950 masl, hilly, pit on midslope, moderately well drained	0 – 20	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
24	**Cheruthoni, Nagarampara Range** 1977 *Eucalyptus grandis*, 850 masl, hilly, pit on midslope, moderately well drained	0 – 20	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

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Table 2.3.14 Contd...

Sr. No.	Forest Division / Sample Location	Depth (cm)	Physical Property of Soil
C	**Kothamangalam division, Ernakulam**		
25	**Malayinchi, Thodupuzha Range** 1961 teak, 650 masl, hilly, pit on midslope, well drained	0 – 20	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
D	**Munnar division, Idukki**		
26	**Vattavada, Marayoor Range** 1958 *Eucalyptus globulus* coppiced in 1969, 1750 masl, hilly, well drained	0 – 20	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
27	**Kanthallur, Marayoor Range** 1965 *Eucalyptus globulus*, coppiced in 1975, 2300 masl, hilly, well drained	0 – 20	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
28	**Vattavada, Marayoor Range** Grassland, undisturbed, hilly, pit on crest, well drained	0 – 20	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
E	**Malayattoor division, Ernakulam**		
29	**Pothupara, Thundathil Range** 1971 teak, 70 masl, rolling, pit on upper slope, well drained, plentiful undergrowth. Plot 1 of 500 m transect	0 – 20	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
30	**Pothupara, Thundathil Range** 1971 teak, 50 masl, rolling, pit on midslope, well drained, plentiful undergrowth. Plot 2 of 500 m transect	0 – 20	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

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Table 2.3.14 Contd...

Sr. No.	Forest Division / Sample Location	Depth (cm)	Physical Property of Soil
31	**Pothupara, Thundathil Range** 1971 teak, 60 masl, rolling, pit on midslope, well drained, plentiful undergrowth. Plot 3 of 500 m transect	0 – 20	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
32	**Pothupara, Thundathil Range** 1971 teak, 90 masl, hilly, pit on upper slope, well drained, plentiful undergrowth. Plot 4 of 500 m transect	0 – 20	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
33	**Pothupara, Thundathil Range** 1971 teak, 30 masl, rolling, pit on lower slope, well drained, plentiful undergrowth. Plot 5 of 500 m transect	0 – 20	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
F	**Vazhachal division, Thrissur**		
34	**Kollathirumed, Kollathirumed Range** 1966 eucalypt, 400 masl, hilly, well drained	0 – 20	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
35	**Vazhachal, Vazhachal Range** Evergreen forest, 400 masl, hilly, well drained	0 – 20	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

Source : Primary data collected by KFRI

Table 2.3.15

Physico-Chemical Properties of Soils in Different Forest Divisions of GKR

Sr. No.	Depth (cm)	Physico-Chemical Properties of Soil						
		Gravel (g/kg)	Sand (g/kg)	Silt + Clay (g/kg)	Organic Carbon (g/kg)	pH (20:40 water)	Exch. Acidity (mg/kg)	Exch. Bases (mg/kg)
A	Konni Forest Division, Kollam							
1.	0 – 20	*	800	200	14	6.2	38	144
	20 – 40	*	760	240	12	6.1	55	132
	40 – 60	*	750	250	10	6.1	49	126
	0 – 60	*	770	230	12	6.1	47	134
2.	0 – 20	*	810	190	10	6.4	34	160
	20 – 40	*	750	250	12	6.0	54	148
	40 – 60	*	740	260	10	6.0	49	142
	0 – 60	*	770	230	11	6.1	46	151
3.	0 – 20	170	620	210	14	5.6	42	100
	20 – 40	350	460	190	8	5.2	32	52
	40 – 60	430	440	130	3	5.0	22	40
	0 – 60	320	510	170	8	5.3	32	64
4.	0 – 20	230	510	260	13	5.4	44	69
	20 – 40	470	340	190	5	5.1	23	37
	40 – 60	550	290	160	3	5.1	15	36
	0 – 60	420	380	200	7	5.2	27	47
5.	0 – 20	300	510	190	12	5.3	39	63
	20 – 40	380	410	210	6	5.0	35	50
	40 – 60	380	420	200	4	5.0	25	43
	0 – 60	350	450	200	7	5.1	33	52
6.	0 – 20	230	580	190	13	5.6	40	85
	20 – 40	210	580	210	12	5.2	47	55
	40 – 60	370	440	190	6	5.1	30	50
	0 – 60	270	530	200	10	5.3	39	63
7.	0 – 20	150	590	260	14	5.8	33	136
	20 – 40	140	560	300	13	5.7	43	120
	40 – 60	210	520	270	10	5.8	32	103
	0 – 60	170	560	270	12	5.8	36	120
8.	0 – 20	270	550	180	14	5.0	80	77
	20 – 40	330	440	230	7	5.2	49	52
	40 – 60	430	380	190	4	5.4	32	39
	0 – 60	340	460	200	8	5.3	54	56
9.	0 – 20	320	500	180	11	5.6	38	76
	20 – 40	370	410	220	6	5.5	32	54
	40 – 60	500	360	140	2	5.6	19	29
	0 – 60	400	420	180	6	5.6	30	54

Contd..

Table 2.3.15 Contd..

Sr. No.	Depth (cm)	Chemical Properties of Soil Gravel (g/kg)	Sand (g/kg)	Silt + Clay (g/kg)	Organic Carbon (g/kg)	pH (20:40 water)	Exch. Acidity (mg/kg)	Exch. Bases (mg/kg)
10.	0 – 20	250	580	170	9	5.5	30	79
	20 – 40	240	550	210	6	5.7	30	71
	40 – 60	270	500	230	4	5.9	36	51
	0 – 60	250	550	200	6	5.7	32	67
11.	0 – 20	190	620	190	9	5.8	37	75
	20 – 40	330	490	180	4	6.0	31	53
	40 – 60	250	540	210	3	5.8	30	45
	0 – 60	260	550	190	5	5.9	33	58
12.	0 – 20	280	530	190	13	5.4	62	42
	20 – 40	370	420	210	8	5.3	40	22
	40 – 60	410	380	210	4	5.5	30	22
	0 – 60	350	450	200	8	5.4	44	29
13.	0 – 20	280	520	200	12	5.4	49	43
	20 – 40	270	520	210	6	5.6	38	33
	40 – 60	430	460	110	2	5.8	19	20
	0 – 60	330	500	170	7	5.6	35	32
14.	0 – 20	310	460	230	11	5.3	67	53
	20 – 40	290	450	260	9	5.4	65	48
	40 – 60	430	360	210	6	5.5	42	38
	0 – 60	340	430	230	9	5.4	58	46
15.	0 – 20	400	420	180	8	5.2	42	33
	20 – 40	550	290	160	4	5.1	31	28
	40 – 60	400	390	210	5	5.0	37	28
	0 – 60	450	370	180	6	5.1	37	30
16.	0 – 20	*	750	250	24	5.6	86	129
	20 – 40	*	670	330	12	5.4	64	108
	40 – 60	*	710	290	4	5.3	41	100
	0 – 60	*	710	290	13	5.4	64	112
17.	0 – 20	*	770	230	23	5.9	66	144
	20 – 40	*	730	270	16	5.5	63	122
	40 – 60	*	690	310	8	5.2	61	96
	0 – 60	*	730	270	16	5.5	63	121
18.	0 – 20	*	730	270	16	5.4	67	116
	20 – 40	*	660	340	10	5.3	57	107
	40 – 60	*	650	350	8	5.2	53	104
	0 – 60	*	680	320	11	5.3	59	109

Contd..

Table 2.3.15 Contd...

Sr. No.	Depth (cm)	Chemical Properties of Soil						
		Gravel (g/kg)	Sand (g/kg)	Silt + Clay (g/kg)	Organic Carbon (g/kg)	pH (20:40 water)	Exch. Acidity (mg/kg)	Exch. Bases (mg/kg)
19.	0 – 20	*	710	290	14	5.4	68	128
	20 – 40	*	680	320	10	5.3	60	120
	40 – 60	*	640	360	5	5.2	51	112
	0 – 60	*	680	320	10	5.3	60	120
20.	0 – 20	*	730	270	17	5.7	63	136
	20 – 40	*	710	290	15	5.7	59	129
	40 – 60	*	640	360	8	5.5	48	108
	0 – 60	*	690	310	13	5.6	57	124
B	Kottayam Forest Division, Kottayam							
21.	0 – 20	200	650	150	22	5.0	73	64
	20 – 40	270	560	170	12	4.8	57	49
	40 – 60	240	590	170	10	4.8	55	43
	0 – 60	240	600	160	15	4.9	62	52
22.	0 – 20	160	680	160	16	5.3	61	53
	20 – 40	260	580	160	9	5.3	44	47
	40 – 60	230	590	180	8	5.2	41	38
	0 – 60	220	610	170	11	5.3	49	46
23.	0 – 20	340	570	90	18	5.2	55	55
	20 – 40	520	390	90	8	5.2	29	25
	40 – 60	410	450	140	7	5.3	31	27
	0 – 60	420	470	110	11	5.2	38	36
24.	0 – 20	190	690	120	16	5.2	71	49
	20 – 40	180	680	140	13	5.1	64	60
	40 – 60	180	660	160	14	5.2	62	49
	0 – 60	180	680	140	14	5.2	66	53
C	Kothamangalam Forest Division, Ernakulam							
25.	0 – 20	360	530	110	11	5.6	41	66
	20 – 40	310	550	140	8	5.4	40	60
	40 – 60	350	510	140	6	5.3	33	67
	0 – 60	340	530	130	8	5.4	38	64
D.	Munnar Forest Division, Idukki							
26.	0 – 20	*	690	310	24	5.4	77	198
	20 – 40	*	620	380	10	4.7	60	102
	40 – 60	*	590	410	9	4.4	66	92
	0 – 60	*	630	370	14	4.8	68	131
27.	0 – 20	*	ND	ND	50	4.4	178	168
	20 – 40	*	830	170	47	4.5	127	120
	40 – 60	*	770	230	31	4.7	79	116
	0 – 60	*	800	200	43	4.5	128	135

Contd...

Table 2.3.15 Contd...

Sr. No.	Depth (cm)	Chemical Properties of Soil						
		Gravel (g/kg)	Sand (g/kg)	Silt + Clay (g/kg)	Organic Carbon (g/kg)	pH (20:40 water)	Exch. Acidity (mg/kg)	Exch. Bases (mg/kg)
28.	0 – 20	*	720	280	5	5.3	87	184
	20 – 40	*	650	350	11	4.6	51	116
	40 – 60	*	540	460	11	4.4	91	160
	0 – 60	*	640	360	9	4.8	76	153
E.	Malayattor Forest Division, Ernakulam							
29.	0 – 20	440	430	130	9	5.9	21	62
	20 – 40	380	440	180	8	5.9	22	68
	40 – 60	470	360	170	5	5.8	15	53
	0 – 60	430	410	160	7	5.9	19	61
30.	0 – 20	110	700	190	18	5.8	44	89
	20 – 40	320	520	160	10	5.7	32	68
	40 – 60	350	500	150	8	5.6	29	52
	0 – 60	260	570	170	12	5.7	35	70
31.	0 – 20	300	530	170	12	5.7	36	70
	20 – 40	400	440	160	6	5.4	27	48
	40 – 60	420	430	150	4	5.4	20	46
	0 – 60	370	470	160	7	5.5	28	55
32.	0 – 20	310	550	140	12	5.6	31	69
	20 – 40	390	440	170	9	5.5	29	61
	40 – 60	500	340	160	6	5.4	20	45
	0 – 60	400	440	160	9	5.5	27	58
33.	0 – 20	330	480	190	10	5.3	27	47
	20 – 40	560	290	150	4	5.3	15	31
	40 – 60	530	310	160	2	5.4	14	33
	0 – 60	480	360	160	5	5.3	19	37
F.	Vazhachal Forest Division, Thrissur							
34.	0 – 20	*	690	310	24	5.8	89	116
	20 – 40	*	660	340	17	4.5	80	125
	40 – 60	*	640	360	12	5.0	61	81
	0 – 60	*	660	340	18	4.8	77	107
35.	0 – 20	*	800	200	13	5.4	39	67
	20 – 40	*	750	250	8	5.5	34	73
	40 – 60	*	740	260	7	5.5	37	74
	0 – 60	*	760	240	9	5.5	37	71

Source : Primary data Collected by KFRI

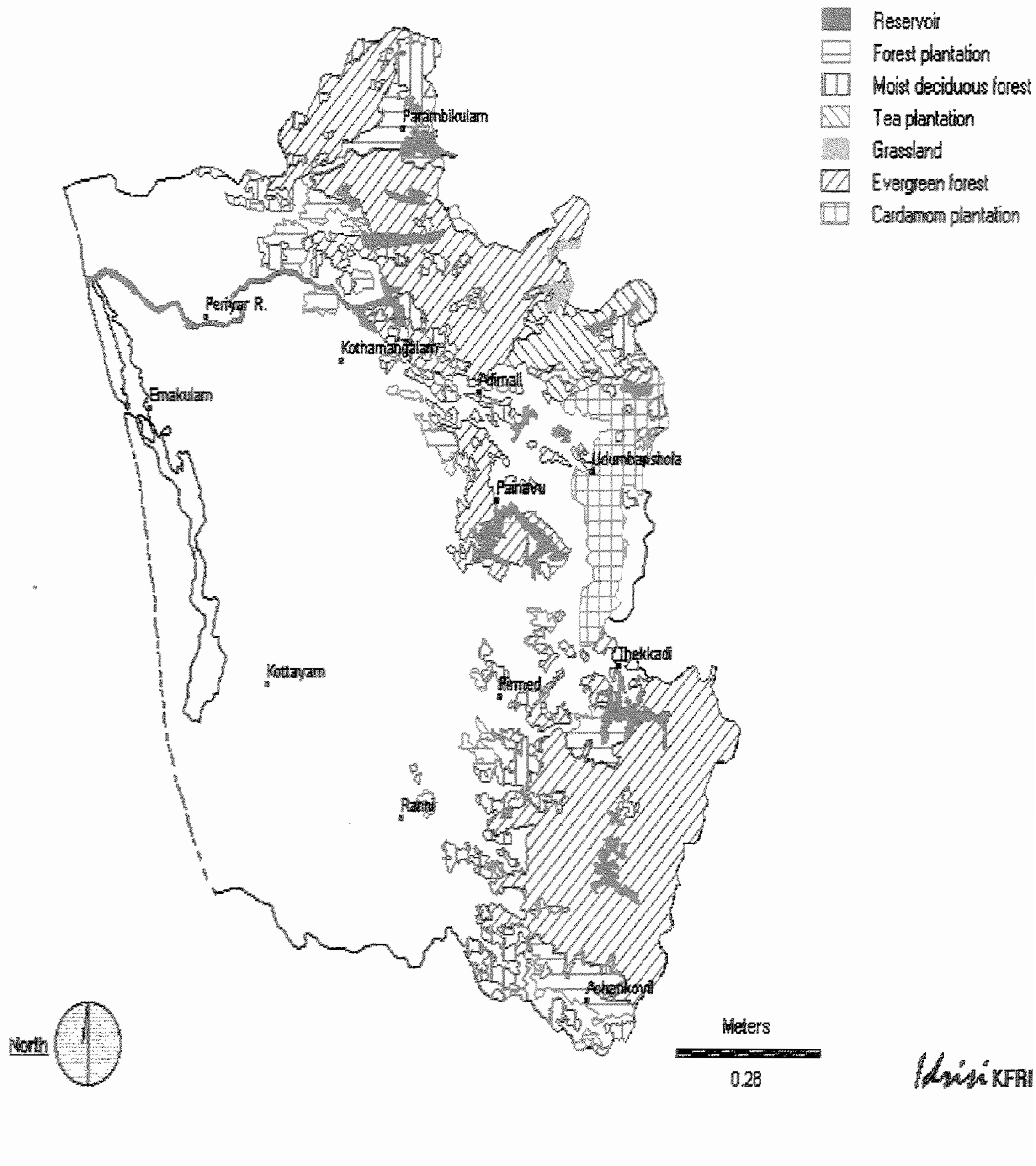

Fig. 2.3.1 : Forest Cover in the Region

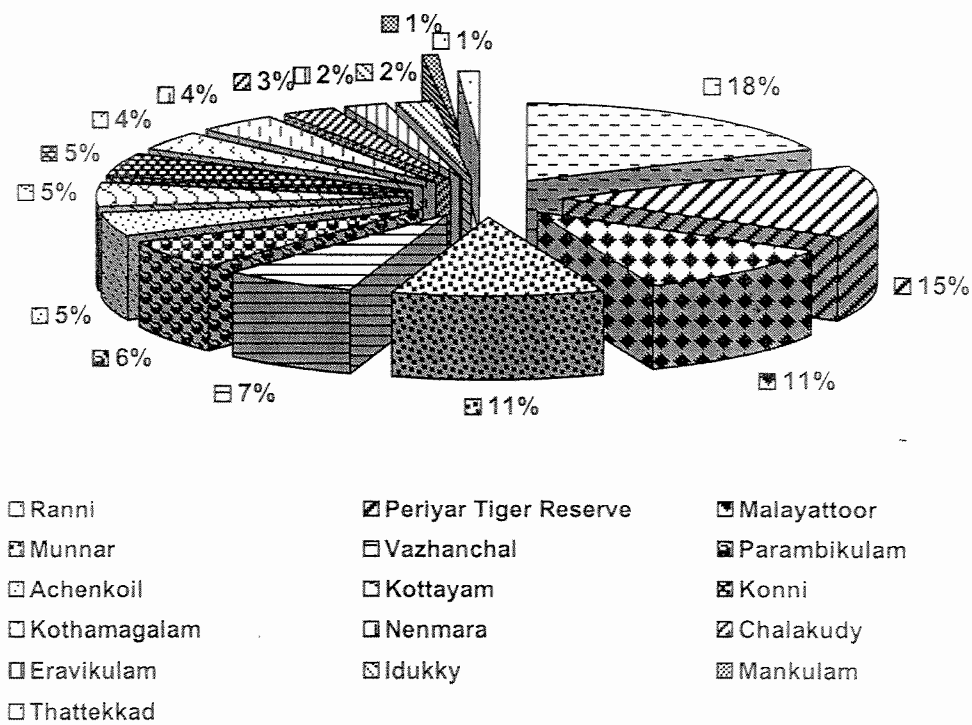

Fig. 2.3.2 : Distribution and Extent of Forest Cover in the Region

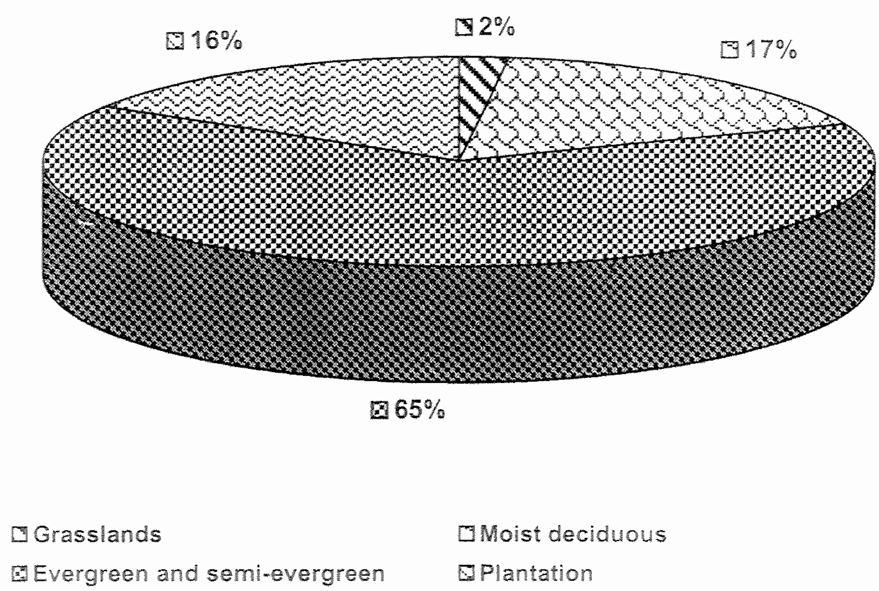

Fig. 2.3.3 : Distribution of Forest Vegetation Types in the Region

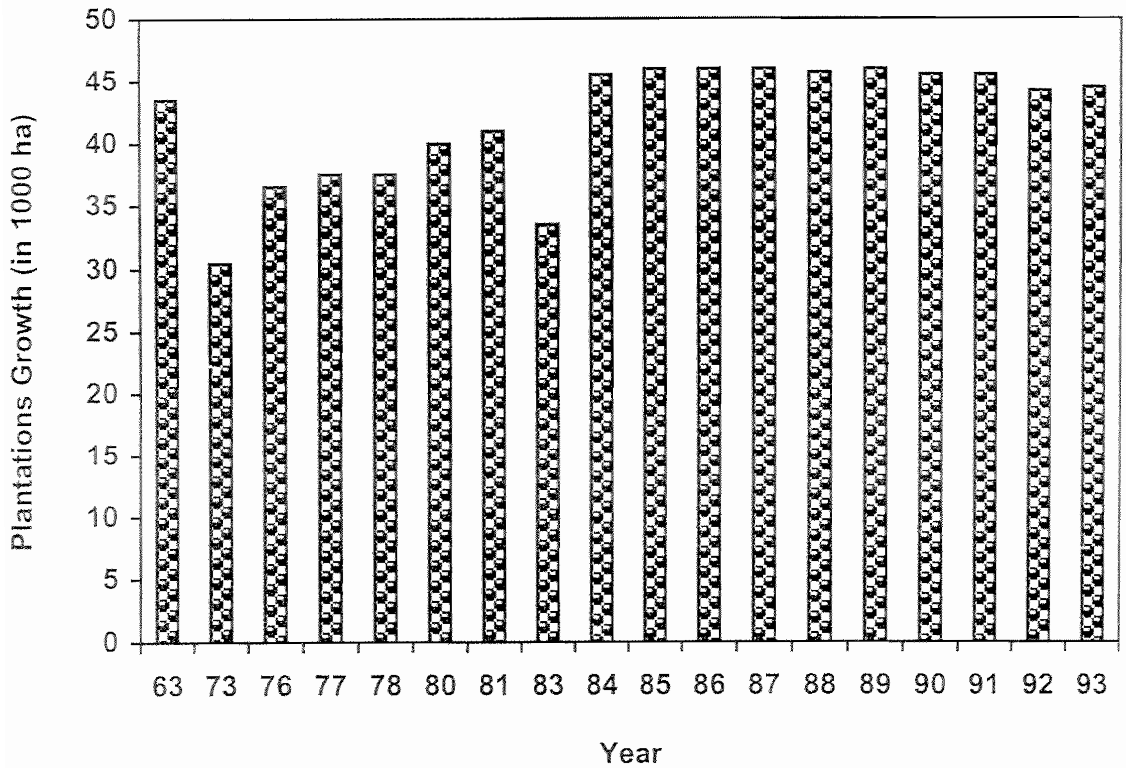

Fig. 2.3.4 : Growth in Teak Plantations in the Study Area

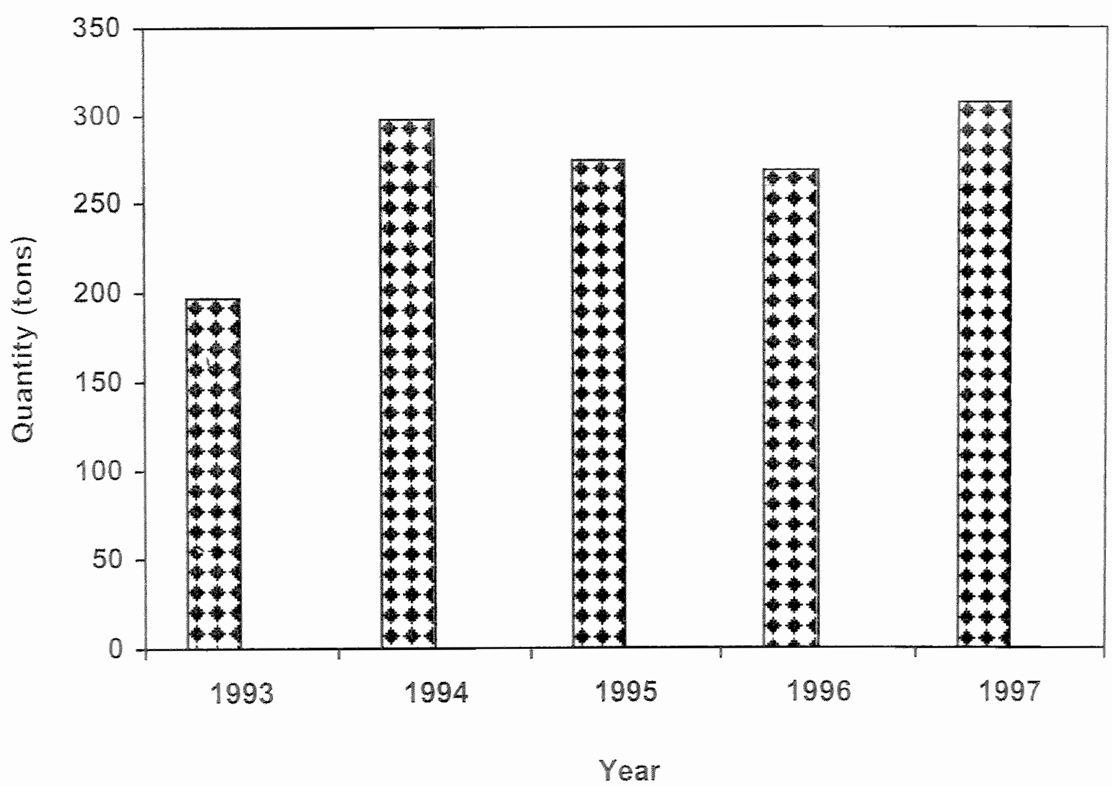

Fig. 2.3.5 : Quantity of NWFPs Collected

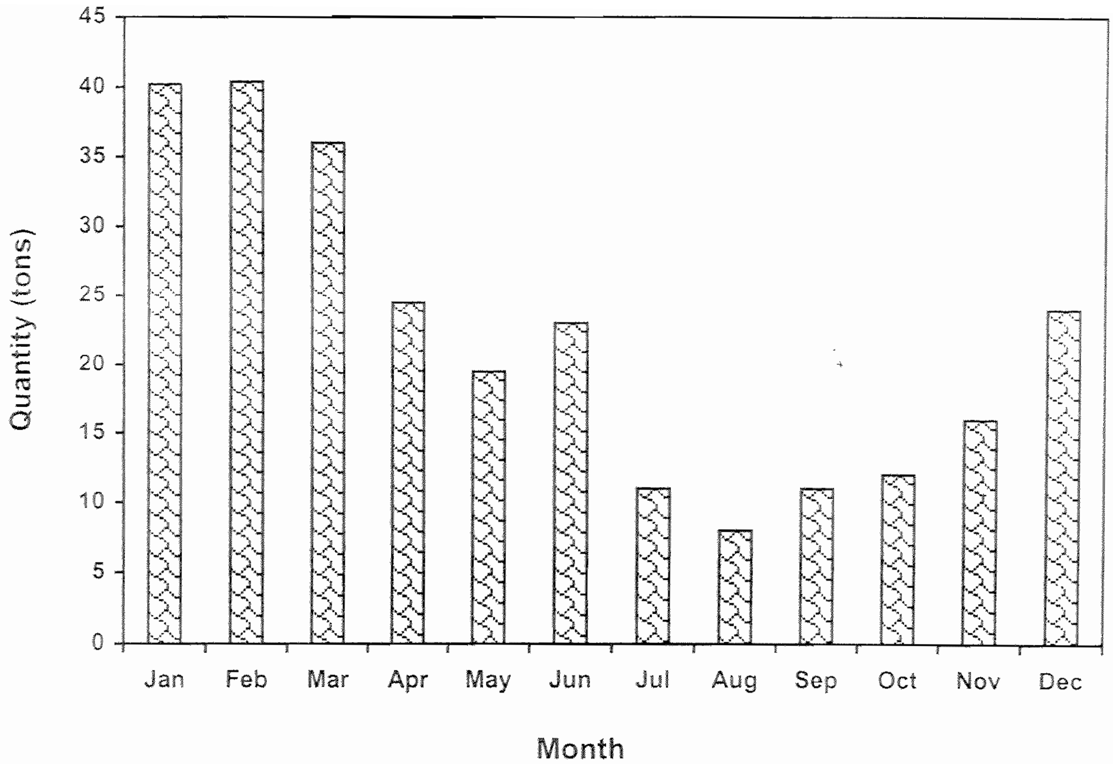

Fig. 2.3.6 : Mean Seasonal Flow of NWFPs

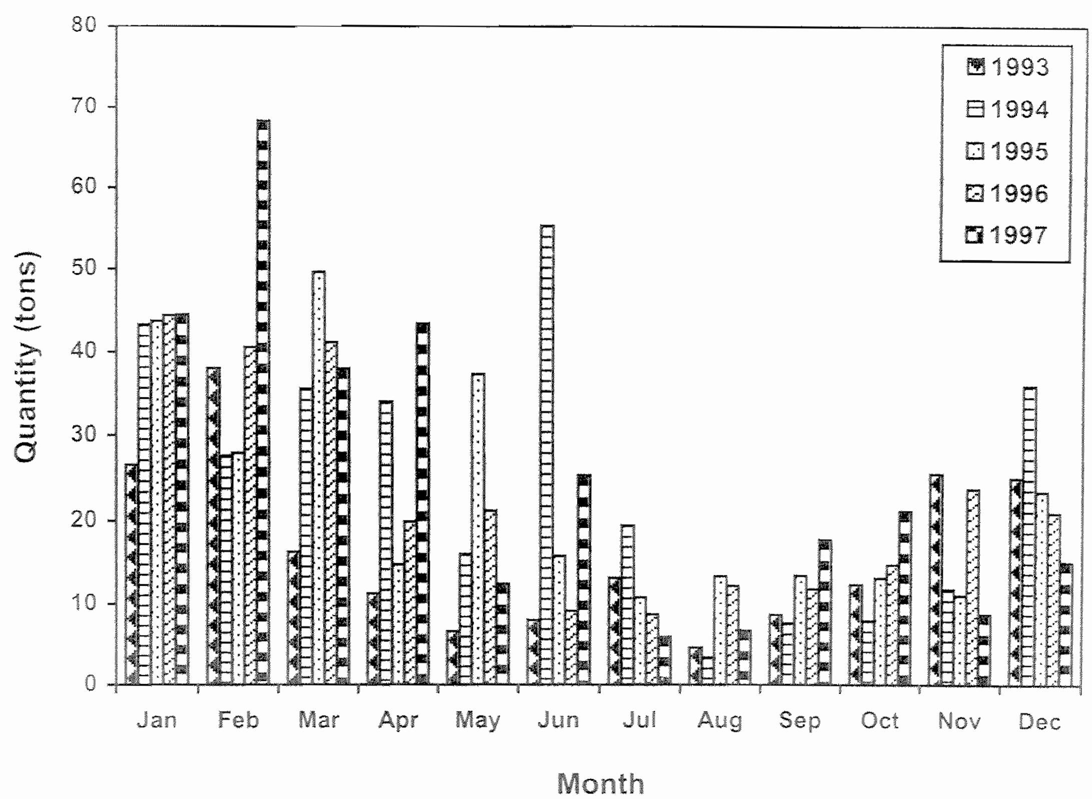

Fig. 2.3.7 : Seasonal Flow of NWFPs

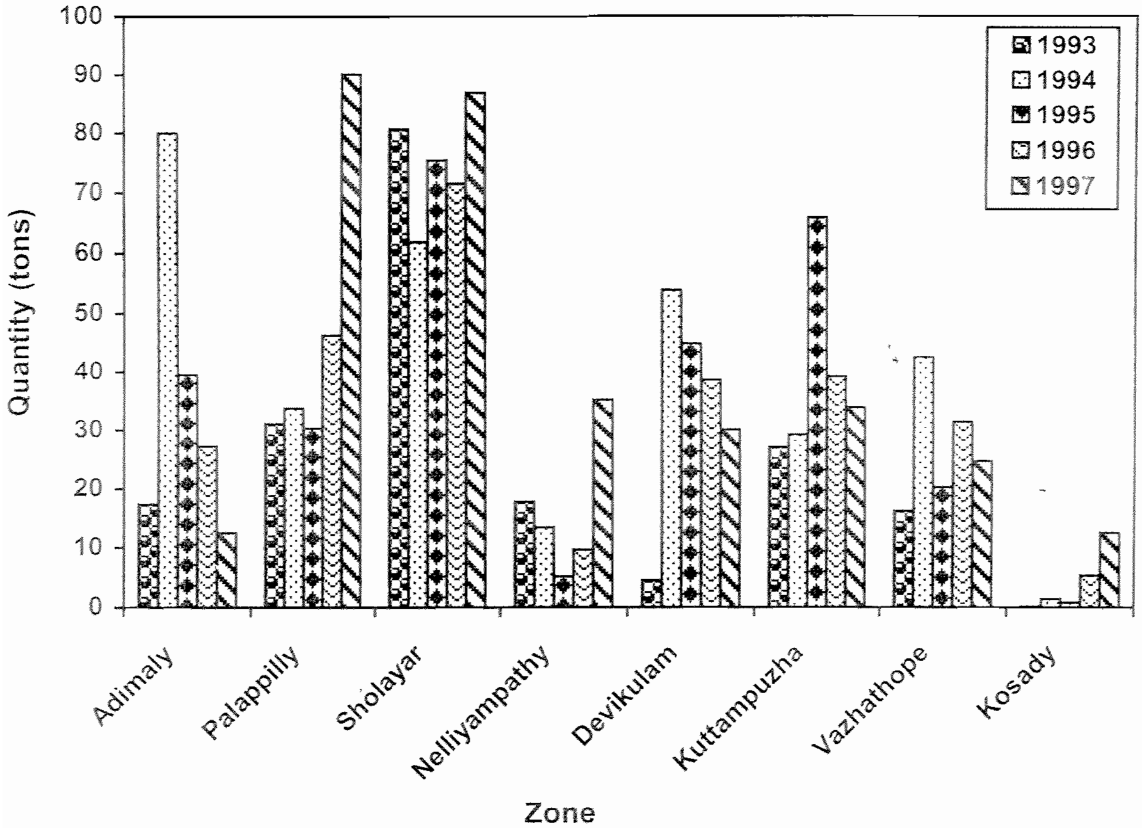

Fig. 2.3.8 : Area Wise Extraction of NWFPs

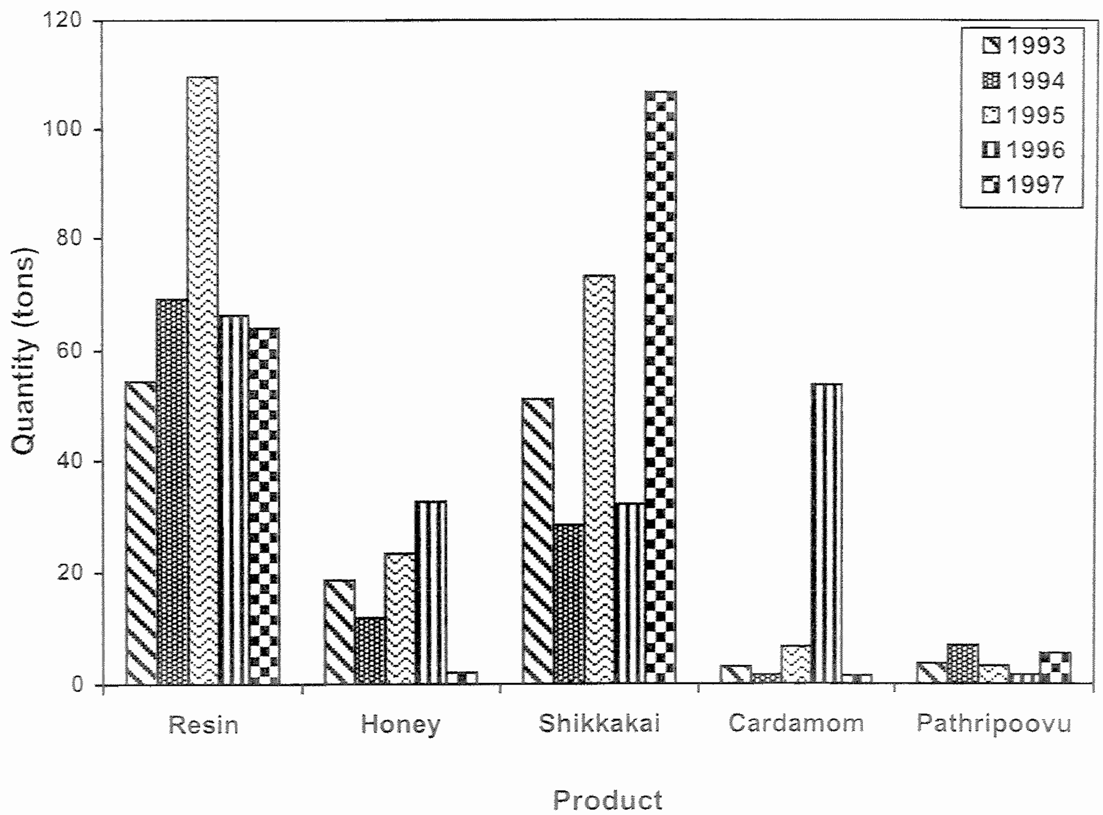

Fig. 2.3.9 : Flow of Selected NWFPs

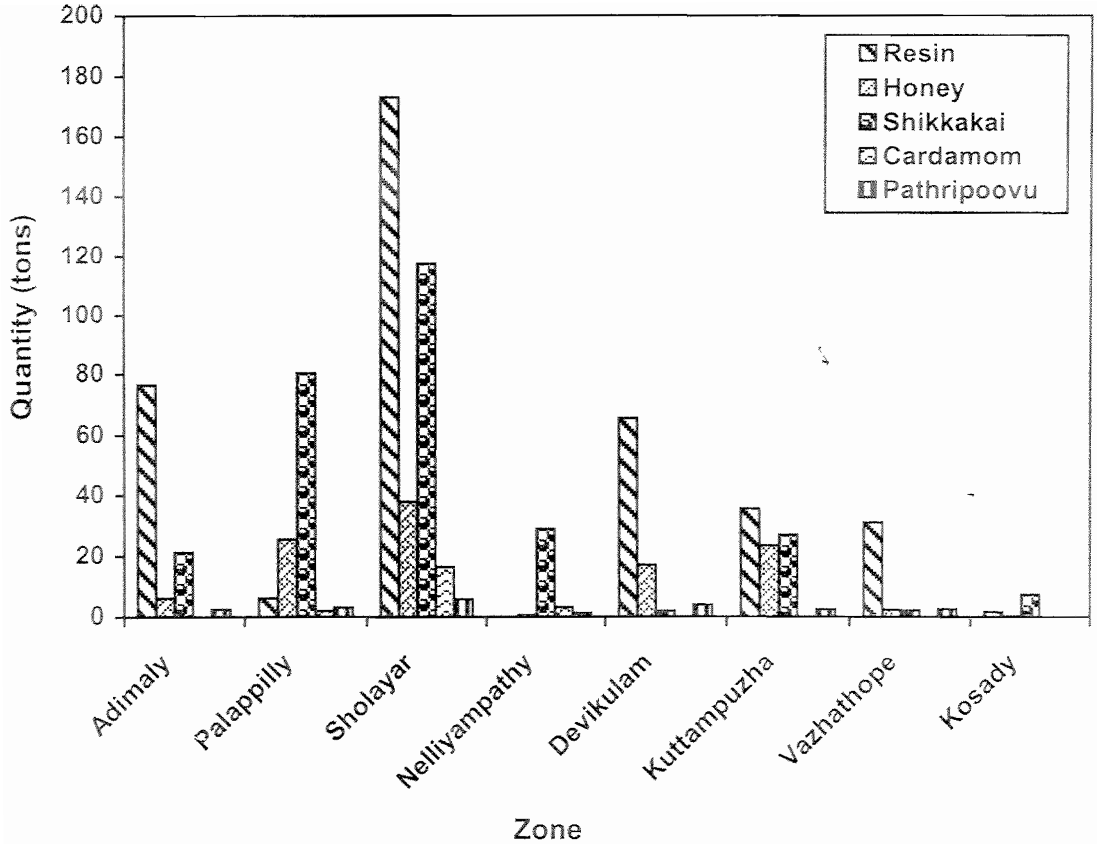

Fig. 2.3.10 : Area Wise Extraction of Selected NWFPs

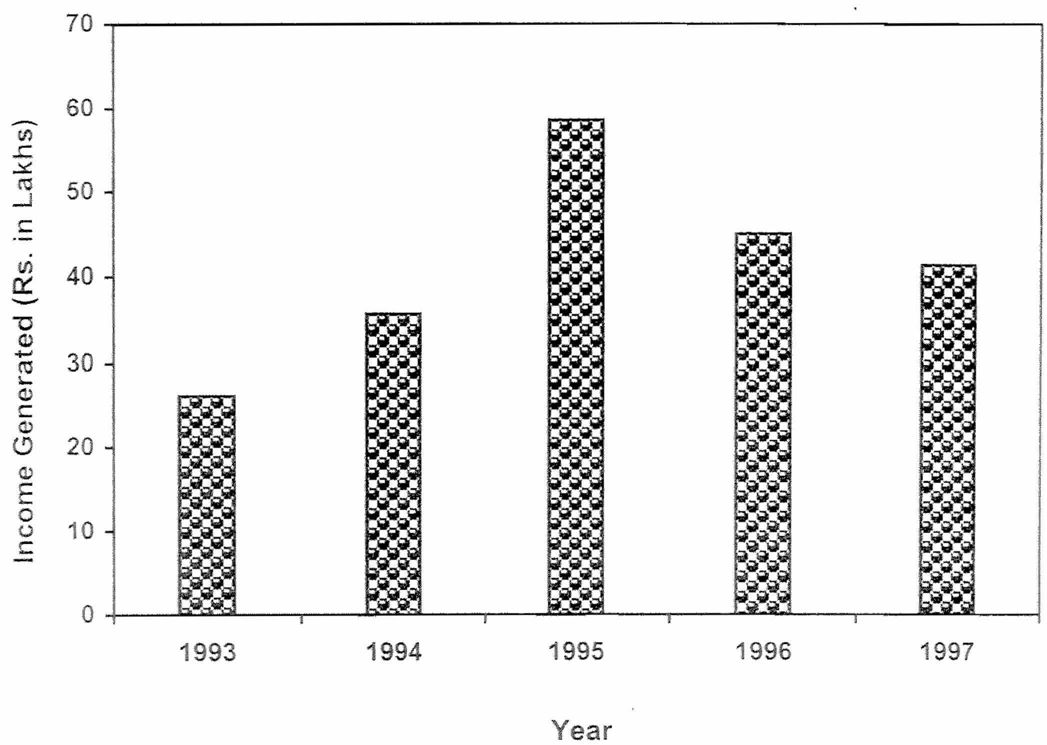

Fig. 2.3.11 : Income Generated Through NWFPs Collection

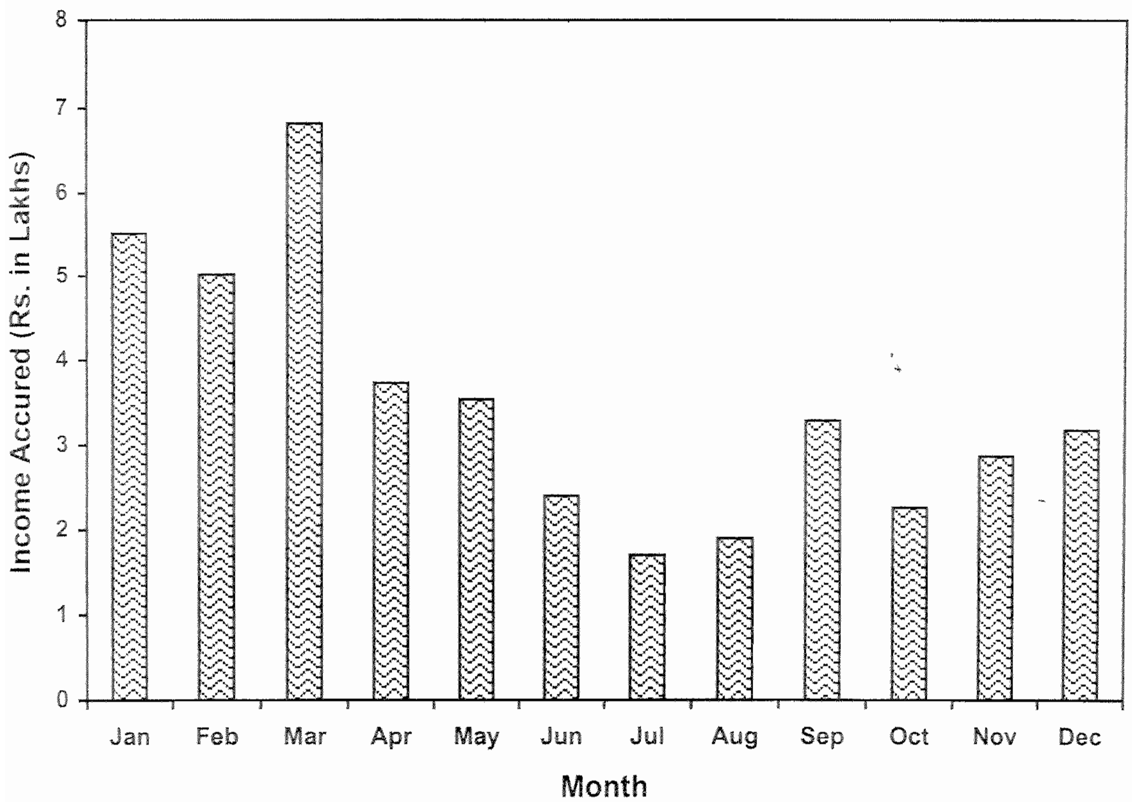

Fig. 2.3.12 : Mean Seasonal Income Accured through NWFP Collection

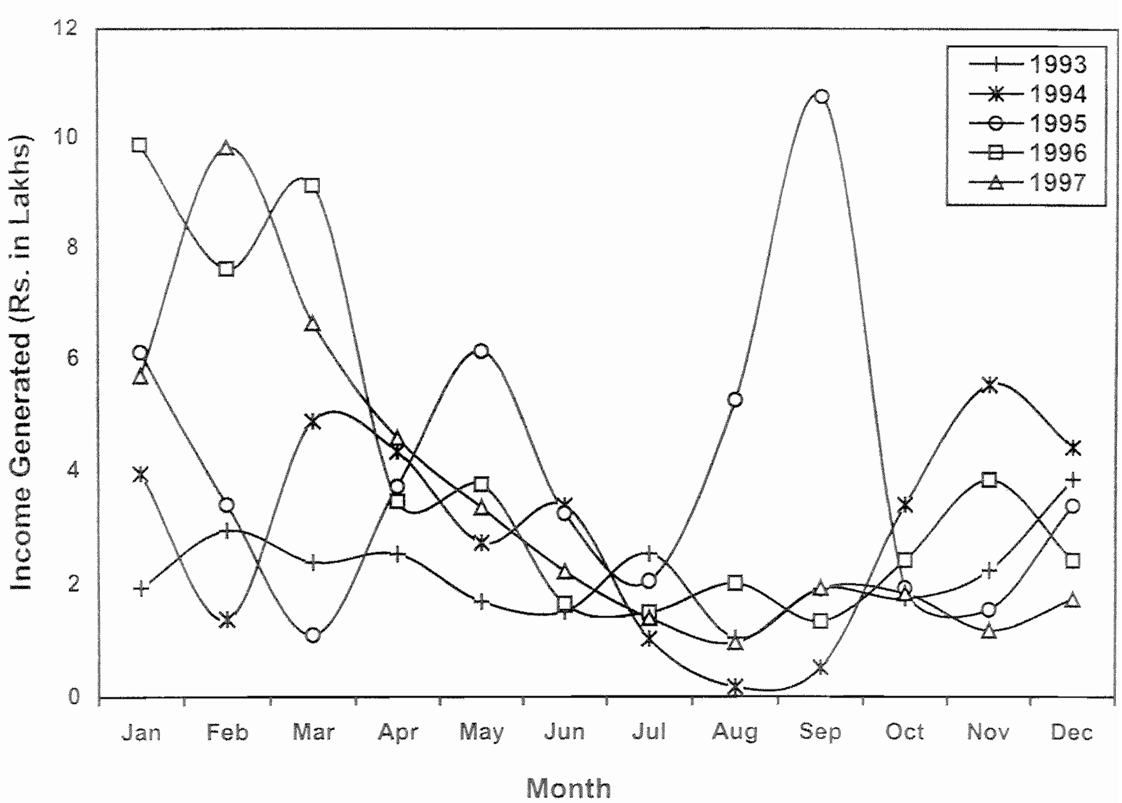

Fig. 2.3.13 : Seasonal Fluctuation in Income Generation through Extraction of NWFPs

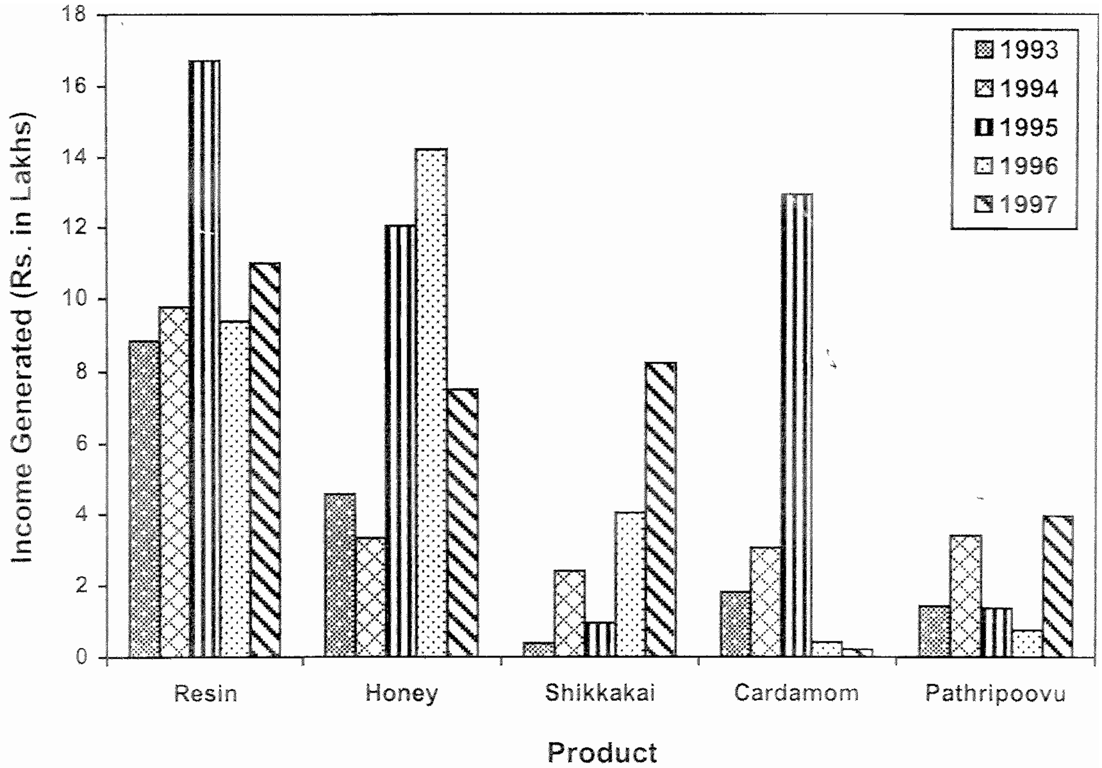

Fig. 2.3.14 : Income Generated through Extraction of Selected NWFPs

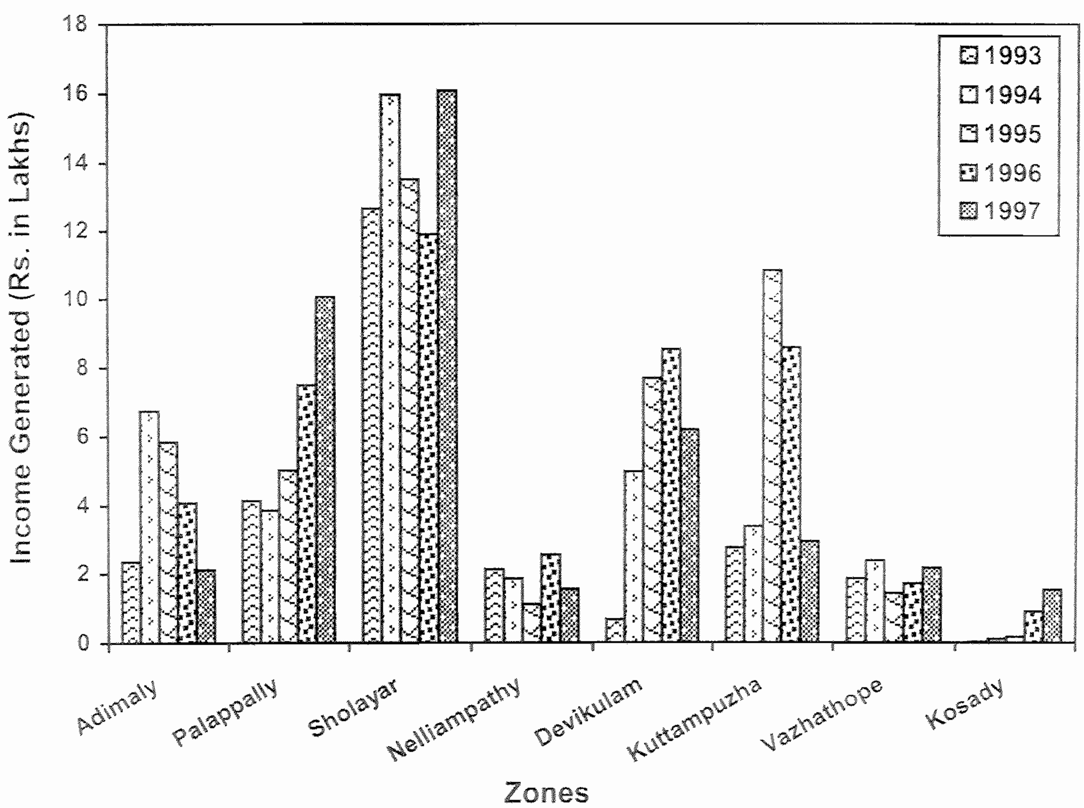

Fig. 2.3.15 : Areawise Income Generated through NWFPs Extraction

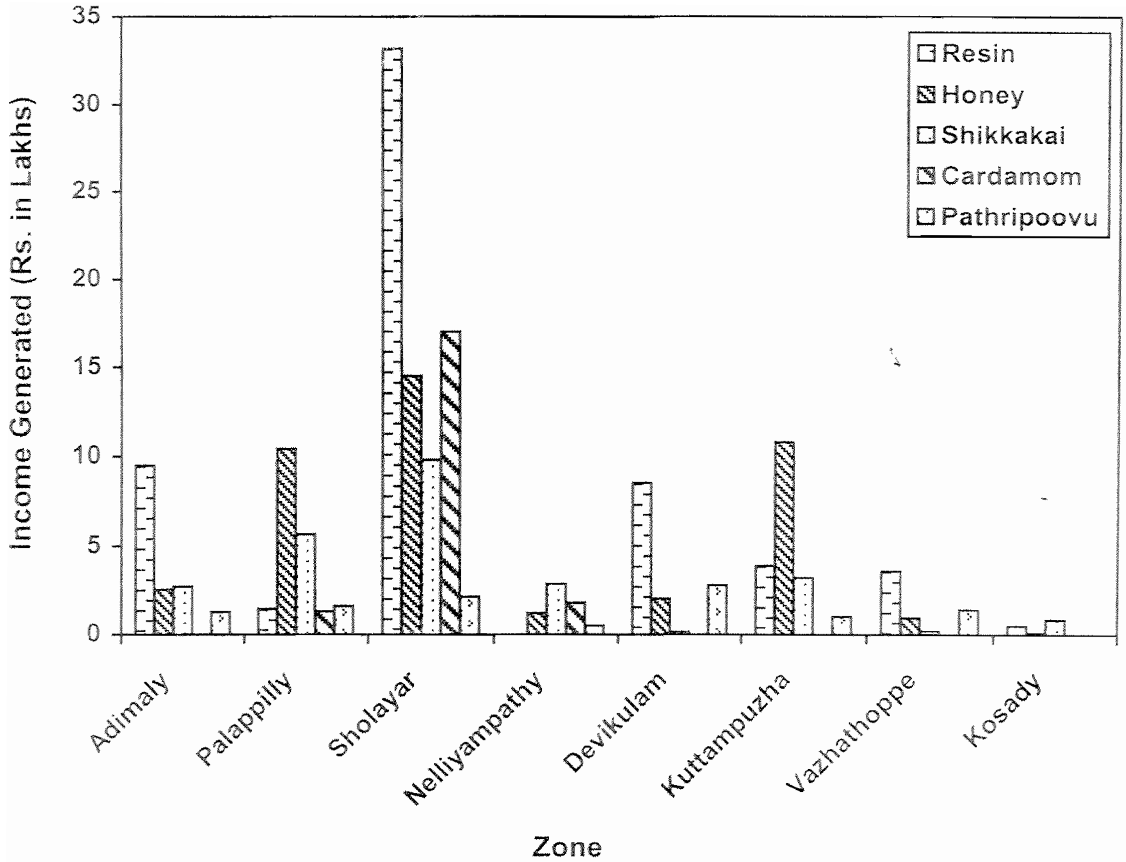

Fig. 2.3.16 : Areawise Income Generated through Extraction of Selected NWFPs

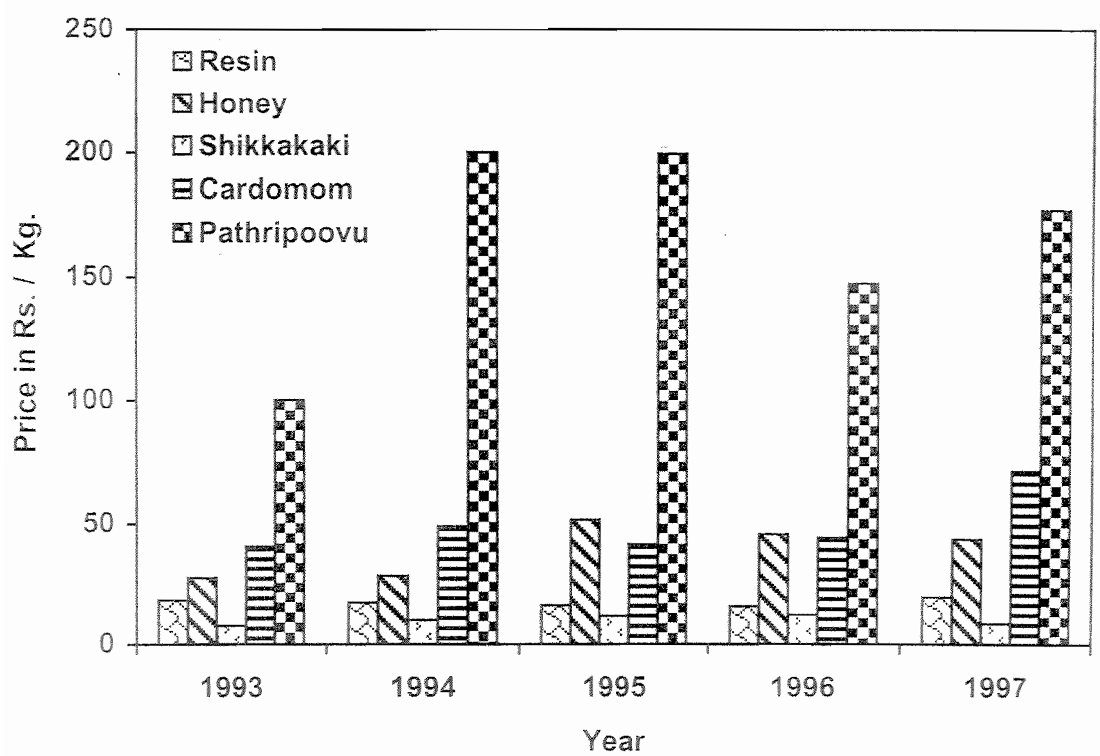

Fig. 2.3.17 : Fluctuation in Prices of selected NWFPs

2.4 Minerals

GKR hosts valuable economic deposits of minerals like lime shells, clays, glass sands and graphite; so also building materials like river sands, crystalline rocks and laterite. In addition, occurrence of iron ores and molybdinite is also reported, as shown in **Fig. 2.4.1**. The estimated (total) reserves are given in **Table 2.4.1**

2.4.1 Lime shells

Lime shell is one of the purest forms of calcium carbonate in nature. It is being used for manufacturing white cement, carbide and other chemicals. Relatively smaller quantities are used for the manufacture of poly fibre and in tanning industry. Lime shell is being mined from Vembanad Lake since a very long time. It has been reported that, in 1991, India produced about 1.26 lakh tonnes of lime shells; of which Kerala's contribution was 67000 tonnes, the source of which, was Vembanad Lake. Two types of lime shells are recovered from the Vembanad Lake - the White shells (fossilized shells) and the Black shells (exoskeletons of living bivalves).

2.4.2 White shells

White shell deposits are nothing but the fossilized lamellibranch (major) and gastropod (minor) exoskeletons intervened within the sedimentary substratum. Although the deposits are concentrated more in regions south of Thanneermukkam regulator, patches of such deposits are also present in other parts of the basin. The total white shell reserve, according to the Geological Survey of India, amounts to 3.75 million tonnes. The white shell deposits are recovered either manually or mechanically using dredgers. The manually recovered shells are collected and disbursed through four Co-operative societies. **Table 2.4.2** shows the year-wise collection of lime shells from the Vembanad Lake and **Table 2.4.3** presents the society-wise details along with the trend analysis for the last five years. The white shell production has been found decreasing remarkably from 1992/93 to 1997/98 (**Fig. 2.4.2**).

2.4.3 Black shells

Clam beds of the genus *Villoritta* occur as patches in the shallow sandy substratum of the Vembanad Lake. These shells are exploited for two purposes. While the protein rich flesh of the clam is used for human consumption, the exoskeleton of the bivalves is used for meeting the lime requirements. The black shell collection and sale are mainly done through Co-operative societies. Eight such societies are currently functioning around the lake. **Table 2.4.2** shows the details of the black shell production from 1992-93 to 1997-98. It is estimated that, on an average, about 30,000 tonnes of black shells are collected, annually. From **Fig. 2.4.3** and **Table 2.4.4**, it is clear that the black shell production for the last five years does not exhibit much significant change, although the number of laborers engaged in the mining sector remains almost the same. This indicates, probably, that the catch has not yet crossed the maximum sustainable yield (MSY).

User agencies

The Travancore Cements Ltd. (TCL), located at Kottayam, is the major user industry of lime shells of the Vembanad Lake. TCL has its own mechanized mining units, which work throughout the day, recovering the resource since 1947. On an average, TCL extracts about 40,000 tonnes of white shells annually. The other user agencies are Travancore Electrochemical Industries Ltd., located at Chingavanam and the Kerala Construction Company Ltd. (Lime-brick manufactures) located at Cherthala. From 1998, the Travancore Electrochemical Industries Ltd. has stopped using lime shells.

Instead, they meet the lime requirements from limestones brought from Tamil Nadu. In addition, a substantial quantity of lime shells (particularly black shells) is being consumed by various limekilns of Kerala as well as in the neighbouring States.

2.4.4 Tile and Brick clays

Deposits of different types of clays are reported from GKR, which include china clay (kaolin), fire clay, ball clay and tile/brick clay (**Table 2.4.1**). However, mining activities are confined only to tile/brick clays, as other varieties are not found on industrial scale. Mining of clays from paddy lands for the manufacture of decorative and roofing tiles, wire cut and ordinary bricks as well as for potteries is taking place extensively in the districts of Trichur, Ernakulam, Alappuzha and Kottayam. **Fig. 2.4.4** shows the major clay mining areas of GKR. These clays are flood plain clays; generally fine, plastic, dull white to variegated colours.

Since there is not much secondary information available on the tile/brick clay mining activities of GKR, detailed work was carried out to quantitatively estimate the extent of the mining activity. **Table 2.4.5** shows the details of tile/brick clay mining from various river basins in the study area. It is estimated that an amount of 5.27 lakh MT of clay is scooped out annually from GKR by mechanical and manual mining.

2.4.5 Silica sands

The silica sand reserve of Kerala comes to about 110 million MT. Of this, over 70 million MT of high-grade sand is concentrated in Alappuzha district, particularly, in areas in and around Thycauttusseri, Pallippuram and Panavally villages - the main silica sand mining centres of Kerala. The silica sand production figures from 1992-93 to 1995-96 are shown in **Table 2.4.6**. Location-wise details of sand extraction from Cherthala - Alappuzha belt for 1998-99 is given in **Table 2.4.7** along with other relevant details.

2.4.6 Graphite

The Kerala Mineral Exploration and Development Corporation have studied the resource potential of graphite in GKR between 1978 and 1981. Graphite occurs as flaky aggregates in Nagapuzha - Muvattupuzha areas. The total reserve comes to about 7,48,000 MT. The recoverable graphite comes to 43,000 MT. The grade (percent carbon), concentration and recovery (percent), respectively, are 7.3, 89 and 79.

The deposits occur close to the land surface or at shallower depths. At present, it is not exploited for any commercial purposes. Inspite of the region having the largest deposit in the State, its mining and beneficiation have not developed so far. In fact, the studies in various laboratories within the country and abroad suggest its good beneficiation characteristics, high recovery of fixed carbon and preservation of suitable flake size for their use in key value added industrial applications.

2.4.7 River Sand

The construction industry is a key sector in any growing economy and river sand is an essential raw material for it. In a State like Kerala, where the high land and the low land lie close by in narrow strips, the rivers are invariably short with limited riverbed resource. Besides, mining of sand from these rivers is fraught with serious environmental consequences. Therefore, a delicate balance between exploitation of the resource and protection of the environment will have to be maintained.

The GKR hosts seven rivers, viz., Achenkovil, Pamba, Manimala, Meenachil, Muvattupuzha, Periyar and Chalakkudy rivers (**Fig. 2.4.5**). A large volume of river sand is being grabbed from these rivers round the year. **Table 2.4.8** shows details of the estimated sand reserve, annual extraction and natural replenishments.

The estimated sand reserve of Periyar River is about 26.62 Mm^3. A recent study revealed that an amount of 3.11 Mm^3 of sand got mined from the Periyar River during the year 1998 from various *kadavus* (sand mining sites) (**Fig. 2.4.6**). The natural replenishment, on the other hand, is only 50708 m^3/year. At the existing rate of mining, the resource will be exhausted within a period of 6-7 years and the riverbed will lower by 4-5m from the present level (**Fig. 2.4.7**).

The sand reserve of the Pamba River is computed to be about 10.42 Mm^3. The present mining rate is about 0.41 Mm^3 per annum as against the natural replenishment of 17883 m^3/year. Compared to Periyar River, the mining in Pamba River is more controlled, which can be seen from the longer resource exploitation period (**Fig. 2.4.8**).

It is estimated that, from Manimala River, about 0.47 Mm^3 of sand is quarried per year against a meagre natural replenishment of 14200 m^3/year. The sand resource, as on 1999, was only about 3.18 Mm^3. At the present level of mining, the resource will be exhausted within a period of about 5-6 years. **Fig. 2.4.9** depicts the relationship between the present rate of mining and what would be the sustainable resource from Manimala River.

The computed river sand reserves of Muvattupuzha and the Chalakkudy rivers are 7.56 and 4.91 Mm^3 respectively. The volume of sand that is extracted is 0.33 Mm^3 for Muvattupuzha River and 0.15 Mm^3 for Chalakkudy River. The computed sustainable yields are 41827 m^3/year for the Muvattupuzha River and 7810 m^3/ year for the Chalakkudy river.

At present, sand mining activity is prohibited/restricted in Achankoil and Meenachil rivers as a result of the intervention of Hon'ble High Court of Kerala. The quarried sand is used mainly for construction purposes in Kerala. It is also exported to the neighbouring States. River sand is often used for filling foundation structures, paving purposes, reclamation of wetlands, etc.

Table 2.4.1

Estimated Reserves of the Mineral Resources in the Study Area & Kerala

Mineral/ Deposit	Places of Occurrence	Reserve (million MT)	
		Study area	Kerala
Clay: Tile clay & Fire clay	Thamarakkulam, Amballur, Kanjiramkulam, Manjal in Ernakulam district and Angamali and Padukkad in Trichur district	1.70 (GSI, 1976)	7.80 (IBM, 1994)
Clay: China clay	Trikkakkara, Mulanthuruthi, Amballur and Kanjiramkulam in Ernakulam district	4.30 (GSI, 1976)	89.41 (IBM, 1994)
Glass sand	Kothamangalam, Panavalli, Cherthala, Alappuzha in Alappuzha district	41.60 (GSI, 1976)	116.87 (IBM, 1994)
Lime shell	Pathiramanal, Kumarakom and other places of adjacent to Vembanad lake	3.75 (GSI, 1976)	---
Graphite	Perungala, Nagapuzha in Idukki district	0.15 (GSI, 1976)	0.52 (IBM, 1994)

Source : Secondary data collected by CESS

Table 2.4.2

Quantity of Limeshell (White and Black) Collected from the Vembanad Lake during 1992 – 1998

Year	Limeshell Production (MT)		
	White Shell	Black Shell	Total
1992-93	104591	30773	135364
1993-94	100464	33025	133489
1994-95	93438	33280	126718
1995-96	109422	26595	136017
1996-97	88836	30243	119079
1997-98	85314	29384	114698

Source : Secondary data collected by CESS

Table 2.4.3

Details of White Shell Extracted from Vembanad Lake (1993-94 to 1997-98)

Sr. No.	Name of Co-operative Society	Average Quantity Collected (MT/year)	Number of Labourers (Approx.)	General Trend
1	Vaikom Co-operative Society Ltd.	8260	400	Decreasing
2	Karappuram Co-operative Society Ltd.	11960	600	Fluctuating
3	Kainakari Co-operative Society Ltd.	28240	1100	Decreasing
4	Kumarakom Co-operative Society Ltd.	3540	200	Decreasing
	Total	52000	2300	

Source : Secondary data collected by CESS

Table 2.4.4

Details of Black Shell Extraction from Vembanad Lake (1993-94 to 1997-98)

Sr. No.	Name of Co-operative Society	Average Quantity Collected (MT/year)	Number of Labourers (Approx.)	General Trend
1	Kattikkunnu Co-operative Society Ltd.	1270	100	Fluctuating
2	Aryad Co-operative Society Ltd.	5630	500	Decreasing
3	Thycauttusseri Co-operative Society Ltd.	5720	500	Markedly decreasing
4	Chempu-TV-puram Co-operative Society Ltd.	6740	231	Increasing
5	Vechur Co-operative Society Ltd.	2845	150	Slightly increasing
6	Kavalam Co-operative Society Ltd.	950	131	Increasing
7	Kuthiyathodu Co-operative Society Ltd.	1370	300	Markedly decreasing
8	Muhamma Co-operative Society Ltd.	5615	400	Fluctuating
	Total	30140	2312	

Source : Secondary data collected by CESS

Table 2.4.5

River Basin wiseTile/Brick Clay based Small Scale / Cottage Industries along with other Relevant Details

Annual Clay Consumption (MT)	Clay Products	No. of labourers			Major Observations
		Male	Female	Total	
Chalakudy					
69750	Ordinary and decorative tiles, potteries, wire cut and ordinary bricks	362	611	973	Mechanized mining using JCB and L&T earth movers in Valoor and adjacent regions of the Kadukutti / Annammanada panchayats
Periyar					
304950	Wire cut and ordinary bricks, decorative and ordinary tiles, potteries	1284	3436	4720	The clay mining close to the river channel at Vazhakulam, Kanjoor and Sreemoolanagaram areas threatens the natural flow of the river system Combined mining for both clay and underlying sand causes over deepening in Alangad area
Muvattupuzha					
27700	Ordinary and wire cut bricks	178	198	376	
Meenachil					
50000	Ordinary bricks	267	374	641	
Pamba					
74250	Ordinary and wire cut bricks	500	125	625	Indiscriminate mining for both clay and underlying sand creates over deepening at many places in the Budhanoor area
526650		2591	4744	7335	

Source : Secondary data collected by CESS

Table 2.4.6

Silica Sand Production in GKR (1992-93 to 1995-96)

Year	Production (MT)
1992-93	65521
1993-94	77163
1994-95	34663
1995-96	80126

Source: Secondary data collected by CESS

Table 2.4.7

Location- wise Details of Silica Sand Extraction of the Cherthala - Alappuzha Belt for the Period 1998 - 99(1)

Sr. No.	Name of the Mine	Extracted Quantity of Silica Sand (MT)		Number of Labourers	User Industries / Agencies
		Daily	Annual(2)		
1	Wilson Enterprises	30	7500	13	Silicate industries in Kerala and neighbouring States, Excell Glass Ltd., Kerala Construction Company Ltd., Cherthala, for foundry applications in various industrial units of Tamil Nadu and Karnataka.
2	Global mines	80	20000	35	
3	Mega mines	40	10000	12	
4	C.G.K. mines	30	7500	16	
5	Sudheesh's mine	20	5000	10	
6	Sushama Asokraj's mine	30	7500	14	
7	Keralathi trust	40	10000	28	
8	Viyani mines	20	5000	5	
9	GP.mines	20	5000	16	
10	Palakkal mines	30	7500	13	
11	Excell mines	100	25000	31	
12	Abraham's mine	30	7500	16	
13	Indus silica mines	30	7500	10	
14	Map Co mines	20	5000	8	
15	Cheruvalli mines	30	7500	13	
16	Mukkada mines	30	7500	11	
17	St.Joseph mines	30	7500	17	
	Total	**610**	**152500**	**268**	

(1) The quantity of silica sands used by the Pallathra - lime brick industry (Kerala Construction Company Ltd.) is not included. (2) Projected quantity for 250 working days from primary surveys

Table 2.4.8

Details of River Sand Mining from Various River Basins of GKR

River basin	River length (km)	Drain-age Area (km^2)	Estimated Sand reserve (10^6 m^3)	Pancha-yats involved in sand mining	Volume of sand extracted (10^6 m^3year)	Sustainable yield (m^3/year)	No. of Labou-rers
Periyar	244	5398	26.7	15	3.11	50708	7000
Pamba	176	2235	10.62	14	0.46	17883	995
Muvattu-puzha	121	1554	7.56	12	0.33	41827	1147
Manimala	90	847	3 18	10	0.47	14200	1300
Chalakudy	130	1704	4.91	5	0.15	7810	1200
Meenachil*	78	1272	3.12	–	–	–	–
Achenkovil*	128	1484	5.8	–	–	–	–

* sand mining prohibited on High Court's intervention.

Source : Primary and Secondary data collected by CESS

CARRYING CAPACITY BASED DEVELOPMENTAL PLANNING FOR GREATER KOCHI REGION

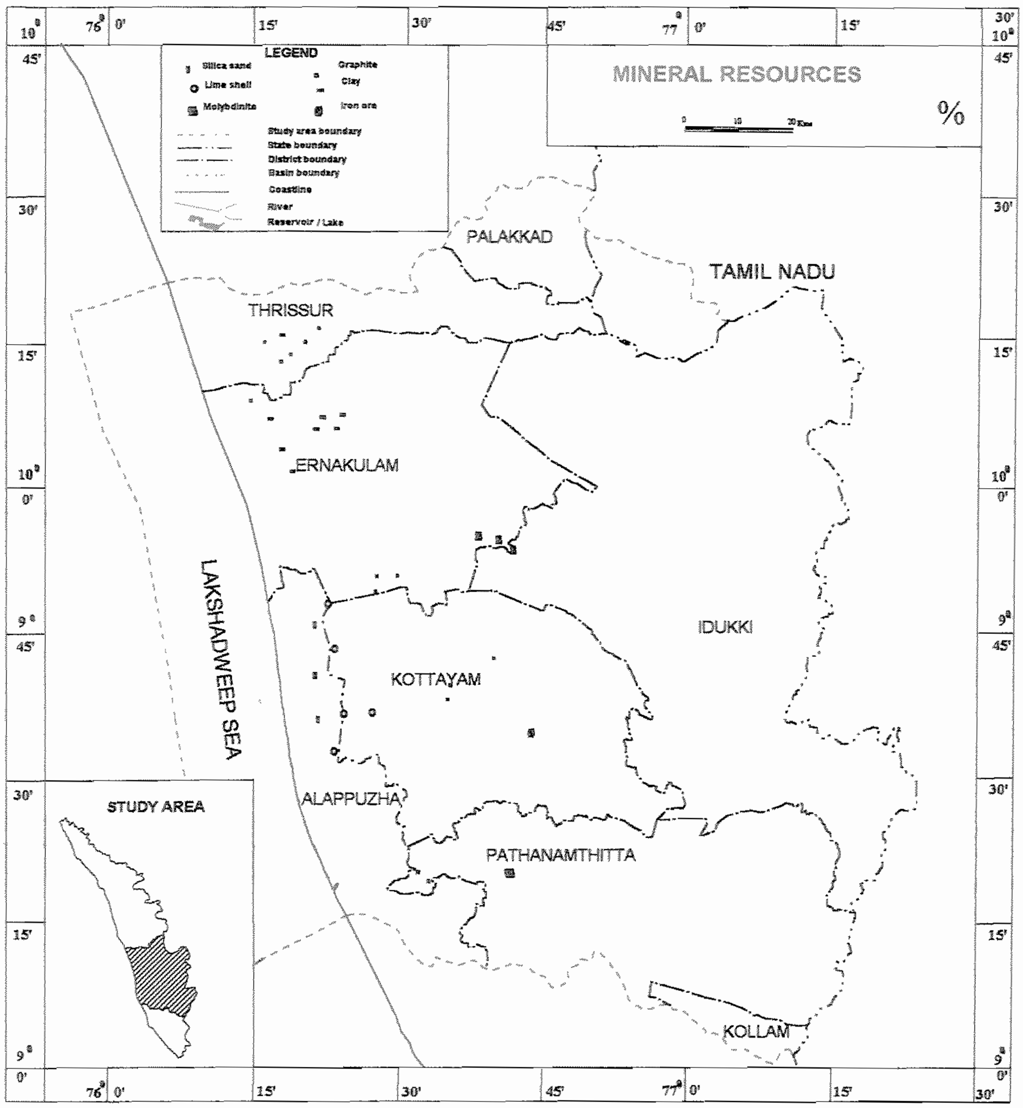

Fig. 2.4.1 : Location of Mineral Deposits in GKR

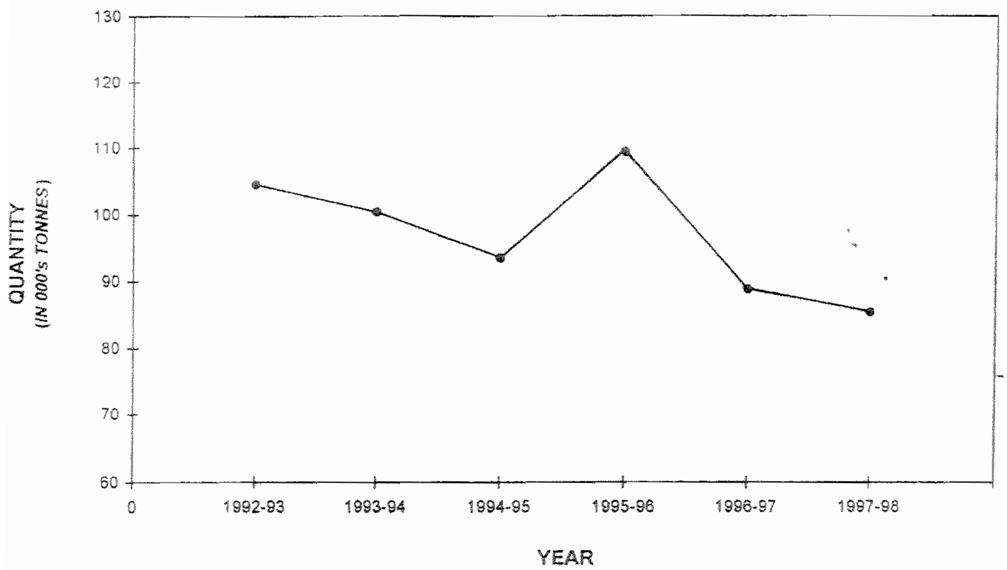

Fig 2.4.2 : Yearwise Production Trend of Whiteshell from the Vembanad lake

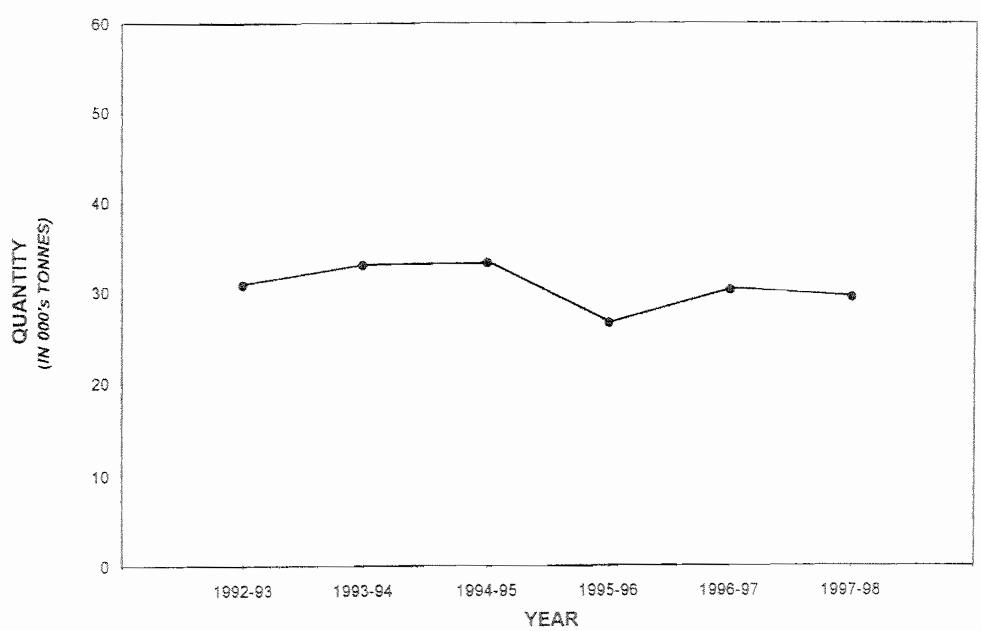

Fig. 2.4.3 : Yearwise Production Trend of Blackshell from the Vembanad lake

CARRYING CAPACITY BASED DEVELOPMENTAL PLANNING FOR GREATER KOCHI REGION

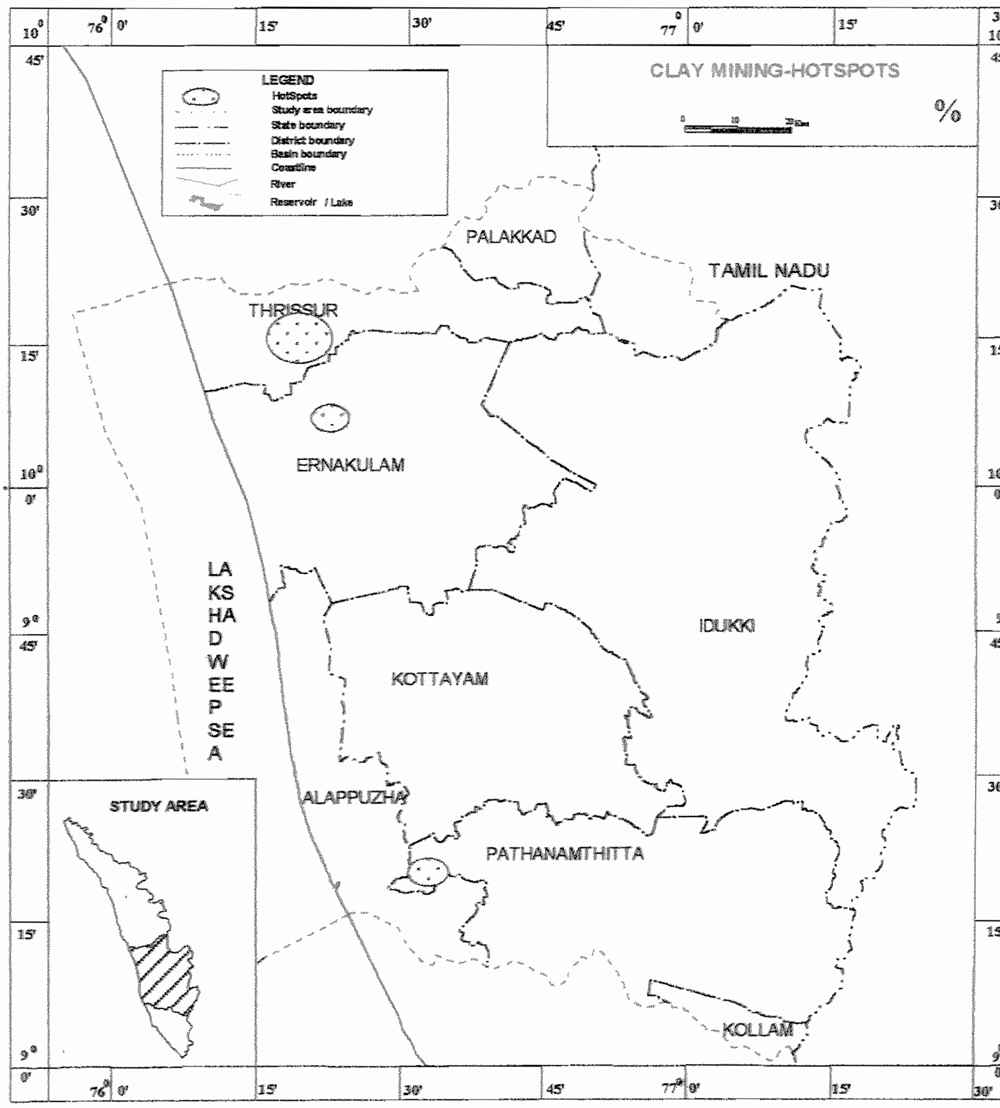

Fig. 2.4.4 : Major Clay Mining Areas of GKR

CARRYING CAPACITY BASED DEVELOPMENTAL PLANNING FOR GREATER KOCHI REGION

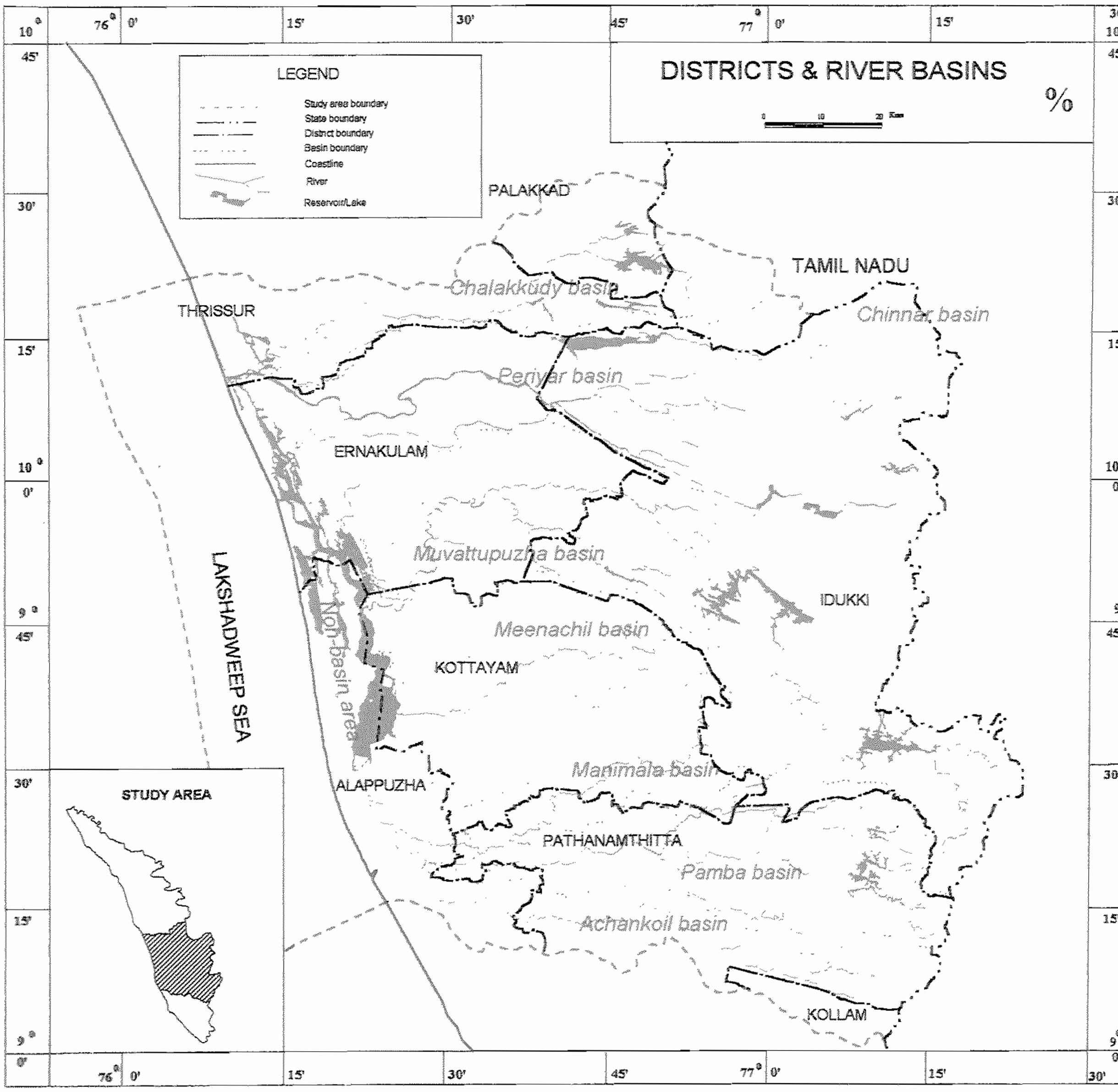

Fig. 2.4.5 : Rivers of GKR

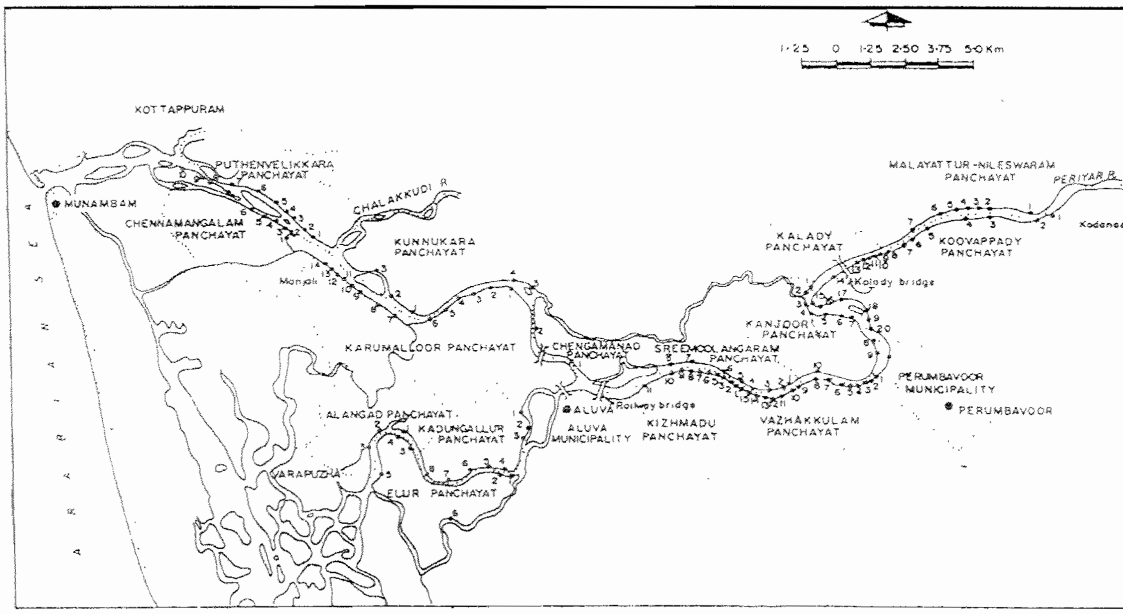

Fig. 2.4.6 : Various Sand Mining Locations (Kadavus) of the Periyar River

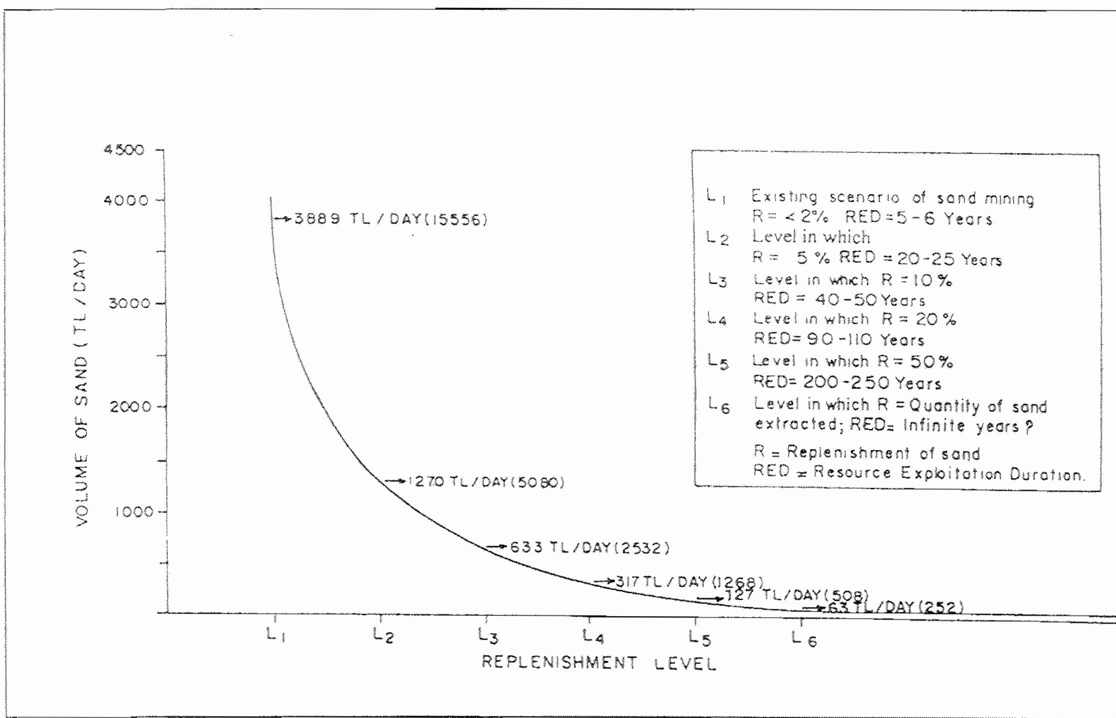

Fig. 2.4.7 : Relation between Existing Rate of Mining and Sustainable Mining (Condition in which Equals Natural Replenishment) : A Case of Periyar River (CESS, 1998-99)

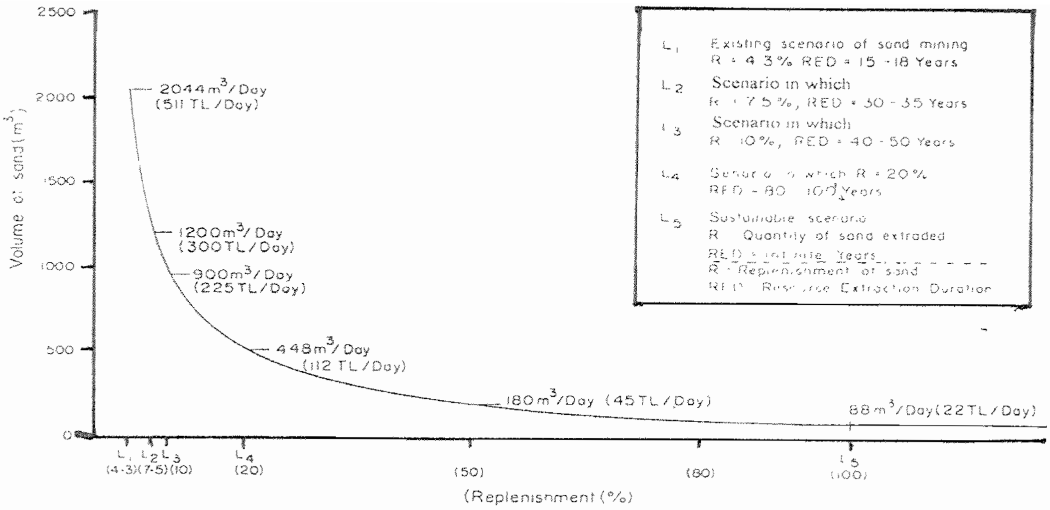

Fig 2.4.8 : Relation between Existing Rate of Mining and Sustainable Mining (Condition in which Equals Natural Replenishment) : A Case of Pamba River (CESS, 1998-99)

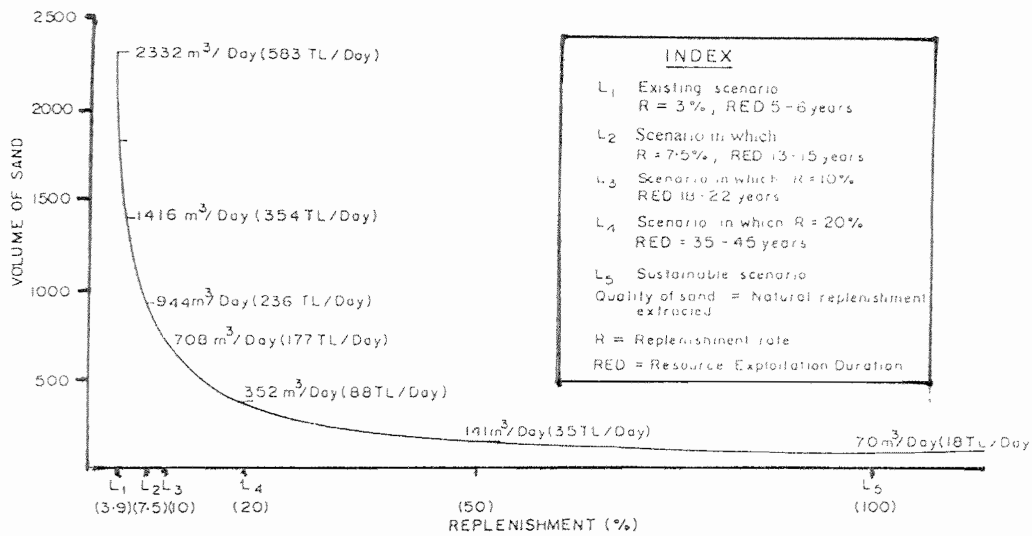

Fig. 2.4.9 : Relation between Existing Rate of Mining and Sustainable Mining (Condition in which Equals Natural Replenishment): A Case of Manimala River (CESS, 1999).

2.5 Fisheries

2.5.1 Salient Features of Fisheries Sector in Kerala

- Kerala contributes to about 29% of the total fish landing in India
- Kerala's Exclusive Economic Zone is about 2,07,200 km^2 of the sea, which is about 5.33 times the State's land area (38,863 km^2)
- Inland water spread available in the state is over 3.61 lakh ha (3610 km^2) and the backwaters laying parallel to the coast has a length of 325 km
- The inland water spreads consists of 2,42,600 ha of brackish water area, 3300 ha of fresh water ponds and tanks, 30000 ha of reservoirs and 85000 ha of rivers and streams
- 3.3 lakhs fishermen spread over 222 coastal villages depend on fisheries for livelyhood
- Pressure of population on the fisheries sector in Kerala is much higher than the national average
- Fish constitutes about 70% of the animal protein intake in Kerala
- Fish consumption in Kerala is about 4 times the national average
- Fish and fishery product account for one fourth of the total export earnings in Kerala
- Fisheries sector contributes about 2% of the state's income and is providing livelyhood for over 3% of population in Kerala
- Population density in the coastal area is 2176 per km^2 against the state density of 749 per km^2
- Fishermen population is spread not only along the coast but also along the banks of inland water bodies
- Even after the VIII[th] plan, the state could not make any advancement worth entioning in evolving appropriate management systems for the optional utilisation of its exclusive water spread, and conservation and sustenance of aquatic resources.

2.5.2 Fishery Resources of Vembanad Lake /Cochin Backwater

Of the total 6.24 lakh MT of the exploited fishery resources of the Kerala state during 1996-97, 54,000 MT were from the inland waters, which work out to be 8.65% of the total landing. The exploited fishery resources of the lake is constituted by 15 species of fishes belonging to 84 genera, 6 species of penaeid prawns, 4 species of palaemonid prawns and 3 species of crabs Fishes dominated the catches from July to December, especially in the southern sector of the lake The major species, which contribute more than 100 MT to the fishery resources, are summarised in **Table 2.5.1.** The distribution and abundance of fishes in the Vembanad lake is mainly dependant on the prevailing environmental conditions, the most important among them being salinity and annual floods.

The fishery resources of the lake is sustained either by migrant species from the adjoining sea, rivers or resident estuarine population. The 128 species of fishes and crustaceans constituting the fishery of the lake can thus be grouped as 68 marine migrant species (60 fish, 6 prawns, 2 crabs), 17 resident estuarine forms (15 fishes, 1 crab, 1 palaemonid), 17 resident common species (17 fishes), 16 oligohaline species (16 fishes) and 10 limnetic migrant forms (7 fish, 3 palaemonids). A month wise analysis of the contribution of migrants and residents in the catches from the lake revealed that resident common group showed its predominance in almost all months, followed by marine migrants and resident estuarine forms. The yield of the marine migrants is primarily correlated with the availability of the penaeid prawns.

The status of resident and migrants **(Table 2.5.2)** in the fishery resources of the two sectors when evaluated shows that on an average 57.4% the production from the northern sector was sustained by marine migrants while its contribution in the southern sector was less than 10%, indicating that the northern sector of the brackish water area maintained a more marine condition. During the monsoon when the salinity gets rapidly reduced, an abrupt reduction occurs in the diversity of marine migrants. While in the southern regions, the faunal characteristics and production remains more or less unchanged during all seasons. Ingression of marine migrants into the lake and the occurrence of resident estuarine species always depend on the salinity conditions, and exercise a profound role in the magnitude of production.

Aroor area offers an ideal nursery ground for penaeid prawns whereas in the harbour area the penaeid prawn landing is composed of both the migratory sub-adult prawn as well as the stock sustained by the lake. Moreover, these 2 areas have dual advantages, when compared to other regions of the lake. The availability of marine migrants is always high due to either the direct ingress from the sea or massive outward migration from the upper reaches.

The annual yield of the whole lake during 1988-89 was 7202.1 MT, consisting of penaeid prawns (4383.4 MT, 60.9%), fishes (2506.1 MT, 34.8%), crabs (181.0 MT, 2.5%) and palaemonids (131.6 MT, 1.8%). Of the total annual estimated landings for the whole lake (7202.1 MT), the northern portion accounted for 6698.1 MT (93%) and the region south of Thannirmukkom barrier for 504 MT (7%). During July to December, except September, fishes dominated the catches. **Table 2.5.3** presents the maximum yielding zones and their corresponding peak season for fishing in Vembanad Lake.

2.5.2.1 Fishing Gears and Methods in the Vembanad Lake

The existing fishing methods of the Vembanad Lake can be classified under 3 major categories, viz., net fishing (2) line fishing (3) miscellaneous methods. Some of the gears are very selective and are designed for a particular species whereas most of them take multi-species catches. Fishing gears fall under *five* major classes based on the mode of operation: Drag nets, Bag nets

Gill nets, Fixed (Stake) nets, Cast nets. Net fishing, line fishing and other miscellaneous methods are used for inland fishing.

Net fishing

- Seine Nets - Valli vala, Pattu kanni vala, Paithu vala, Neria vala, Manu vala and Peru vala, etc. come under this category **(Table 2.5.4)**.
- Gill Nets - Drift gill net and set gill nets come under this category
- Drag Nets - Cycle vala (a single type of drag net) is operated at Azheekode mouth during February to May.
- Falling Nets - This type of nets are used during high tide.
- Chinese dip net - It can be operated day and night and is found to be very common in northern sector of Vembanad Lake.
- Fixed bar nets (Onni vala, Kutti vala) - This net is set at the close of ebb tide period. The time of operation extend even to the early hours of the night or to the day break.

Line fishing

Commonly called Choondayum Kangoose, which is widely used in all the sectors throughout the year.

Miscellaneous methods

- In handpicking method (Karimeen Thappu), 6-8 men are involved with the help of a single canoe. The operation is during daytime. Long coir rope is stringed with tender coconut leaves and lashed in the water in a semicircular manner. The fishes are scared and bury in the mud and can be detected by skilled fishermen.
- Chnagala Payikkal – This method is used mainly for Prawn catching.
- Trapped fishing – Various types of fish traps and cages are sporadically used in the southern most region of the lake for catching *Etroplus suratensis*, lesser carps and catfishes.

The operation of different types of gears in the lake starts from post monsoon season and attains its peak during the pre monsoon season. During monsoon the catch seems to be very less. In February – May the conditions prevailing in the northern central sectors of the lake are very similar to that of the near sea and so most of the coastal marine fishes perform long term feeding migration in to the lake. Medium and small dug out canoes are the principal crafts employed for fishing in the Vembanad Lake.

Diversified fishing gears and methods are employed in Vembanad Lake and they are specially designed to suit the local conditions and the availability of different fishes in the lake. The gears operated in different sectors of the lake are different since the fishes inhabiting various parts of the lake are distinctly varied.

Moreover, it was noticed that different terminologies are used for the same type of nets in different sectors of the lake. The operation of different types of gears in the lake starts from post-monsoon season and attains its peak during the pre-monsoon season. During pre-monsoon, the hydrological conditions prevailing in the northern and central sectors of the lake vary similar to that of the adjacent sea and so most of the coastal marine fishes perform long term feeding migration into the lake.

The fishing methods of the lake are classified into 7 categories viz. stake nets, dip nets, gill nets, seine nets, cast nets, lines and indigenous methods. 4861 stake nets are found in the different fishing zones of the study area of which 77 are located in the upstream regions of thannnirmukhom band **(Table 2.5.5)**. Of the total number of stake nets used, 90% have a cod end mesh size of less than 3 mm and 47% of these are below 8 mm. Stake nets, are also illegally operated during the high tide periods by planting temporary stakes.

The peak period of' stake net operation in the harbour area is pre-monsoon season. Chinese dip nets are abundant in the lower reaches of the estuary, and are operated during the pre-monsoon and post monsoon months. 23 types of gill nets are operated in the lake. They are used mainly for catching penaeid prawns and *Etroplus suratensis* from the upstream regions. Among the 8 types of seines used, *Chemmeenkoru vala* is used extensively for catching *Metapenaeus dobsoni* during pre-monsoon. Five types of cast nets are operated in the lake, which are specifically designed for *Penaeus indicus*, palaemonids, pearl spot and other fishes. The cast net fishing in the areas south of Thannirmukkom bund commences by June, it gradually extends to other parts of the lake and lasts till November. 12 varieties of the other indigenous fishing methods are employed in the lake, which are more pronounced in the upstream regions.

A critical evaluation of the annual landing trends of the lake revealed that the zones nearer to the bar mouth are the most lucrative sectors. Highest values were encountered from harbour area and the rate of decrease in catch towards Aroor in the south was gradual. The fishery of Vaikom area showed more resemblance to that of Muhamma area than that of Murinjapuzha area. The drastic ecological changes encountered in the Vaikom area and its adjoining downstream areas due to man-made changes in the ecosystem, can possibly be taken as the reason for the observed depletion in resources. In Aroor-Vaikom area, the stake net operation is partly suspended during the pre-monsoon season. The closure of the barrier reduced the intensity of the tidal current in these regions and hence adversely affected the stake net fishery.

The differences noticed in the fishing activity of the various zones have a direct bearing on the dissimilarity observed in the resources. The stationary gears are almost entirely confined to the downstream regions of the lake, with maximum distribution in the harbour area. The variation in landings is given in **Table 2.5.6.** Blocking of the regions proximal to the sea with stationary gears is inimical to the lake fishery, because they either indiscriminately filter out the incoming prawns and fishes irrespective of their size, or destroy downstream migrating fishes such as *Mugil cephalus*, *Liza parsia*, *Chanos chanos* etc

Among the various types of gill nets used, *Narimeen vala*, *Poomeen vala* and *Chavala vala* which are selective gears used for catching *Lates calcarifer* and *Chanos chanos* during the 60s have disappeared from the lake by 1987. The complete absence of the above-mentioned gears is due to the depletion of *C. chanos* and *L. calcarifer*.

2.5.2.2 Fishery of Macrobrachium Rosenbergii

The exploited stock of *M. rosenbergii* from Vembanad lake was quantified as 112.9 tonnes in 1994-95 and 129.4 MT in 1995-96, with an annual average of 121.1 tonnes. Upstream part of the lake (south of Thannirmukkom bund) contributed 33.2% of the total exploited stock, whereas the downstream regions contributed 36.4%. The remaining part of the total catch was registered from riverine zones (30.2%). The fishery got intensified from June onwards and continued up to December. Peak landings could be recorded in September and October.

Among the fishing gears operated, cast net operation appears to be the principal method employed, contributing 80% of the exploited stock **(Table 2.5.7)**. Fixed gears like stake net and Chinese net contributed 6.5% and 3% while gill net and hand lines accounted for 4.9% and 3.5% respectively. Indigenous fishing gears and traps like *Ottal* (2.4%), *Padal* (1%) and spears like *Muppalli* (1%) were also employed in the fishery of *M. rosenbergii* in the lake. Cast net (*Pongu veechal* and *Thady veechal*), gill net; stake net, trap and hand lines are involved in the exploitation of ovigerous females from the lake.

While assessing the average annual landing of *M. rosenbergii*, it was found that the annual landing which was about 300 MT during 1957-62 suffered a heavy decline by 1992 to mere 39 MT. The depletion of the stock was mainly due to the impact of man made changes such as habitat alteration, reduction in the natural grow outs due to intensification of paddy cultivation and cropping patterns, reclamation of about 10,000 ha of the lake as paddy fields, over fishing and also the impacts of Thannirmukkom barrier causing pollutional hazards, physical obstruction in the migratory pattern of the berries and post larvae and the shifting of breeding ground from Kumarakom to 40 km downwards.

The seasonal fishery of *M. rosenbergii* in the downstream regions of the lake (Harbour- Vaikom) is predominantly contributed by the migratory stock, characterized by the dominance of males during the early periods of June & July while in later months of August-October by the females, presumably as a result of their differential breeding migration.

In 1967, only occasional landing of *M. rosenbergii* occurred in Chinese dip nets and stake nets, but by 1995, substantial landings of *M. rosenbergii* were obtained from September onwards which may be attributed to the availability of these prawns in downstream area as a result of the shifting of their breeding ground from Kumarakom to Perumbalam area in downstream part of the lake consequent to the commissioning of Thannirmukom salinity barrier.

A scrutiny of operation schedule of the barrier showed that till 1992, it was kept closed for 5-6 months, from Nov-Dec till the onset of south west monsoon every year. The juveniles trapped in downstream areas during this period may either migrate to Muvattupuzha River or succumb to unfavourable environmental conditions and predation in the lake and thereby leading to severe depletion of stock. However, the duration of closure of the barrier has been restricted to 3-4 months since 1993 and this could be attributed as one of the reasons for the increase in the exploited stock of *M. rosenbergii*.

2.5.2.3 Fishery of Penaeid Prawns

Among the 6 species, *M. dobsoni*, *M. monoceros* and *P. indicus* are available throughout the year, contributing to 48% of the total production from the lake. While *M. dobsoni* formed 74.2% of the total *penaeid* yield, *P. indicus* and *M. monoceros* contributed to 15% and 10% respectively.

Natural emigration of penaeid post larvae into Vembanad Lake occurs during high saline periods. Prior to the construction of Thannirmukkom barrier, salinity incursion was noticed up to Pulinkizh, about 90km away from Cochin and salinity in the upstream region reached up to 23% in Kumarakom-Muhamma region. However in the present conditions, the salinity of this region does not go beyond 6%. In the downstream region from the salinity barrier, in Vaikom salinity does not go beyond 10%. This may be either due to Periyar diversion into Muvattupuzha or commissioning of the Edamalayar hydroelectric project. Therefore, reduction in the nursery area has been affected due to the above reasons.

The post larvae, which arrive in the lake, can tolerate a wide range of salinity and hence invade the best feeding grounds, even those areas with moderate salinity regime, for rapid growth. As they grow bigger in size, they become more sensitive to low salinities and descend into more favourable downstream areas. The shrinkage of the nursery grounds has resulted in the overcrowding of juveniles in the lower reaches, viz., harbour area. These areas where shrimp juveniles become concentrated are subjected to heavy fishing pressure due to the indiscriminate operation of stake net.

It is obvious that the salt-water exclusion project is responsible for the remarkable difference in the yield pattern in the upstream and downstream regions of the lake. Further, the depletion of the resources in the upstream is not adequately compensated either by natural propagation of fresh water species or by ranching using fast growing fresh water fishes like the carps. Prior to the construction of the barrage, the fishery of this region was also sustained by *P. indicus, P. monodon, M. monoceros, Mugil cephalus, Liza macrolepis, Chanos* etc. But after the commissioning of the barrage, practically very little catch is obtained from the southern part. Some of the fresh water fishes, such as *Horabagrus brachysoma, Clarias betrachus and Ompok bimaculatus* are on the wane, and need protection and artificial propagation. Nevertheless, the production of *Etroplus suratensis* has increased in Kumarakom, during December to May when the barrier remains closed. Highest yield of pearl spot has been recorded from Kumarakom and Alappuzha during April. The stagnant oligohaline conditions prevalent in the upstream regions of the lake may be very congenial for the survival of this species.

2.5.2.4 Fishery of the Edible Crabs

The edible crabs contribute 4% of the exploited fishery resources of the Vembanad take, with an annual yield of 288.2 tonnes. *Scylla serrata*, *Portunus pelagicus* and *P. sanguinolentus* contribute the crab fishery of the Vembanad Lake. Based on their salinity tolerance, they exhibit different levels of spatial penetration. *S. serrata* is the most tolerant and abundant in regions of the lake with 18-32% salinity . From the harbour region upto Aroor, the fishery of this species is observed on a year round basis. From Perumbalam to Thannirmukkom bund, *S. serrata* was available only during the pre-monsoon season accompanying elevated saline condition. Of the two pelagic crabs, the occurrence of *P. sanguinolentus* was very much restricted to high saline areas, while *P. pelagicus* was more tolerant to low saline conditions. The penetration of the latter species was noticeable upto Vaikom, where the salinity was as low as 8.5%. The presence of the former species was noticed only during January to April, whereas the latter was available from January to June.

Fishing for *S. serrata* is done by line fishing or by indigenous methods like crab traps or hooked iron rods. In all net fishing methods, crabs are obtained as a bye-catch. The major portion of the fast moving Portunid crabs are obtained from cast and stake nets. A gear wise analysis of the crab landings revealed that 46.17% of the exploited resources came from line fishing. Landing by the two stationary gears viz., stake net and dip net, accounted for 29.5% and 5.9% respectively. Among the wandering gears gill nets accounted for 10.5%, cast nets 2.4%, seines 1.8% and the indigenous fishing methods contributed to 3.8%.

The annual production of edible crabs from the lake during 1988-89 is estimated to be 288.2 MT, constituting of *S. serrata* (255.5 MT), *P. pelagicus* (22.1 MT) and *P. sanguinolentus* (10.52 MT). The highest contribution is recorded from the harbour area. No crab fishing existed in the area south of Thannirmukkom bund. The absence may be due to the impact of the barrier.

In the case of *S. serrata*, the major peak was from Feb-June and a minor one was from Oct-Dec. The maximum availability of the pelagic crabs was noticed during Feb-March. A season-wise analysis revealed that pre-monsoon recorded the highest production (63.2%), followed by post-monsoon (20.6%) and the lowest during monsoon (16.1%)

2.5.2.5 Fishery of Edible Clams

The black clam Villorita cyprinoides exclusively sustains the Molluscan fishery of the lake. The presence of extensive clam beds was noticed in regions where the lake bottom is sandy indicating that the species avoid areas where a high percentage of silt is prevalent. The size range of the exploited black clams varies from 9-59 mm. The annual catch of live clam from July 88- June 89 is estimated at 7025.9 MT.

In the 1920s, the black clam was not nearly so abundant in the lake as the back water clam *Meritrix meritrix*, its habitat being restricted to regions usually far interior from the sea than that of the latter. However, over the years, a drastic change has occured in the distribution and abundance of these species. The zone wise black clam beds and their production are given in **Table 2.5.8.** Even though extensive beds of *Meritrix meritrix* and *M. casta* have been recorded in1970s from the northern parts of the lake in addition to *V. cyprinoides*, their distribution is now confined to very narrow stretches along the high saline barmouth area. The black clam has taken up their niche in the lake and the fishery of the lake is at present almost exclusively supported by this species. Even though *V. cyprinoides* can tolerate extreme salinity variations from 0.8-29.5%, the perennial abundance of this species and the fact that 80% of the clam beds was encountered only from areas where the prevailing bottom salinity was less than 13% are significant observations. Furthermore, populations of *V. cyprinoides* in the highest size groups are found in very low saline regions (0-2%) of the lower Kuttanad. These findings support the view that *V. cyprinoides* is purely a fresh water species and its presence in brackishwater conditions, indicates a marked change in its habits and a non-genetic adaptation for changed saline conditions.

5.5% of the total area of the northern sector supports a regular live clam fishery in contrast to 10.2% of the southern sector. The catch per clam bed area is 5392.5 kg/ha in northern sector and 3786.4 kg/ha in the southern sector. The marginally high values recorded from the downstream regions are due to the higher values obtained in Murinjapuzha. The commissioning of the Idukki hydropower project provided perennial flow of fresh water into the Muvattupuzha river which discharges into this region of the lake. This has resulted in optimizing the salinity requirements (0.5-13%) of *V. cyprinoids*, thus providing a conductive environment, for its growth and reproduction even during the pre-monsoon season.

The commissioning of Thannirmukkom barrier has brought about no marked adverse on the black clam resources in the southern part (Thannirmukkom- Alleppey) of the lake. The decline in the catch in the northern sector **(Table 2.5.9)** is due to increased fishing pressures and the resultant massive removal of the under sized clams in the size group 10-14 mm, the indiscriminate fishing practices using toothed iron rakes for combing the clam bed and disturbing spat settlement, pollution hazards from coconut husk retting grounds and industries.

Marketed Quantity of Fin and Shell Fish Resources

Among the 110 sp. of fishes marketed, *Etroplus suratensis* constituted the maximum **(Table 2.5.10)**, so is the case of the fresh water prawn *Macrobrachium idella*. Of the exploited fishery resources of the lake, 80% of the fishes arrive in the markets in contrast to 26% of the penaeids and 42.6% of crabs. A species level assessment reveals that while only 20.1% of *P. indicus* reaches the market, 26% each of M.dobsini and *M.monoceros* are available in the markets. In the case of *M. rosenbergii* and *S. serrata*, 34.5 and 38.7% respectively are the marketable surplus production. The difference between the estimates of the exploited resources and the marketable surplus is accounted for by the quantity that is being let either into processing plants or directly to hotels, households etc

Important black clam beds of Northern sector and Zonewise Clam Production in Vembanad Lake are given in **Table 2.5.11** whereas the same in Southern Sector are given in **Table 2.5.12**. Annual yield of commercially important fishes and crustaceans in different zones in the Vembanad Lake given in **Table 2.5.13** and **2.5.14** presents the estimated production from Pokkali fields and Vembanad Lake.

2.5.3 Fishery Resources of Coastal Waters

Major resource of the area is the fishery resource. The average fish landings from the near shore waters of Kochi both by mechanized and non mechanized fishing vessels form about 8% of the total fish landings of Kerala Fish landing data for Alappuzha and Ernakulam Districts are given in **Table 2.5.15.** From the long term data, there is an indication that the catch in Ernakulam district is more than that of Alappuzha district. During recent years. the quantity of marine exports has nearly doubled that of during the seventies and eighties. Nearly 20% of the total catch is being exported leaving the remaining part for the domestic consumption.

The fish landing in the mudbank region is very high. The data for the last 10 years indicate that during the period June to August, the annual catch is about 31,800 MT and that for the non-mudbank region it is about 26,600 MT. The catch in the mudbank region includes oil sardine, other sardines, sciaenids. leiognaths and penaeid prawns. The penaeid prawns are highly observed during the southwest monsoon months of June and July.

Some of the commercially important fishes and prawns have an estuarine phase in their life cycle (eg. M.dobsoni and P.stylifera). Juveniles and larvae migrate into the estuary immediately after monsoon as the system becomes more saline. They return to the sea as adults and breed in the nearshore region (may be during monsoon). Thus estuaries form the nursery grounds. The marine migrants to the estuaries constitute about 60 species of fishes, 6 species of prawns and 2 species of crabs. These contribute to about 3900 MT per annum to the fisheries in the backwater system.

2.5.3.1 Longterm Trends in the Marine Fish Production

The longterm trend in marine fish production for the period 1951-1996 for Kerala and India as a whole indicated increasing production **(Fig. 2.5.1)**. The percentage growth and the percentage share of Kerala are also presented in **Fig. 2.5.1**.

Marine fish production in India shows an increasing trend from 1950 to 1996. An increasing trend is noticed in Kerala also. But the average rate of growth in Kerala appears to be lower in Kerala than the all India average. The percentage share of Kerala was almost 40% during the sixties, but started decreasing around 1974-75. Thus Kerala has lost its dominant position in the marine fish production. The fish catch is almost stagnant since 1991. Similar pattern is observed in Alappuzha and Ernakulam districts also **(Fig. 2.5.2)**.

On an average 47.4 % of the total catch was by mechanised units and 47% by motorised country crafts. Trawl gear contribute about 46.2% and ring seine about 34% only. Traditional (non-motorised) sector contributed only 5%. Though these figures are for Kerala, as a whole, these are applicable to the study area also. An exception is perhaps, the handtrawls, which contribute about 8000 MT on an average in Alappuzha and Ernakulam region.

Fluctuations in a few major fisheries in Ernakulam and Alappuzha districts are given in **Figs. 2.5.3 to 2.5.6**. In general, oil sardines mackerels and elasmobranchs are more in Alappuzha than in Ernakulam, whereas prawn landing is more in Ernakulam than Alappuzha. This may perhaps be due to the existence of two fishery harbours only in Ernakulam districts at Kochi (Thoppumpady) and at Munambam where operational facilities for mechanised boats exist whereas in Alappuzha district there is no fishery harbour. The landings recorded in Alappuzha district are mainly from traditional fishery (motorised and non-motorised). There are wide fluctuations in the annual catch of mackerel (**Fig. 2.5.5**) and prawns **(Fig. 2.5.6)** in both the districts. One interesting feature noticed is the drop in the catch of elasmobranchs (skates rays, sharks, etc.) in both the districts since 1989 **(Fig. 2.5.3)**.

Fisheries potential in Kerala is presented in **Tables 2.5.16** to **2.5.18**. Fish landings achieved by using various crafts and gears are summarised in **Tables 2.5.19** to **2.5.24**.

2.5.3.2 Fishing Crafts

Mechanisation of fishing crafts appears to be increasing over the years. In Alappuzha district, the number of mechanised boats is not showing any increase over the years, whereas in Ernakulam district there is a steady increase in the number of mechanised boats **(Table 2.5.25)**. This may be due to the reason that there is no fishing harbour in Alappuzha district whereas in Ernakulam district two fishing harbours exist at Kochi and Munambam. Mechanised fishing trawlers are used for fishing in the coastal waters beyond 5 km from the shore.

In the nearshore area, either motorised country crafts mainly with outboard engines or traditional non-motorised country crafts are used for fishing. Over the years, motorisation of country crafts seems to be increasing with some support from the Government. In Alappuzha and Ernakulam districts, the country crafts used are mainly plank built boats, whereas in other parts of Kerala dugout canoes and catamarans are also used. This pattern of using country crafts varies from place to place. Although the mechanised boats are more in Ernakulam District, the number of country crafts is much less in Ernakulam district than in Alappuzha district. Data on motorised and non-motorised country crafts in Alappuzha and Ernakulam districts are given in **Table 2.5.26**. The number of non-motorised country crafts is more in Ernakulam district as compared to Alappuzha district. The details of country crafts in whole Kerala during 1987 is presented in **Tables 2.5.27** and **2.5.28**.

2.5.3.3 Fishing Gears

A variety of fishing gears are being used for catching various types of fishes. Most commonly used gears are gill net, cast net and trawl net. The type of fishing gear used is important in respect of maintaining the fish stock. Distribution of fishing gears used in Alappuzha and Ernakulam districts is given in **Table 2.5.29**. Details of fishing activities in Ernakulam district are given in **Table 2.5.30.** Details of Seine nets and Gill nets operated are given in **Tables 2.5.31** & **2.5.32.** Distribution of licensed fishing nets and year-wise details of nets are presented in **Tables 2.5.33** & **2.5.34**.

2.5.3.4 Species Composition of Fish Catches

Out of the total fish catch, the pelagic and the rest form 64% by the demersal fishes. Among the pelagic fishes landed, oil sardine *Sardinella longiceps*, ranked first of the total marine fishes caught from Kochi. Peak fishery is from November to December. The mackerel, *Rastrelliger kanagurta*, formed the next important pelagic fish. Species like *Escualosa thoracata and Stolephorus commersonii* are also caught in abundance Silver bellies belonging to the species *Leiognathus splendens*, L. equlus, *L. dussumieri* and *Gazza* sp. formed the important fishery. Sciaenids contributes about 2% of the total catch and Johnius dussumeri, Otolithus, Cuvieri, and Johnius carutta represent the catch. Other important fishes landed include *Lactarius* lactarius, ribbonfishes like *Lipturus Savala* are caught from here. Fishes like *Thrissocles* sp, *Sillago Sihama*, *Mene maculata*, *Nematalosa* sp., *Pomaclassis* sp *Hemirhamphus* sp, Ambassis *commersonii* etc., are also caught occasionally.

The family Nemipteridae, which is chiefly represented by Nemipterus delugoc, N. Japonicus and N.Meso-prion represents demersal fishes. Dominant species of the family Serranidae is represented by *Epinephelus diacanthus*. Catfishes belonging to the family Tachysuridae contribute 3% of the total marine catch and are chiefly represented by *Tachysurus* Dussumieri, *T. serratus*, and *T.tenuispinis*, lizardfishes, *Sourida tumubil*, S. Undosquamis are also caught from this area. Flat fishes, which form the fishery, are *Cynoglossus macrostomus* and *Psettodes erumei*. Sharks are represented by *Scoliodon laticaudus*, *Carcharias melanopterus*, *Rhizoprinoclon sp. Sphyraena zygaena* etc., Ray like *Aetocatus narinari* (eagle ray), *Casyatis uarnak* (bat ray), Narcinetimlei, Astrapedipterygia (electronic ray) are also caught from here.

In addition to fishes, many species of prawns, crabs and molluscs also contribute to the fishery activity substantially. Prawn fishery ranks second in the total marine landings. Some of the commercially important species are *Penaeus indicus, P.monodon, Metapenaeus dobsoni, M. Monoceros, M. Affinis,* and *Parapenaeopsis stylifera*. Commonly occurring crabs, which formed the fishery, are *Neptunus sanginolentus, N.Pelagicus, Charybdaea cruciata* and *C.edwardsi*. Among the Cuttle fishes the common forms caught are *Sepia aculata*, *S.Pharonis* and *Sepiella inermis*. Only one species of squid *Loligo buvaceli* is caught from this region.

In the nearshore region, the fishing activity is carried out by traditional methods and the catch mostly constituted of mullets (Mugil sp), milkfishes (Chanos sp), anchovies, flat fishes, sharks and rays, crabs, prawns etc. Fish landings at Kochi and Alappuzha vary in composition. Fish landings at Kochi is rich in number of species whereas in Alappuzha fishes caught were represented only by 25% of the major groups caught at Kochi.

A list of various groups/species of fishes landed in Alappuzha and Ernakulam districts in 1995 is given in **Table 2.5.35.**

2.5.3.5 Trend in the Export of Marine Products

Export of marine products from the country has increased over the years. In Ernakulam district the exports increased from 30782 MT in 1973 to 78682 MT in 1995 **(Table 2.5.36)**. The number of exporters of marine products in Ernakulam and Alappuzha Districts are 82 & 34, respectively. The total number of marine product exporters is 614 in India (Indian Marine Products Exporter s Directory, MPEDA, 1998). The summary of quantity & value of marine products exported in the period of 1994-1997 is given in **Tables 2.5.37** to **2.5.40.**

2.5.3.6 Socio-economic Aspects

State Domestic Product (SDP) increased by 69% from 1980-81 to 1994-95. During this period, the primary sector product (PSP) increased only by 39% and the Fishery Sector Product (FSP) increased only by 29% **(Table 2.5.41)** During the same period increase in the state population was 20.6% whereas the fishing community increased by 27.3% indicating growth of fishermen population faster than the state average. The state average of per capita income increased by 40% whereas the increase in the income per fisherman was nil.

District wise distribution of fishermen are summarised in **Tables 2.5.42** & **2.5.43.** The collection of data about people around the Vembanad Lake, their income, types of fishing gears used by them and their occupations are given in **Tables 2.5.44** to **2.5.47.**

Table 2.5.1

Important Fin-Fish Species Constituting the Fisheries and their Percentage Contribution

Group	% Contribution	Major Species Contributing more than 100 MT to the Fishery
Croakers	8.3	
Glassy perchlets	4.7	*Ambassis gymnocephalus*
Cat fishes	4.3	*Tachysurus maculates, T.subrostratus*
Pearl spot	4.5	*Etroplus suratensis*
Mullets	2.8	*Liza parsia*
Estuarine sprat	2.3	
Gerreids	1.6	*Gerres filamentosus*
Half beaks	1.2	

Table 2.5.2

Production Status of Resident and Migrant Species

Group	Species	Number	Production/ Annum (MT)	Area of Dominant Catch
Marine migrants	Fishes Prawns Crabs	60 6 2	3899	Aroor, Kumbalam, Vaikom
Resident estuarine species	Fishes	17	1389	Harbour, Aroor, Kumbalam, Vaikom
Resident common species	Fishes Crab Palaemonid Prawn	15 1 1	117	Vaikom, Thannirmukkom, Muhamma, Alapuzha
Oligohaline species	Fishes	16	165.5	Thannirmukkom, Muhamma, Kumarakom, Alapuzha
Limnetic migrants	Fishes Palaemonid prawns	7 3	122.7	Thannirmukkom, Muhamma, Kumarakom, Alapuzha

Table 2.5.3

Maximum Yielding Zones and Peak Fishery Seasons in the Vembanad Lake

Group	Major Species	Max.Yielding Zone/Period	Min. Yielding Zone	Peak Fishery Season
Fishes		Murinjapuzha-Alappuzha, July-Dec.		Monsoon
Penaeids	*M.dobsoni* (74.2%) *M.monoceros* (10.3%), *P.indicus* (14.9%)	Harbour and Aroor, Jan-June	Muhamma-Alappuzha	Pre-monsoon
Palaemonids	*M.rosenbergii, M.idella*	Murinjapuzha-Thannirmukkom. July-Oct	Alappuzha	Monsoon
Crabs	*S. serrata*	Harbour-Kumbalam, Feb- June(major) Oct-Dec(minor)	Thannir-mukkom Alappuzha	Pre-monsoon, Post-monsoon (Moderate)

Table 2.5.4

Fishing Gear and Fishing Methods in Vembanad Lake

Seine Nets	Gill Nets		Fixed Nets		Line Fishing	Other Nets	Miscell-aneous Methods
Valli Vala	Set gill net	Drift gill net	Dip or	Fixed	Hand Line	Cycle vala	Hand Picking
Pattukanni vala	Koori vala	Loop vala	Lift net	Bag net	Long line with	Falling net	Changla Payikkal
Thirutha vala		Ozhukku vala	Chineese	Oonni vala	Baited hook	(Vessur Vala)	Trap Fishing
Paithu vala		Murasu vala	Dip net				
Neria vala		Karimeen vala	(Kamba vala) or				
Chemmeen vala			(Cheena Vala)				
Mandu vala							

Table 2.5.5

Number of Stationary Gears Operated in Different Fishing Zones

Zone	Stake Nets	Dip Nets
Harbour	1080	61
Aroor	1300	498
Perumbalam	540	376
Murinjapuzha	936	329
Ithipuzha	645	88
Vaikom	276	70
Thannirmukkom	77	6
Kumarakom	-	-
Aryad	7	-
Alappuzha	-	-

Table 2.5.6

Variation in the Landings of Different Types of Fishing Gear

Gear	% Contribution of Total Catch	Period of Activity	Area of Operation
Stake nets	53.1(3827.5 MT)	All months (max. Jan.)	Harbour area
Dip nets	19.4 (1393.3 MT)	Aug-April (max. Jan-April)	Harbour area, Aroor Kumbalam, Vaikom
Gill nets	10.2 (730 MT)	March-April	Harbour (penaeids), Aroor (Pearl spot)
Seines	9.7(697.1 MT)	Jan-May	Throughout the lake
Cast nets	3.5 (251.2 MT)	Feb-May June- Nov.	Harbour-Vaikom Thannirmukkom-Alappuzha
Line fishing	2.5 (183 MT)	Jan & Nov.	Aroor, Harbour
Other indigenous methods	1.7 (119.4 MT)	March-April	Upstream regions

Table 2.5.7

Percentage Exploitation of *M.Rosenbergii* in Vembanad Lake by Various Gears and Methods

Gears Used	Share (%)	Month & Area of Operation	Size of Prawns Caught (mm)
Cast net Ponguveechal	71.3	June onwards throughout the lake but restricted in upstream areas from Feb-May	>120
Kotikuthi veechal	5.2	April-October, Upstream	60-260
Thady veechal	2.13	July-mid Nov, Northwest end of Perumbalam island	160-300
Stake net	6.5	Sept-January, Downstream area	<160
Gill net-Neetu vala	4.9	-do-	Large
Hand line	3.5	-do-	<160
Chinese net	3	-do-	Large
Trap-Ottal	2.4	June onwards, Upstream area	<160

Table 2.5.8

Zone Wise Black Clam Beds Production

Zone	Area (ha)	Exploited Quantity (MT)	Month of Highest Landings	Size (mm)
Harbour	51	284	Sept.	30-34
Aroor	57	739	Jan.	15-19
Perumbalam	30	476	Nov.	10-14
Murinjapuzha	290	1561	May	15-19, 20-24, 25-29
Vaikom	255	634	March, May, Oct.	20-24
Thannirmukkom	165	583	Nov-Dec	20-24
Kumarakom	275	978	-do-	20-24
Aryad	440	1772	July-Dec.	30-34

Source : Secondary data collected by CUSAT

Table 2.5.9

Live Clam Resources of the Lake : 1968-1996

Year	Catch (MT)
1968	26,858
1979-1983	21,490
1984	13,804
1988-1989	7203

Table 2.5.10

Marketed Fishery Resources of the Vembanad Lake with the Market Prices of Important Species

Species	Marketed Quantity (MT)	Average Price (Rs/kg)
A. dayi	33.7	8
A. gymnocephalus	9.19	6
Amblypharyngnodan mola	21.2	7
C.ignobilis	13.4	16
Chanos chanos	4.94	21
Daysciaena albida	16.3	23
Ehirava fluviatilis	19.8	7
Etroplus suratensis	45.9	26
Gerres filamentosus	40.9	13
Glossogobius giuris	61.6	14
Hyporhamphus limbatus	18.5	9
H. xanthopterus	52.4	13
Lates calcarifer	12.0	21
Leioganthus brevirostris	9.0	7
L. equulus	8.4	8
Liza macrolepis	19.1	22
L. parsia	78.7	22
Megalops cyprinoids	52.1	17
Mugil cephalus	34.4	27
Mystus gulio	12.4	9
Puntius filamentosus	18.8	8
P. sarana	59.6	9
Scatophagus argus	7.8	15
Sillago sihama	38.0	20
Tachysurus maculates	106.6	11
T. subrostratus	94.8	10
Wallago attu	14.2	18
Metapenaeus dobsoni	69.4	8
M. monoceros	99.4	18
P.indicus	104.7	28
P.monodon	11.7	46
Macrobrachium idella	258.5	12
M.rosenbergii	13.6	70
Scylla serrata	90.5	10
Villorita cyprinoids var. cochinensis	348.1	5

Table 2.5.11

Important Black Clam Beds of Northern Sector and Zonewise Clam Production in Vembanad Lake

Name of the Bed (Ref. Point)	Area (ha)	Mean Depth (m)	Exploited Quantity (MT)
1. Veluthully Kayal	20.0	3.00	
2. Kumbalangi	17.5	2.70	
3. Ezhupunna	8.0	3.00	
4. Pandathu	7.5	3.60	
Total	**53.3**		**284.33**
1.Thaikkattusserry	28.0	3.50	
2.Eramelloor	12.0	4.00	
3.Aroor	17.0	3.00	
Total	**57.0**		**739.05**
1. Perumbalam north	30.0	2.00	475.74
1. Perumbalam South	8.0	2.8	
2. Nediathuruthu	32.0	3.5	
3. Chempu Kayal	110.0	2.75	
4. Poochakkal	12.0	2.00	
5. Manappuram	60.0	2.40	
6. Anjuthuruthu	28.0	2.50	
7. Murinjapuzha	40.0	3.75	
Total	**290.0**		**1560.86**
1. Pallipuram Thanneermukkom	120.0	2.20	
2. Vaikom Jetty	80.0	3.45	
3. Vaikom electric tower	55.0	3.5	
Total	**255.0**		**633.85**
Grand Total	**685.00**		**3963.83**

Source : Secondary data collected by CUSAT

Table 2.5.12

Important Black Clam Beds of Southern Sector and Zonewise Clam Production in the Vembanad Lake

Name of the bed (Ref. Point)	Area (ha)	Mean Depth (m)	Exploited Quantity (MT)
1 Vechoor	55	1.75	
2. Pathiramanal north	42	2.25	
3. Kayıppuram Kannankara	36	2 30	
4. Thanneermukkom	4	4.00	
5. Puthenkayal	28		
Total	165		582.71
1. Muhamma	210	2.15	
2. Kumarakom	15	2.35	
3. Kavanathhinkara	50	2 50	
Total	275		977.68
1. Aryad	440	2.0	1771.63
Grand Total	880		3332.02

Table 2.5.13

Annual Yield of Commercially Important Fishes and Crustaceans in Different Zones in the Vembanad Lake

Sr. No.	Species	Catch / ha/ year (Kg)	
		North Sector	South Sector
	Fishes		
1.	*Daysciaena albida*	53.22	0.15
2.	*Ameassis gymnocephalus*	39.93	0.12
3.	*Etroplus sqratensis*	14.37	17.51
4.	*Tachysurus maculates*	23.62	0.13
5.	*Tachysurus subrostratus*	12.85	1.52
6.	*Ehirava fluviatilis*	13.03	1.05
7.	*Gerres filamentosus*	8.11	0.15
8.	*Liza parsia*	10.13	0.34
9.	*Mystus (m) gulio*	8.60	0.24
10.	*Hyporhamphus (h) xanthopterus*	0.69	4.27
11	*Ambassis commersoni*	5.56	0.00
12	*Ambassis dayi*	1.97	3.08
13.	*Leiognathus brevirostris*	4.41	0.03
14.	*Sillago sihama*	4.46	0.00
15	*Mugil cephalus*	4.39	0.16
16.	*Amblypharyingodon mola*	0.05	5.24
17.	*Glossogobius giuris*	3.35	0.00
18.	*Megalops cyprinoids*	3.20	0.89
19.	*Caranx ignobilis*	3.89	0.13
20.	*Leiognathus equulus*	2.48	0.01
21.	*Liza macrolepis*	2.73	0.00
	Crustaceans		
1.	*Metapenaeus dobsoni*	202.50	5.52
2.	*Penaeus indicus*	42.96	0.00
3	*Metapenaeus monoceros*	28.21	0.16
4.	*Penaeus monodon*	0.97	0.00
5.	*Penaeus semisulcatus*	0.81	0.00
6.	*Macrobrachium idella*	5.73	2.22
7.	*Macrobrachium rosenebergii*	2.53	1.75
8.	*Scylla serrata*	23.96	0.19

Source : Secondary data collected by CUSAT

Table 2.5.14

Pokkali Fields and the Estimated Production in the Vembanad Lake

Region	Total Area (ha)	Area Surveyed (ha)	Mean Production /Season/ha & Range (kg)	Total Production (MT)
Thevara-Maradu Valanthakad	396	99.98	774 (406-1800)	306.5
Madavana-Panangad Aroor	158	77.53	859 (333-1463)	135.7
Thevara – EdaKochi	210	12.00	792 (310-1410)	166.3
EdaKochi-Kumbalangi Veluthully	900	205.19	805 (173-1350)	724.5
Arookutty-Kakkathuruthu	168	67.22	739 (225-1050)	124.2
Kakkathuruthu-Sherthalai	260	95.28	408 (170-877)	105.8
Panangad-South Parur	72	12.00	694 (420-900)	50.0
Total	**2164**	**569.20**	**745 (170-1800)**	**1613.0**

Source : Secondary data collected by CUSAT

Table 2.5.15

Annual Marine Fish Landing in Alappuzha and Ernakulam Districts (MT)

Year	Alappuzha	Ernakulam	Year	Alappuzha	Ernakulam
1980	24306	37863	1989	68284	79871
1981	38127	34192	1990	117358	100334
1982	34076	35603	1991	161120	85358
1983	37254	37365	1992	49639	83338
1984	54962	49351	1993	44585	103486
1985	43928	56690	1994	75768	101592
1986	44580	51773	1995	56805	68742
1987	35949	37602	1996	72340	92024
1988	58300	55863	1997	107524	62340

Table 2.5.16

Total Area and Production of Polders for Trapping and Retaining of Fishes in the Vembanad Lake

Name of Polder	Area (ha)	Mean Production & Ranges (kg/day)	Total Monthly Production (MT)
Mathikayal	900	800 (400-1200)	24
Marthandam	300	212 (70-400)	6.38
Manimangalam	300	287 (160-680)	8.62
C-block	500	220 (90-360)	6.60
Chithira	375	175 (60-270)	5.25
H-block	1500	475 (140-700)	14.25
Total	3875	**2169 (920 – 3610)**	65.10

Source : Secondary data collected by CUSAT

Table 2.5.17

Marine Fishery Potential of Kerala (MT)

a)

Fish	Fish Potential at Depth Zone		
	0 – 50 m	50–200 m	Total
Pelagic	263500	284300	547800
Demersal	129000	175500	304500
Total	392500	459800	852300
Sustainable yield	235500	275800	511380

Source: Kalawar committee

b)

Fish	Fish Potential at Depth Zone			
	0 – 50 m	50 – 100 m	100 – 200 m	Total
Pelagic	191520	102480	34720	328720
Demersal	125160	35392	16296	176848
Total	316680	137872	51016	505568
Sustainable yield	190008	82723	30610	303341

Marine fish catch in Kerala - 5,72,000 MT

Source : FSI

Table 2.5.18

Potential of Demersal Fishery Resources of Kerala

Item	Fish Potential at Depth Zone			
	0 – 20 m	20 – 80 m	80 – 200 m	Total
Area (m^2)	5057	37935	10224	39773
Potential (MT)	37935	90432	17046	145413
Sustainable Yield (at 60%)(MT)	22761	54259	10224	87244

Table 2.5.19

Pelagic, Dermersal and Total Annual Marine Fish Landings in Kerala during 1974 - 88

Year	Annual Marine Fish Landings (MT)		
	Pelagic	Dermersal	Total
1974	226	194	420
1975	216	205	421
1976	248	83	331
1977	222	123	345
1978	263	110	373
1979	228	103	331
1980	147	132	279
1981	203	71	274
1982	225	100	325
1983	274	112	386
1984	253	140	393
1985	206	120	326
1986	218	165	383
1987	153	150	303
1988	292	177	469

Source: CMFRI

Table 2.5.20

Important Resource wise Annual Marine Fish Landings in Kerala : 1974-88

Year	Annual Fish Landing (MT)						
	Oil sardine	Mackeral	Stolephorus	Tunnies	P.Prawns	Cat fishes	Cephalopods
1974	102135	10335	19463	5927	60829	33526	2175
1975	97183	14930	11432	5845	77207	32603	3342
1976	123937	19978	9987	12880	34478	12743	872
1977	117356	19968	10105	6705	40150	7947	4973
1978	119937	25917	21203	6548	45934	9125	6516
1979	116834	18585	6552	15391	29522	11328	2976
1980	69667	18474	7772	10611	52633	13936	4244
1981	146986	16200	4293	5509	22268	9562	2376
1982	143215	10717	13597	7534	26708	9532	3536
1983	154879	12683	55042	5846	29754	15332	1730
1984	147139	11746	41505	6488	35529	11582	5422
1985	79237	18115	36235	9857	26685	5184	8308
1986	40595	21881	27158	14830	37098	8589	15017
1987	44717	10063	16599	10611	52866	4660	7535
1988	60618	43938	45994	12913	67498	9960	15155

Source: CMFRI

Table 2.5.21

Contribution of Traditional Non Motorised and Motorised Sectors in the Marine Fish Landings in Kerala : 1980-88

Year	Annual Fish Landings (MT)			
	Traditional		Mechanised	Total
	Non-motorised	Motorised		
1980	144238	1621	133161	279020
1981	178074	22848	73056	273978
1982	177127	63050	85190	325367
1983	188130	99082	98070	385282
1984	129941	133313	129641	392985
1985	77127	120767	127835	325729
1986	66722	186540	129526	382788
1987	39900	112208	151178	303286
1988	33220	234178	201309	468807

*Excluding large vessels' landing which is less than 500 MT
Source: CMFRI

Table 2.5.22

Resource-wise Distribution in the Ring Seine Landings in Kerala : 1986-88

Resource	Ring Seine Landings (MT)		
	1986	1987	1988
Shark	-	-	2
Cat Fish	274	758	691
Oil Sardines	2372	15471	30835
Other sardine	620	1478	6008
Anchovies	5846	-	4478
Perches	278	1119	688
Croakers	134	335	302
Ribbon Fish	5	1	1
Carangids	11103	3245	12783
Pomfrets	-	405	-
Mackeral	1015	2916	20651
Seerfish		227	23
Tunnies	12	256	236
Penaied prawns	168	2351	1274
Others	676	2987	3917
Total	**22503**	**31549**	**81886**

Source: CMFRI

Table 2.5.23

Growth Trend in the Number of Ring Seines in Kerala : 1986-89

Sr. No.	Name of District	Number of Ring Seines as on		
		December 1986	Septmber 1988	March 1989
1	Trivandrum	1	1	1
2	Quilon	119	126	142
3	Alappuzha	98	1172	1005
4	Ernakulam	120	175	450
5	Trichur	138	171	238
6	Malappuram	15	29	180
7	Calicut	49	51	116
8	Cannanore	16	16	32
9	Kasargod	192	192	215
	Total	748	1933	2379

Source: Matsyafed/Dept. of Fisheries

Table 2.5.24

Resource-wise Landings of Mini Trawling in Kerala : 1988

Resource	Landings (MT)
Anchovies	1
Croakers	618
Carangids	1
Mackeral	2
Penaeid prawns	4662
Others	1088
Total	**6372**

Source: CMFRI

Table 2.5.25

Mechanised Crafts in Alappuzha and Ernakulam Districts

District	1982	1983	1984	1985	1986	1987	1988	1989	1990
Alappuzha	218	218	218	235	242	242	242	244	244
Ernakulam	836	836	836	1132	1175	1241	1241	1241	1241

Table 2.5.26

Distribution of Country Crafts in Alappuzha and Ernakulam Districts

District	Country Crafts (Motorised)	Plank built Boats (Non-Motorised)
Alappuzha	2163	1473
Ernakulam	465	1740
Total	**2628**	**3213**

Table 2.5.27

Details of Country Crafts in Kerala : 1987

Type of Craft	Motorised	Non-Motorised	Total
Plank built Canoe	5869	7023	12892
Dug-out Canoe	3496	9165	12661
Catamaran	235	9949	10184
Plywood Canoe	57	...	57
Total	9657	26137	35794

Source: Department of Fisheries - 1987

Table 2.5.28

Details of Motorised (OBM fitted) Country Crafts in Kerala : 1989

Sr. No.	District	No. of Motorised Crafts Registered	No. of OBMs Issued through Matsyafed	No. of Kerosene Permits given to OBMs	No. of Registered Non Motorised Country Crafts
1	Trivandrum	918	324	1178	4517
2	Quilon	1350	42	1350	2206
3	Alappuzha	2551	105	1240	1508
4	Ernakulam	368	90	500	1721
5	Trichur	632	383	709	1203
6	Malappuram	1176	976	1281	2707
7	Kozhikode	2234	584	1646	3903
8	Cannanore	1352	380	935	900
9	Kasargod	277	141	1022	266
	Total	**10858**	**3025**	**9861**	**18931**

Note : Unregistered crafts, both motorised and non-motorised, are there. Their number is not estimated. Details are gathered by the committee through the District Officers of the Department of Fisheries and Matsyafed.

Table 2.5.29

Distribution of Fishing Gears in Alappuzha and Ernakulam Districts, 1990

District	Number of Fishing Gears	
	Alappuzha	Ernakulam
Ring seine	519	280
Encircling net	2634	438
Boat seine	4	41
Shore seine	493	193
Gill net	3312	2698
Drift net	302	179
Trawl net	362	1432
Cast net	3607	2074
Hooks line	1035	121
Purse seine	-	40
Others	2314	1074
Total	14582	8570

Source : Secondary data collected by NIO

Table 2.5.30

Details of Fishing Activities in Ernakulam District

Components	Number
Coast line (km)	46
No. of fishery villages	21
No. of fish landing centres • Traditional and mechanized	5
No. of fishing crafts	
• Mechanised	1241
• Non motorised country crafts	1740
• Motorised country crafts	465
No. of fishing gears	
• Ring seine	280
• Encircling net	438
• Boat seine	41
• Shore seine	193
• Gill net	1698
• Drift net	179
• Trawl net	1432
• Cash net	2074
• Hook and line	121
• Purse seine	40
• Others	1074
Total fishermen population	60524
Active fishermen population	13605

Table 2.5.31

Details of Seine Nets Operated

Name of Gear	Length (m)	Total Width (m)	Mesh Size (cm)	Correspon-ding Width (m)	Material used	Man Power	No. of Canoes	Species Caught
Vallivala	25	13	2.0*2.0 1.5*1.5 1.0*1.0	1.0 6.0 6.0	Cotton	4	1	*Mugil cephalus, Liza parsia, L. macrolepis , Valamugil cunnesius, Gerres filamantosus, Sillago sihama*
Pattukan-vala	20	8	1.3*1.3 1.0*1.0 0.8*0.8	1.0 1.5 6.5	Cotton	4	1	*L.parsia, Anodontostoma chacunda, V.cunnesius, Caranx sexfasciatus, Alepes djeddabe, Siganus javus, S.canaliculatus, Etroplus maculatus, Therapom jarbua, Ambassis commersonii, Scatophagus argus,Tylosurus leiurus, Strongylur strongylura, Sardinella longiceps, Leiognathus brevirostris, G.filamentosus.*
Thirutha-vala	20	24	5.0*5.0 3.0*3.0 4.0*3.0	4.0 14.0 6.0	Nylon	8	2	*Mugil cephalus*
Paithu-vala	12	5	2.0*1.5 1.0*1.0 1.0*0.5	1.0 1.0 4.0	Cotton	6	2	*Daysciaena albida, Tachysurus maculatus, Silago sihama, Hypothamphus xanthopterus, S.argus, Thryssa mystax, A.chacunda*
Neravala	35	6	0.5*0.5	Uniform	Cotton	4	1	*E.maculatus, Glossogobious giuris, A.gymnocephalus, A.dayi*
Chemm-eenvala	9.5	4.5	0.4*0.4	Uniform	Cotton	3	1	*Stolephorus commersonii,Stenogobius malanabricus, Puntius amphibius, A.gymnocephalus, E.maculatus, T.maculatus.*
Mandu-vala	40	4	0.7*0.5	Uniform	Cotton	3	1	*Ehirava fluviatillis, Dayella malabarica, Stolephorous commersonii, Siganus javus.*
Peruvala	1500	24	1.5*1.5 0.7*0.7	4 20	Cotton	12	2	*D.malabarica, A.dayi, S. malabaricus, Chelondond pectoca, E.maculatus, A.gymnocephalus, Megalops cyprinoides, G.giuris.*

Table 2.5.32

Details of Gill Nets Operated

Name of Gear	Length (m)	Total Width (m)	Mesh Size (cm)	Corres-ponding Width (m)	Material used	Man Power	No. of Canoes	Species Caught
With foot rope (set gill net) Koori vala	140	4	2.4x1.4	Uniform	Cotton	2	1	*Mystus gulio, Tachysurus subrostratus, T.maculatus, Triacanthus brevirostris, Daysciaebna albia.*
Without foot rope (drift gill nets) Loop vala	120-140	1.5-2.25	1.5-1.8x1.5	Uniform	Nylon	2	2	*D.albida, Thryssa purava, Dendrophyss russelli, Sillage sihama, Gerres filameeentosus, Tachysurus maculatus.*
Ozukku vala	85-105	0.8-1.5	1.5-1.7x1.0	Uniform	Nylon	2	1	*Thryssa mystax, T.Kammalensis, T.purava Leiognathus eguulus, Platycephalus crocodilus, P.indicus , T.subrostratus, Sphyranea jello, Ambassis commersoii.*
Murasu vala	60-150	0.35	1.25-0.5x1.0	Uniform	Nylon	2	1	*Hyporhamphus (H.) xanthopterus, H.(H.) limbatus, Stringylura leiura, S.strongylura.*
Karimeen vala	100	2	4.0x4.0	Uniform	Nylon	2	1	*Etroplus suratensis, E.maculatus, Megalops cyprinoides, Wallago attu, Ompok bimaculatus, T.sbrostratus, Puntius sarana, P.filamentosus, Labeo dussumieri.*

Table 2.5.33

Distribution of Licensed Fishing Nets (Fixed Engines) in the Backwaters of Kerala

Sr. No.	District	Chinese dip nets			Stake nets			Total
		Licensed	Unlicensed	Total	Licensed	Unlicensed	Total	
1	Kollam	154	1093	1247	918	...	918	**2165**
2	Alappuzha	415	79	494	2072	686	2758	**3252**
3	Kottayam	117	31	148	723	36	759	**907**
4	Ernakulam	964	1793	2757	3617	2676	6293	**9050**
5	Trichur	42	135	177	478	334	812	**989**
6	Malappuram	..	...	...	30	9	39	**39**
7	Kozhikode	...	...	...	105	52	157	**157**
8	Cannanore & Kasargod	...	...	...	1070	94	1164	**1164**
	Total	1692	3131	4823	9013	3887	12900	17723

Source: Secondary data collected by CUSAT

Table 2.5.34

Trend of Increase in the Number of Fishing Nets in the Backwaters of Kerala

Sr. No.	District	Chinese Dip Nets			Stake Nets			Free Nets			Total		
		1975-76	1983-84	1986-87	1975-76	1983-84	1986-87	1975-76	1983-84	1986-87	1975-76	1983-84	1986-87
1	Trivandrum	1	-	-	7	-	-	234	234	276	242	234	276
2	Kollam	88	75	1247	873	844	918	406	1785	2815	1367	2704	4980
3	Alappuzha	282	376	494	508	1911	2758	2335	8250	9219	4125	10537	12471
4	Kottayam	90	117	148	869	722	759	560	3500	3828	1519	4339	4735
5	Ernakulam	1082	1303	2757	3116	3672	6293	682	3200	4680	4880	8175	13730
6	Trichur	42	42	177	401	427	812	41	143	476	484	612	1465
7	Malappuram	-	-	-	28	30	39	-	112	128	28	142	167
8	Kozhikode	-	-	-	127	158	157	-	230	364	127	388	521
9	Cannanore	-	1	-	-	1070	1164	-	380	625	-	1451	1789
10	Kasargod	-	1	-	-	1070	1164	-	380	625	-	1451	1789
	Total	**1585**	**1914**	**4823**	**6929**	**8834**	**12900**	**4258**	**17834**	**22411**	**12772**	**28582**	**40134**

Source: Secondary data collected by CUSAT

Table 2.5.35

Groups/Species Composition of Marine Fish Landing at Alappuzha and Ernakulam during 1995

Name of Fish	Fish Landing (MT)	
	Alappuzha	Ernakulam
Elasmobranchs	-	2
Sharks	121	351
Skates	-	12
Rays	9	114
Eels	2	-
Catfishes	2	39
Wolf herring	59	78
Oil sardine	4241	1839
Other sardines	4361	4413
Hilsa shad	-	17
Other shads	-	1
Setipinna	1	-
Stolephorus	11588	6212
Thryssa	481	1416
Other clupeids	1031	1354
Lizard fishes	-	2120
Half beaks & full beaks	48	245
Rock cods	-	726
Snappers	9	10
Threadfin breams	18	6055
Other perches	1528	1083
Goatfishes	238	35
Croakers	165	3180
Ribbon fishes	62	385
Horse mackeral	1522	354
Scads	6037	6245
Leather-jackets	11	41
Other carangids	502	1036
Silverbellies	61	573

Source : Secondary data collected by NIO

Name of Fish	Fish Landing MT	
	Alappuzha	Ernakulam
Big-jawed jumber	4	2
Pomfrets	-	351
Black pomfret	104	12
Silver pomfret	44	114
Indian mackeral	18063	-
Seer fishes	-	39
S. commersoni	1050	78
S.guttatus	-	1839
S.lineolatus	-	4413
Acanthocybium spp.	-	17
E. affinis	99	1
Auxis spp	-	-
K.pelamis	-	6212
T. tonggol	-	1416
Other tunnies	-	1354
Bill fishes	-	2120
Barracudas	6	245
Mullets	-	726
Flounders	-	10
Soles	1335	6055
Crustaceans	-	1083
Penaeid prawns	3751	35
Lobsters	-	3180
Crabs	47	385
Stomatopods	913	354
Molluscs	-	6245
Gastropods	-	41
Cephalopods	97	1036
Miscellaneous	213	573

Table 2.5.36

Annual Export of Marine Products from Ernakulam District : 1993 to 95

Year	Quantity (MT)	Year	Quantity (MT)
1973	30782	1984	30385
1974	24214	1985	30043
1975	32331	1986	34212
1976	31024	1987	34874
1977	27757	1990	50997
1978	31652	1991	58743
1979	31633	1992	49094
1980	28136	1993	63809
1981	31901	1994	74576
1982	32946	1995	78682
1983	32514		

Source : Secondary data collected by NIO

Table 2.5.37

Port-wise Export of Marine Products in Kerala and India

Name of Ports		1994-95	% Share	1995-96	% Share	1996-97	% Share
Kandla	Q	32581	10.60	23462	7.92	41463	10.96
	V	174.17	4.87	131.96	3.77	196.26	4 76
Porbandar	Q	54405	17.70	59096	19.95	81750	21.62
	V	243.67	6.82	263.32	7.52	374.32	9.08
Mumbai	Q	46006	14.97	31213	10.54	42579	11.26
	V	312.22	8.73	272.48	7.78	281.11	6.82
JN Port	Q	24653	8.02	24144	8.15	29081	7.69
	V	221.72	6.20	211.88	6.05	237.17	5.75
Goa	Q	13334	4.34	13938	4.70	13603	3.60
	V	59.20	1.66	70.36	2.01	63.36	1.54
Mangalore/ Bangalore ICD	Q	148	0.05	137	0.04	1123	0 30
	V	8.71	0.24	11.54	0.33	8.50	0.21
Kochi	Q	74576	24.26	78682	26.56	91616	24.22
	V	314.96	22.79	853.76	24.39	925.71	22.46
Tuticorin	Q	9956	3.24	13028	4.40	16640	4.40
	V	187.32	5.24	191.54	5.47	253.75	6 16
Chennai	Q	18876	6.14	18302	6.17	24238	6.41
	V	592.78	16.58	527.65	15.07	821.91	19.94
Vizag	Q	19811	6.45	20017	6.76	18560	4.91
	V	637.29	17.83	608.88	17.39	522.18	12.67
Calcutta	Q	12914	4.20	14044	4.74	16281	4.30
	V	321.11	8.98	354.60	10.13	422.64	10.25
Karwar	Q	--	--	--	--	593	0.16
	V	--	--	--	--	3.94	0.10
Trivandrum	Q	77	0.03	214	0.07	672	0.18
	V	2.13	0.06	3.14	0.09	10.51	0 26
Total	Q	307337	100.00	296277	100.00	378199	100.00
	V	3575.27	100.00	3501.11	100.00	4121.36	100.00

Q : Quantity in MT V : Value in Rs. Crores

Source : Marine Products Export Review 1996-97, MPEDA, Kochi, 1998

Table 2.5.38

Item-wise Export of Marine Products through the Kochi Port

Item		1994-95	1995-96	1996-97
Frozen shrimp	Q	33736	32720	34514
	V	498.74	488.19	535.99
Frozen lobster tails	Q	130	53	92
	V	1.94	1.87	2.55
Frozen cuttle fish	Q	12203	16582	15098
	V	115.49	142.25	144.47
Frozen squid	Q	15988	18669	15803
	V	114.64	144.96	119.20
Fresh/Frozen fin fish	Q	7192	7105	20603
	V	26.52	28.84	66.68
Dried items	Q	89	273	598
	V	0.93	1.29	5.75
Frozen clam	Q	1136	431	782
	V	4.68	2.45	2.88
Freeze dried shrimp	Q	193	166	188
	V	19.07	22.73	23.36
Other items	Q	3899	2683	3938
	V	32.95	21.18	24.83
Total	**Q**	**74576**	**78682**	**91616**
	V	**814.96**	**853.76**	**925.71**

Q : Quantity in MT; V . Value in Rs. Crores
Source : Marine Products Export Review 1996-97. MPEDA, Kochi. 1998

Table 2.5.39

Country-wise Export of Marine Products through the Kochi Port

Countries		1994-95	1995-96	1996-97
Japan	Q	10157	9403	13547
	V	176.55	165.80	222.45
Europe	Q	32243	42949	33932
	V	290.68	413.56	341.53
USA	Q	18492	13551	13518
	V	247.22	183.29	181.12
South East Asia	Q	10671	9628	26713
	V	74.08	63.58	151.83
Middle East	Q	1452	1578	1171
	V	12.27	13.45	8.31
Others	Q	1561	1573	2735
	V	14.16	14.08	20.47
Total	Q	74576	78682	91616
	V	814.96	853.76	925.71

Source : Marine Products Export Review 1996-97. MPEDA. Kochi, 1998
Q : Quantity in MT; V : Value in Rs. Crores

Table 2.5.40

Export Growth of Ornamental Fish

Year	Export (Crore Rs.)	Annual Growth (%)
1992 – 93	35.42	-
1993 – 94	55.32	56.18
1994 – 95	65.03	17.55
1995 – 96	81.67	25.59
1996 – 97	117.28	43.60

* Ornamental fishes are being exported in numbers and not by weight. hence quantity not given

Source : Marine Products Export Review 1996-97. MPEDA, Kochi, 1998

Table 2.5.41

Trends in the Net State Domestic Product, Primary Sector Product, Fishery Sector Product and per Capita Income

Item	1980-81	1990-91	1994-95	Growth (%)	Annual Growth
State Domestic Product (SDP)	382273	526234	646104	69	4.92
Primary Sector Product (PSP)	149970	189386	208873	39	2.80
Fishery Sector Product (FSP)	7743	9380	10010	29	2.09
FSP/SDP	2.02	1.78	1.55	-	-
FSP/PSP	5.16	4.95	4.79	-	-
State Population (,000)	25357	28987	30584	20.6	1.47
Fishing community Population (,000)	779	917	992	27.3	1.95
Fishery sector income per Fisherman (Rs/Yr)	994	1023	1008	0	-
State Per Capita Income (Rs/Yr)	1508	1815	2113	40	2.8

Rs. lakhs in 1980-81 prices

Table 2.5.42

District-wise Distribution of Fishermen Households and Fishermen Population in Kochi

Sr. No.	District	Marine Population				Inland Population				Total population			Total
		No. of households	Male	Female	Total	No. of Households	Male	Female	Total	No. of Households	Male	Female	
1	Trivandrum	22070	61551	55577	117128	162	510	505	1015	22232	62061	56082	118143
2	Kollam	10922	35395	32072	67467	5296	15150	14336	29486	16218	50545	46408	96953
3	Pathanamthitta	-	-	-	-	224	658	656	1314	224	658	656	1314
4	Alappuzha	14695	52830	51585	104415	8434	24589	23494	48083	23129	77419	75079	152498
5	Kottayam	-	-	-	-	3328	9665	9149	18814	3328	9665	9149	18814
6	Ernakulam	10032	32276	31234	63510	7950	23558	22746	46304	17982	55834	53980	109814
7	Trichur	7307	25413	24698	50111	2536	7968	6646	14614	9843	33381	31344	64725
8	Palghat	-	-	-	-	1312	4149	3461	7610	1312	4149	3461	7610
9	Malappuram	8890	38247	37969	76216	508	1824	1743	3567	9398	40071	39712	79783
10	Kozhikode	11244	41374	39734	81108	1496	4420	4361	8781	12740	45794	44095	89889
11	Wynad	-	-	-	-	131	402	375	777	131	402	375	777
12	Cannanore	7186	27861	25059	52920	949	3172	3200	6372	8135	31033	28259	59292
13	Kasargod	5832	19054	18214	37268	-	-	-	-	5832	19054	18214	37268
	Total	98178	334001	316142	650143	32326	96065	90672	186737	130504	430066	406814	836880

Source: Department of Fisheries, Socio-Economic Survey of Fishermen-Kerala, 1985

Table 2.5.43

District-wise Percentage Distribution of Active Fishermen

Sr. No.	District	Marine Fisherman			Inland Fisherman			Total Fisher man		
		Total	Active	% Active	Total	Active	% Active	Total	Active	% Active
1	Trivandrum	117128	28377	24.23	1015	332	32.71	118143	28709	24 30
2	Kollam	67467	16223	24.04	29486	7150	24 24	96953	23372	24.00
3	Pathanamthitta	-	-	-	1314	258	19.63	1314	258	19.63
4	Alappuzha	104415	22876	21.91	48083	11422	23.75	152498	34298	22.49
5	Kottayam	-	-	-	18814	4140	22.00	18814	4140	22.00
6	Ernakulam	63510	13353	21.03	46304	9652	20.84	109814	23005	20.95
7	Trichur	50111	10573	21.1	14614	4020	27.51	64725	14593	22.55
8	Palghat	-	-	-	7610	1614	21.21	7610	1614	21.21
9	Malappuram	76216	15581	20.44	3567	650	18.2	79723	16231	20.36
10	Kozhikode	81108	19062	23.5	8781	1760	20.04	89889	20822	23.16
11	Wynad	-	-	-	777	156	20.08	777	156	20.08
12	Cannanore	52920	12118	22.89	6372	1439	22.58	59292	13551	22.85
13	Kasargod	37268	9719	26.08	-	-	-	37268	9719	26.08
	Total	**650143**	**147875**	**22.74**	**186737**	**42593**	**22.81**	**836880**	**190468**	**22.76**

Source: Department of Fisheries; Socio-Economic Survey of Fishermen-Kerala, 1985.

Table 2.5.44

Average Household Size with Number and Income per Household in the Vicinity of the Vembanad Lake

Region	Average Household Size			Estimated Number of Household			Average Income per Household (Rs)		
	All	Fisher men	Non-Fisher men	All	Fisher men	Non-Fisher men	All	Fisher men	Non-Fisher men
1	5.76	-	5.76	33918	0	33918	669	-	669
2	5.84	5.56	5.86	10775	817	9958	1001	1558	955
3	5.50	5.91	5.34	25124	6989	18135	661	482	730
4	5.30	5.62	5.25	21978	2656	19322	458	431	452
5	4.89	4.81	4.91	26140	4579	21561	817	907	797
6	5.40	5.33	5.41	20756	2328	18428	389	261	406
Total	5.43	5.48	5.42	138691	17369	121322	646	607	652

Table 2.5.45

Estimated Population in the Vicinity of the Vembanad Lake

Region	Total Population (1981)	Number of Persons Engaged in			Estimated Fishermen
		Fishing	Allied Occupation	Non Fishing Occupation	
1	195368	0	575	42521	--
2	62926	1277	204	13329	4542
3	138184	9924	4253	25708	41304
4	118184	3489	1375	28639	14926
5	127826	6005	1049	35364	22024
6	112081	3297	194	23851	12408
Total	752866	23992	7650	169412	95204

Source : Secondary data collected by CUSAT

Table 2.5.46

Number of Fishermen Operating Different types of Fishing Gears in the Vembanad Lake

Sr. No.	Gears & Fishing Methods	Northern Sector		Southern Sector		Total No. of Units	Total No. of Fisher men	%
		No. of Units	No. of Fisher men	No. of Units	No. of Fisher men			
1	Gill net	770	1531	175	346	945	1877	8.94
2	Seine net	382	1362	104	349	486	1711	8.15
3	Stake net	4777	9421	84	167	4861	9588	43.67
4	Dip net	1422	3728	6	18	1428	3756	17.89
5	Cast net	393	649	314	513	707	1180	5.62
6	Hand net	449	569	255	335	704	904	4.30
7	Other methods	599	1630	78	349	677	1979	4.43

Table 2.5.47

Persons Engaged in Different Occupations in the Vicinity of Vembanad Lake

Occupation	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	All Regions
All Households							
Fishing	0.00	2.03	7.18	3.30	4.70	2.94	3 19
Related occupations	0.29	0.32	3.08	1.18	0.82	0.17	1.02
Other than fishery related	21.76	21.02	18.60	24.59	27.67	21.28	22.50
Total	**22.05**	**23.37**	**28.86**	**29.07**	**33.19**	**24.39**	**26.71**
Fishermen Households							
Fishing	-	28.09	24.03	25.77	27.27	26.56	25.20
Related occupations	-	2.25	8.01	7.36	3.46	00.00	5.54
Other than fishery related	-	23.60	1.84	5.52	15.15	04 69	6.91
Total	-	53.94	33.98	38.65	45.83	31.25	37.65
Other than Fishermen households							
Fishing	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Related occupations	0.29	0.18	0.98	0.27	0.27	0.19	0.37
Other than fishery related	21.76	20.82	25.76	27.39	30.27	23.35	24.76
Total	22.05	21.00	26.74	27.66	30.54	23.54	25.13

All values are in %

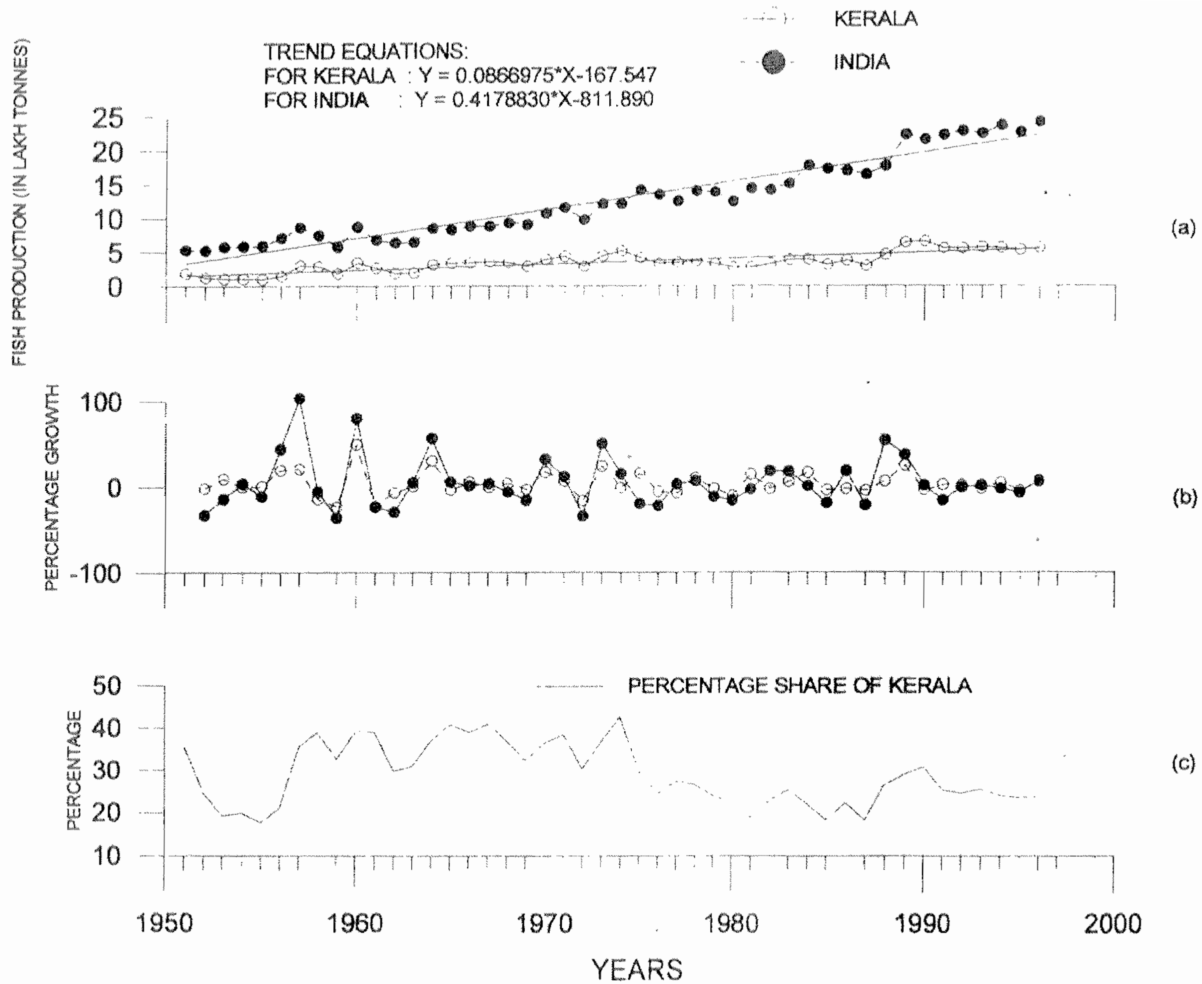

Fig. 2.5.1 : **Details of Annual Marine Fish Production in Kerala and India during 1951 - 1996**

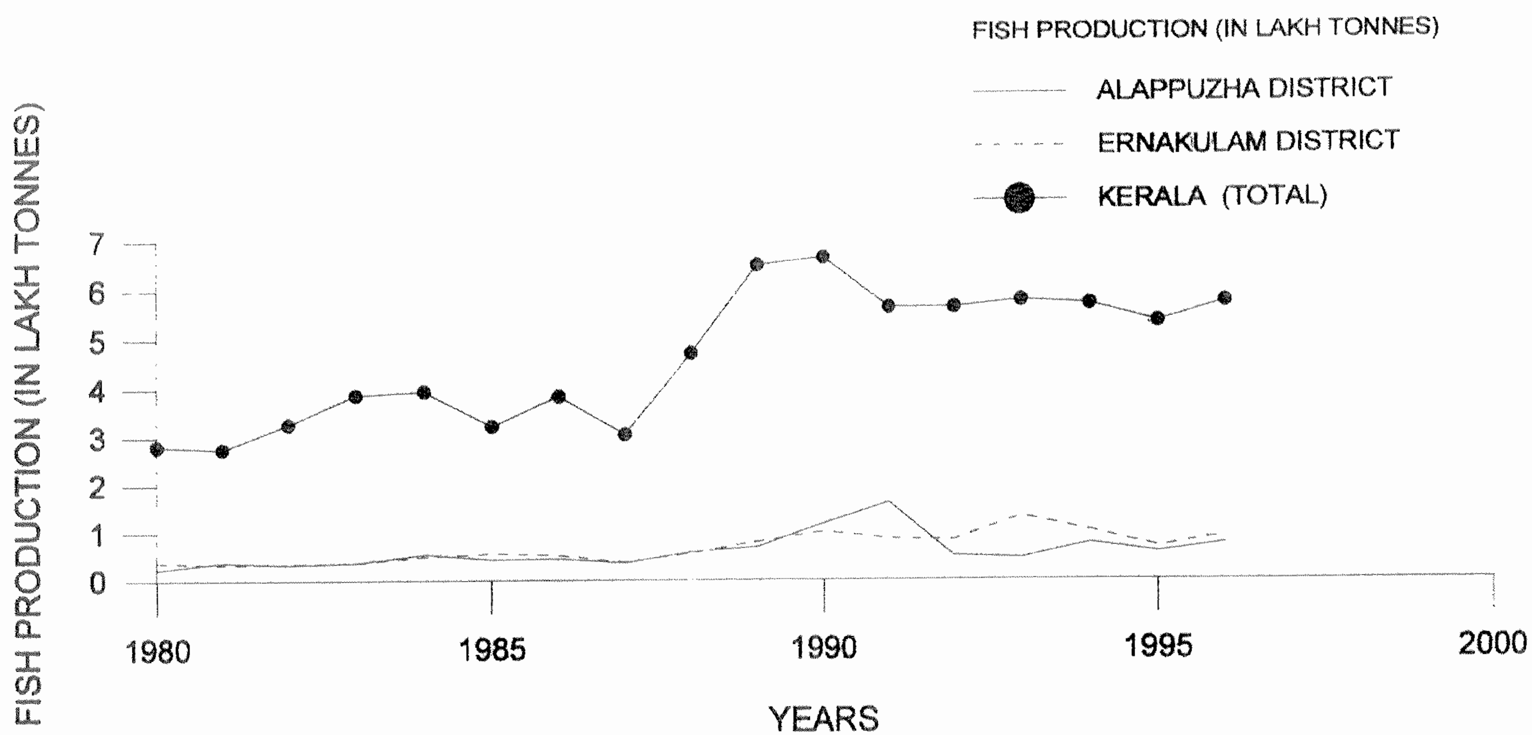

Fig. 2.5.2 : Variation in Annual Marine Fish Production in Alappuzha and Ernakulam Districts and in Kerala

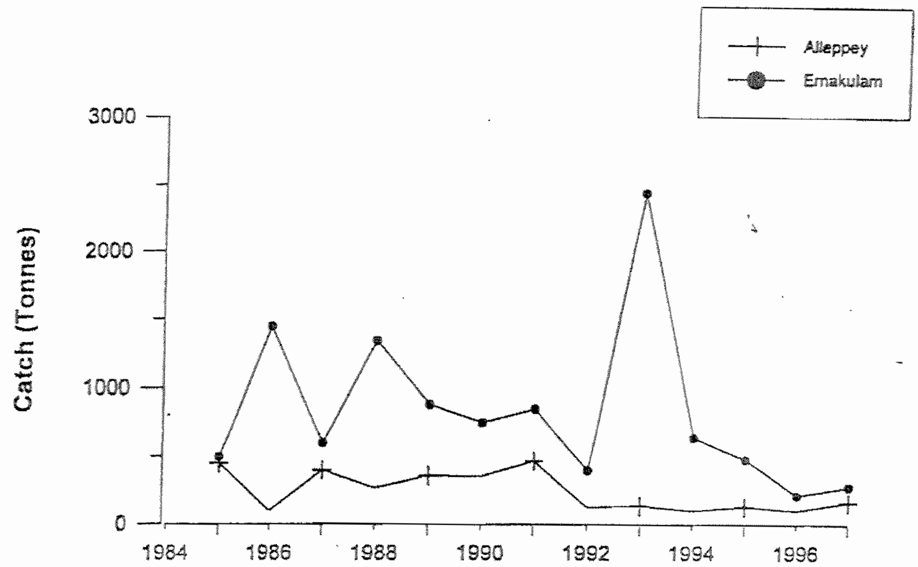

Fig. 2.5.3 : Annual Fluctuations in the Catch of Elasmobranchs

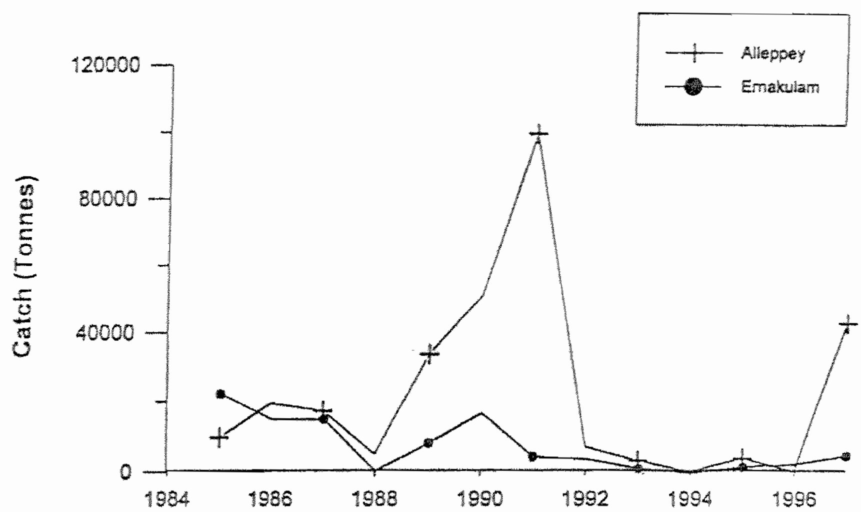

Fig. 2.5.4 : Annual Fluctuations in the Catch of Oil Sardine

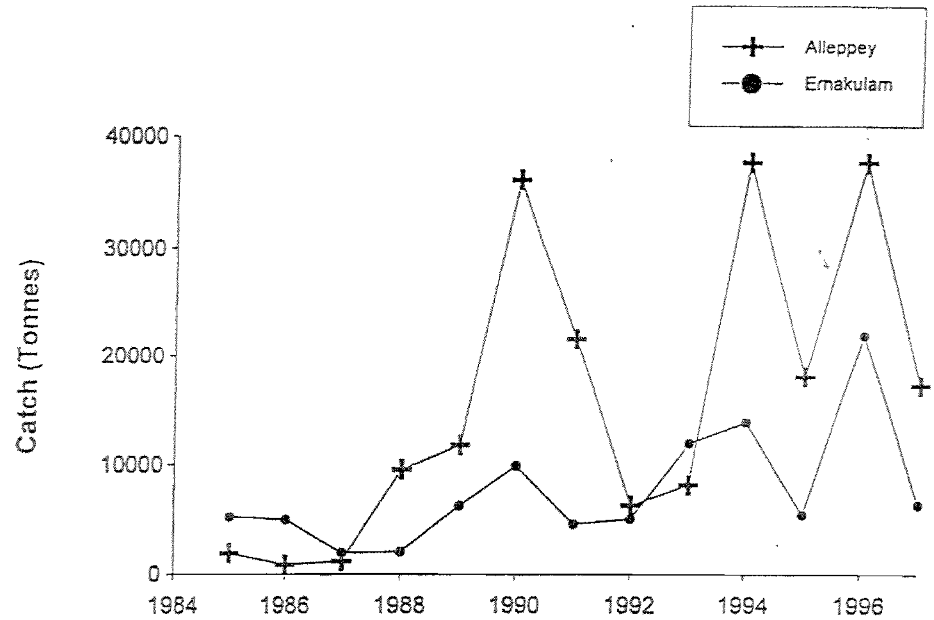

Fig. 2.5.5 : Annual Fluctuations in the Catch of Mackeral

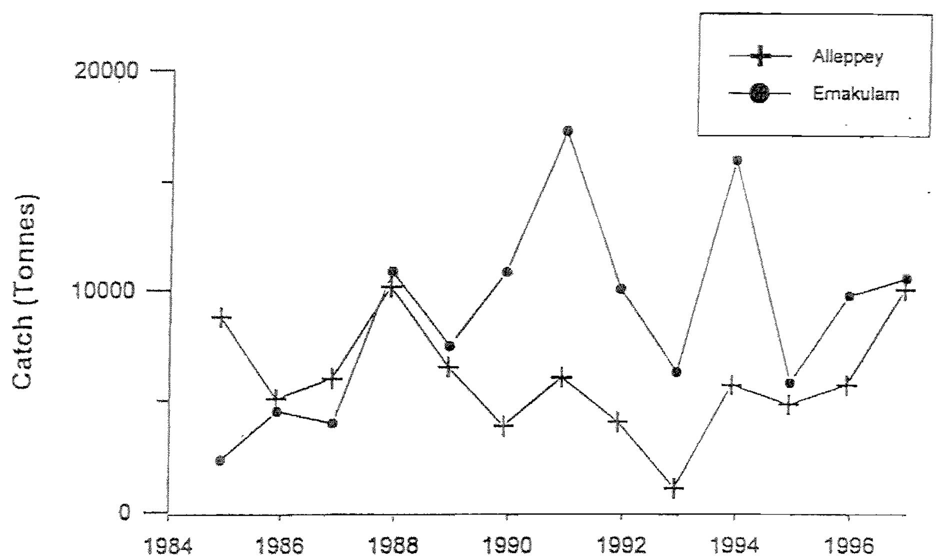

Fig. 2.5.6 : Annual Fluctuations in the Catch of Penaeid Prawns

2.6 Agriculture and Allied Activities

The Agricultural Sector details excluding fisheries and animal husbandry is presented here. Production potential of all crops for which data are available has been incorporated alongwith agro-management practices for each crop

The general trend in production and productivity of the agricultural sector of GKR reflects the overall performance of the State, as a whole. Economic Review (1998) of the State Planning Board has summarized the performance of the agricultural sector of post-independent Kerala, as briefly given below:

- In spite of rich resource endowments and high intensity of cropping, the productivity of most of the crops grown in Kerala is lower than those in the other producing States in the country
- The contribution of the agriculture sector to the State GDP declined from 66% in the early fifties to 30% in the mid-nineties
- The population dependent on the sector has remained more or less the same in proportionate terms during the period. In absolute terms, it has increased. The pressure of population has further marginalized the size of holdings from an average of 0.73 ha to 0.33 ha
- Area under food crops declined from 14.8 lakh ha to 8.8 lakh ha, while that of non-food crops increased from 7.0 lakh ha to 19.6 lakh ha
- Overall agricultural growth was positive but it was not all pervasive and was mainly confined to few select commodities, in particular rubber, coconut and milk
- Internal production of food grains declined from 14 lakh MT in the mid seventies to 7.8 lakh MT, making the State increasingly dependent on external sources for meeting her requirements
- Even in the case of crops where there was increase in production, perhaps with the only exception of rubber, it was largely contributed by expansion in area rather than improvement in productivity
- Even in the midst of a declining phase in area and production, the important food crops such as rice and tapioca recorded increase in productivity.

Agriculture in Kerala which has the distinction of having the highest gross income per net cropped area at the very beginning of the plan era could not sustain this prestigious position largely due to the failure of the productivity of major crops to keep in pace with the growth rate recorded in other important agricultural states in the country. In respect of gross income per ha, other States have pushed down Kerala to the fourth position. The overall average growth rate recorded by the Kerala farm front between 1960 and 1990 is estimated to be around 1.66% only against the national average of 2.71%. The growth rate in agriculture is lower than the average population growth recorded during the period, thereby, making the average per capita income originating from agriculture still lower inspite of substantial investment of plan resources during the last four decades.

The cumulative investment under the State sector upto the Eighth Plan works out to Rs.3945 crores under "Agriculture and Allied Sectors" including irrigation, thus accounting for over a quarter of all plan investments. These accounts, if reworked in terms of 1997-98 prices, would show that total investment in agriculture and allied activities including irrigation has been substantial. As against that, growth in agricultural production in Kerala has not kept pace with that in the whole country, not to speak of states where agricultural growth spurted during the sixties and seventies. However, during the second half of Nineties, Kerala was gradually getting out of the stagnancy in growth of agriculture income.

Agriculture Income

"The ten year period from the mid seventies is considered as a period when the Kerala agriculture was in stagnation. The Nineties, in general, showed positive signs of recovery. The average growth rate recorded during the Eighth Five Year Plan was 3.6%, which is higher than the projected target of 2.75%. For attaining the projected growth of 7% in NDP during the Ninth Plan, it was imperative that the agriculture sector had to be geared to attain a growth rate that is much higher than the Eighth Plan level of 3.6% already achieved. The provisional estimate for the first year of Ninth Five Year Plan, namely, 1997-98 shows that the agricultural economy of Kerala registered a higher growth rate of 4.01%. Although the growth performance for the sector as a whole is very much encouraging from 1990-91 onwards, it is noteworthy that the engine of growth is fuelled by two principle crops, namely, coconut and rubber and that too on account of the large scale expansion in area through the shift in cropping pattern. Also, it is notable that in spite of growth in the state's agricultural income, the contribution of agriculture to state income has been on the decline as the other sectors registered even higher rates of growth" Sectoral distribution of SDP in Kerala is given **Table 2.6.1**.

2.6.1 Major Crops and Cropping Patterns

The districtwise area under principal crops, coconut, rice, rubber, coffee, tea, pepper, cardamom and vegetables, fruits and banana is given in **Table 2.6.2**, and production and productivity pattern of different crops are discussed below.

Coconut

The vital statistics on area under coconut, production and productivity are given in **Table 2.6.3** and shown in **Fig. 2.6.1** for GKR, Kerala and India. The area under coconut in Kerala in 1995-96 comes to about 9.1 lakh ha; out of which, about 46% of area under coconut is in GKR. However, only 44% of the total production of coconut in Kerala comes from GKR. Over a period of 20 years, (from 1976-77 to 1995-96), the area under coconut increased from 3.5 lakh ha to 4.26 lakh ha in GKR. The production level also registered an increase from 1663 million nuts to 2286 million nuts during the same period. On the face of it, it may appear as a positive sign. Although the productivity of both GKR and Kerala showed an increasing trend, the productivity in GKR was lower than the State. The disparity is obvious from the fact that in twenty years, while the productivity in GKR rose from 4574 nuts/ha to 5153 nuts/ha, for the same period for Kerala, it rose from 4817 nuts/ha to 5638 nuts/ha. The paradox is that the national average productivity stood at a higher level of 7066 nuts/ha in 1995-96. The total revenue receipt from coconut during 1995-96 comes to about Rs.1143 crores @ Rs.5 per unit.

Rice

District wise area, production and productivity of rice are given in **Table 2.6.4** and shown in **Fig. 2.6.2** for GKR, Kerala and India. Rice cultivation in Kerala, as a whole, has been declining since some time and it appears as though there is no point of return to normalcy. The high pressure of population combined with a cropping pattern that is more oriented towards cash crops makes the State more and more dependent on neighbouring States for its food requirements. The situation in GKR reflects more or less the same scenario.

In GKR, the cultivated area under paddy reduced from 5.63 lakh ha to 2.97 lakh ha over a period of 20 years (1978-98). The corresponding figure for the State was 7.99 lakh ha to 3.87 lakh ha. The production of rice in GKR decreased considerably from 9.5 lakh MT in 1978-79 to 6.07 lakh MT in 1997-98, (-36.19%). Productivity on the other hand, showed an increase from 1681 kg/ha in 1978-79 to 2030 kg/ha in 1997-98, (+20.76%). State-wise also, there was increase in productivity from 1592 kg / ha to 1975 kg/ha (+ 24.06%) during the same time periods.

It may be argued that the short fall in area has been compensated for, to some extent, by increase in productivity. However, in recent years, the fall in area has been so steep that increase in productivity cannot make up for the short fall in total production. The highest productivity of 2743 kg/ha in Alappuzha was achieved in the year 1995-96 while the highest production of 10.27 lakh MT was recorded in the year 1981-82.

In spite of the fact that the climatic conditions prevailing in all districts of GKR are quite favourable, considerable variation in yield existed among districts. The highest yield of 2743 kg/ha was recorded from Alappuzha district in the year 1995-96, whereas, the lowest of 1322 kg/ha was recorded by Trichur district in the year 1978-79.

Rubber

District wise area, production and productivity of rubber in GKR are given in **Table 2.6.5** and shown in **Fig. 2.6.3** for GKR and Kerala. Among the plantation crops, rubber ranks first in respect of area and production. About 90% of India's rubber production is from Kerala. The area under rubber in GKR comes to about 3.26 lakh ha, which constitutes about 72.68% of the total area under rubber in Kerala. From 1978-79 to 1995-96, the area under rubber plantation in GKR went up form 1.50 to 3.26 lakh ha, registering an increase of 117%, whereas, it was 109% for the corresponding period in Kerala.

In conformity with increase in area, the production also increased by 298% and 283%, respectively, for GKR and Kerala. The productivity almost doubled during 1978-79 to 1995-96 interval, from 577 kg/ha to 1062 kg/ha in GKR and 577 kg/ha to 1057 kg/ha in Kerala. Productivity varied between estate sector and small grower sector, the former with productivity 1110 kg/ha as compared to 904 kg/ha of the latter. The total production of rubber in Kerala was 4.75 lakh MT in 1995-96 whereas that of GKR was 3.54 lakh MT. The estimated value of production from GKR would exceed Rs.1600 crores. According to an estimate, it is possible to get a yield of 2000 kg/ha, easily provided the small growers tap the potential of the extension network of the Rubber Board is fully tapped. Realization of production potential of 2000 kg/ha would mean an estimated value of Rs.3000 crores from GKR alone.

Coffee

Data on area, production and productivity of coffee in GKR are patchy especially from 1986-89 onwards. District-wise area, production and productivity of coffee in GKR are given in **Table 2.6.6** and shown in **Fig. 2.6.4** for GKR and Kerala. There was steady increase in area under coffee, production and productivity in GKR during the period 1976-77 to 1995-1996. The area under coffee was just 7204 ha in 1976-77, which rose to 15348 ha in 1995-96, registering an increase of more than 100%. There was a quantum jump in production for the same period, from 1829 to 11200 MT, which constituted about 25% of State production. Productivity also increased from 225 kg/ha in 1976-77 to 840 kg/ha in 1995-96, which was much higher than that of the State (546 kg/ha). The average productivity of coffee in India in 1995-96 was 860 kg/ha, which was more than the estimated productivity of 505 kg/ha of the world. The reported research station productivity is 2800 kg/ha. Monetarily, the foreign exchange earnings of 1995-96 of GKR will work out approximately Rs.89 crores. It is left to imagination as to how much monetary value will be attached if the full production potential of 2800 kg/ha is realized in GKR.

Tea

Area, production and productivity of tea are given in **Table 2.6.7** and shown in **Fig. 2.6.5**. Tea plantations of the districts of Kollam, Kottayam, Idukki, Thrissur and Palakkad, constitute about 8% of the cultivated area of GKR. 82% of Kerala's production of tea comes from GKR alone, wherein almost 94% of tea produced in GKR comes from Idukki district.

From 1976-77 to 1995-96, the area under tea has been marginally reduced from 29547 to 28034 ha in GKR. On the other hand, the production increased from 38043 to 53507 MT with a productivity range from 1.23 to 1.58 MT/ha for the same period. The corresponding State productivity was 1.15 and 1.87 MT/ha, respectively, indicating that the GKR performance was far better than that of the State, as a whole. The national productivity stood at a lower level of 1.75 MT/ha in 1995-96. The relative share of Idukki district in area was 68%

The yield can further be increased up to 7.5 MT/ha (four times in GKR) through cloning. At the rate of Rs. 60 /kg, the value of 53507 MT produced in GKR will come to about Rs.320 crores.

Pepper

Kerala State has been continuously holding the monopoly in pepper production. Almost 99% of pepper produced in India is from Kerala. Although the area under pepper is only 6% of the total area of GKR, it produces about 45% of the total production of pepper in Kerala. From 1978-79 to 1995-1996, the area under pepper in GKR increased from 53098 to 84220 ha. The production of pepper was 9501 MT in 1978-79, which rose to 31266 MT in 1995-96. There was also an increase in productivity, which rose from 206 kg/ha in 1978-79 to 250 kg/ha during 1995-1996. However, the productivity figure was much lower as compared to Kerala of 358 kg/ha for the year 1995-96. The total revenue from pepper during 1995-96 comes to about Rs. 625 crores @ Rs. 200/kg.

The actual productivity potential has been estimated to be above 1000 kg/ha (Economic Review, 1991). This would mean that there is tremendous scope for further improvement in productivity both in Kerala as well as in GKR. Area, production and productivity of pepper in GKR, Kerala and India are given in **Fig. 2.6.6**. Further, district -wise breakup is given in **Table 2.6.8**.

Cardamom

Area, production and productivity of cardamom in Kerala, Karnataka and Tamil Nadu are given in **Table 2.6.9**. Idukki district produced the lion's share of cardamom in the State, almost 90% during 1995-96. In terms of tonnage, it came to 4861 MT in Idukki, followed by Palakkad-200 MT and Kottayam-33 MT during the same year, thus GKR production alone constituted about 95% of the State (5250 MT) during 1995-96 with a productivity of 165 kg/ha, almost double to the all India figure of 84 kg/ha.

Kerala is the largest producer of the crop in the country contributing more than 65% of cardamom produced in the country. The area under cardamom remained stagnant in the southern states. However, because of the increase in productivity there had been a spurt in production. This is especially so, in the case of Kerala where the increase in production from 1989-90 (1900 MT) to 1995-96 (5250 MT) was nearly three times. These figures of Kerala virtually represent the state of GKR.

Going by the unit value realization of Rs. 343/kg through exports, the production of cardamom at GKR was worth Rs. 174.7 crores. This figure may appear quite impressive; but hardly so. During 1997-98, India could export only 260 tonnes, valued at Rs.8 to Rs.9 crores. This was mainly because, after internal consumption, very few were left for exports; so also because of international competition. This would mean that there is every need for bringing in higher productivity, more area under production as well as competitive pricing in Kerala, in particular, and other producing States in India, in general.

Vegetables, Fruits and Banana

Kerala's homestead farming has been characterized by a number of seasonals like vegetables, fruits and banana as single crops. Statistical information on these is inadequate and often misleading. The information on area, production and productivity is given in **Table 2.6.10**. Vegetables, excluding tubers, cover an area of 85122 ha in Kerala, as compared to 53226 ha (about 62%) in GKR. Surprisingly, and alarmingly so, in 17 years (1978-79 to 1995-96), the area under vegetables got reduced drastically both in Kerala and in GKR, from 3,43,041 to 85,122 ha and from 1,74,863 to 53,226 ha, respectively. This accounts for more than 70% of reduction in area under vegetables.

On the other hand, in the case of fruits, there is a marginal increase in area, whereas, except for banana, the productivity figures show a declining trend for the same period, both for Kerala and GKR. The very low production and productivity have remained a matter of great concern for the State as well as for GKR. The Agricultural Marketing Unit of Agricultural Dept. has estimated the present production of vegetables in Kerala as 5.8 lakh MT, and the import from neighboring States as 7.5 lakh MT. According to Kerala State Planning Board (1997), even this quantity meets only less than 50% of the ICMR levels of intake. Thus, in order to meet the ICMR level and without importing from outside, Kerala will have to produce 26.6 lakh MT of vegetables indigenously. This is more than four times the production as of today.

The vegetables consumption excluding tuber crops in Kerala is only 23 gm/day/head as against the recommended moderate daily requirement of 150g/day/adult. ICAR recommended per capita value is 258 gm/day.

2.6.2 Operational Holdings and Cropping Intensity

District wise percentage distribution of operational holdings and its area of operational holdings of GKR, Kerala and India for 1990-91 are given in **Tables 2.6.11** & **2.6.12**. There are three divisions under the Marginal, i.e. below 1 ha, namely, below 0.02 ha, 0.02-0.50 ha and 0.50-1.00 ha. Out of these, below 0.02 ha constitutes 12.83%; 0.02-0.50 ha, 69.67% and 0.50-1.00 ha, 9.34%. About 98% of holdings are Marginal in GKR as compared to 93% of Kerala and 58% of India. Just 0.06% of GKR and Kerala come under Large holding category of above 10 ha. These figures indicate as to how fragmented are the holdings of GKR and Kerala, and as to how difficult it would be for the region to introduce any kind of innovative managerial measures to improve production and productivity.

The intensity of cropping in GKR is 139% as compared to 135% of Kerala. Among the districts of GKR, Palakkad had the maximum intensity of cropping of 161 % followed by Alappuzha, (155%). The net area sown in GKR was 12.7 lakh ha as compared to the total 22.50 ha of Kerala. The corresponding figures for the total cropped area was 17.66 and 30.46 lakh ha respectively **Table 2.6.13** gives the intensity of cropping in different districts of GKR and Kerala during 1960-1993

2.6.3 Irrigation Trends, Fertilizer Consumption and Other Inputs

Average rainfall of Kerala is higher (3000 mm per annum), as compared to GKR (2654 mm per annum). Eventhough the total rainfall is relatively high compared to the rest of the regions in the country, its temporal and spatial distribution is not equitable in Kerala.

In Kerala, irrigation is almost entirely centered around surface water resources with emphasis on development of major and medium size irrigation projects followed by minor irrigation ones. It is believed that there is enormous potential for tapping ground water for irrigation, which however remains underutilized.

Eventhough five projects namely, Pamba, Muvattupuzha, Periyar valley, Idamalayar and Meenachil were targeted for completion in GKR, only Pamba and Periyar valley projects have been completed. Idamalayar project is unlikely to come up, since it is held up for clearance on environmental grounds. In the case of Muvattupuzha project, eventhough the construction was started in the year 1974, the work on distributory canals is still going on. In terms of net area irrigated (1995-96), Alappuzha, Ernakulam, Trichur and Palakkad are better placed in GKR **(Table 2.6.14)**.

In the case of Pamba project, the net area expected to be served is 21135 ha in Pathanamthitta and Alappuzha districts. The net area expected to be served by Muvattupuzha project is 18616 ha in Idukki, Ernakulam and Alappuzha districts. The Meenachil project will cover an Ayacut net area of 996 ha in Kottayam district.

The Kerala State could pay attention on minor irrigation programmes only from Seventh Plan onwards. They are, by and large, externally aided projects,, assisted by EEC, Dutch assisted Community Irrigation Project and Kuttanad Water Balance Study Project. Kerala Minor Irrigation Project assisted by EEC aims at creation of or rejuvenation of surface water irrigation structure in select potential areas. The details of some of the schemes in GKR are summarized in **Table 2.6.15.** The Dutch assisted Community Irrigation Project aims at development of groundwater resources in Trichur district with the active participation of the beneficiary communities.

Consumption of Fertilizers and Other Inputs

There is no district-wise data on consumption of fertilizers available. State-wise information reveals that during 1995-96 to 1997-98 period, on an average, Kerala consumed 66.32 kg/ha of NPK as compared to the all India average of 75.60 kg/ha. In terms of N: P: K, it stood at 75.50% for Kerala.

The percapita power consumption for agricultural purpose during 1994-95 was only 4.2 KWH for Kerala as compared to 24.3 KWH for India.

2.6.4 Major Food items and Food grain Production

The Kerala Statistical Institute (KSI) study provides the details of per capita per week consumption in respect of 14 major food items also. The requirement and availability of these items for 1991 and 1996 have been computed and are given in **Table 2.6.16**. Other than rice no major food grains are commercially produced in Kerala, which is already detailed.

2.6.5 Live Stock

The compilation of data on animal resources in all the districts in GKR is given in **Table 2.6.17**. As per this data, the total livestock in GKR is 23,19,102. Cattle population represents about 63.6% of the total livestock in GKR. Buffaloes contribute 4.3%, goats 26%, sheep 0.42%, pigs 4.4% and other animals like dogs, rabbits etc. contribute 1.23%.

The highest percentage of live stock population and poultry are in Ernakulam district i.e. 20.76% and 22.8% respectively. The lowest percentage of livestock is in Alappuzha and Pathanamthitta district (12.9%), Idukki district has 14.3% of the total livestock in GKR. Kottayam and Thrissur districts have 19.8% and 19.4% of livestock respectively. The lowest percentage of poultry (8.5%) is in Idukki district. In Alappuzha district the percentage of poultry is 15.9%, Kottayam 19.4%, Pathanamthitta 12% and Thrissur district has 21.3% of the poultry population in GKR.

The population-wise details of other animals such as buffaloes, goat, sheep, pigs and fowls etc. are given in **Table 2.6.18.**

Table 2.6.1

Sectoral Distribution of SDP in Kerala (% Share)

Sector	1980-81	1990-91	1992-93	1993-94
Agriculture	33.84	33.47	31.74	31.42
Primary	39.23	35.98	34.18	33.84
Secondary	24.38	23.92	24.59	24.73
Tertiary	36.39	40.10	41.23	41.43

Source : Economic Review, 1995

Table 2.6.2

Districtwise Area under Principal Crops (1995 - 96)

Area in ha

District	Coconut	Rice	Rubber	Coffee	Tea	Pepper	Carda -mom	Vegetables Fruits & Banana
Alappuzha	67030	44132	3573	10	-	1982	-	-
Ernakulam	62502	56533	55247	274	2	7010	-	-
Idukki	17510	4660	37240	11908	23402	45011	-	-
Kottayam	40333	24878	109582	824	1947	7687	-	-
Pathanam-thitta	23712	10860	47063	-	91	4718	-	-
Thichur	85138	58703	12254	.32	505	5222	-	-
Palakkad	48336	135630	26031	2291	829	3460	-	-
Kollam	81034	23252	35347	9	1258	9130	-	-
GKR	425595	358648	326337	15348	28034	84220	-	117328
Kerala	914370	471150	448988	82348	34605	191596	43.34	361655
India	1833000	42837000	-	-	-	198000	-	-

Source : Secondary data Collected by CESS

Table.2.6.3

Yearly District wise Area, **Production**, Productivity of Coconut in GKR : 1976-77 to 1995-96

(Area in ha, Production in million nuts, Productivity in nuts/ha)

Sr. No.	District	1976-77			1977-78			1978-79			1979-80		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	93465	391	4183	87563	357	4077	81381	323	3969	84488	333	3941
2	Pathanamthitta	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Alappuzha	64338	334	5191	59354	283	4768	61814	319	5161	62907	328	5214
4	Kottayam	56535	228	4033	51300	192	3743	53959	190	3521	49747	188	3779
5	Idukki	14594	50	3426	14257	40	2806	14526	34	2341	15794	50	3166
6	Ernakulam	53524	251	4689	57304	276	4816	61304	329	5367	60070	312	5194
7	Trichur	50030	342	6836	49641	311	6265	50690	333	6569	53549	326	6088
8	Palakkad	18325	67	3656	18937	62	3274	19768	71	3592	21785	73	3351
	GKR	**350811**	**1663**	**4574**	**338356**	**1521**	**4250**	**343442**	**1599**	**4360**	**348340**	**1610**	**4390**
	Kerala	**694985**	**3348**	**4817**	**673479**	**3053**	**4533**	**660628**	**3211**	**4861**	**662657**	**3032**	**4576**
		1980-81			**1981-82**			**1982-83**			**1983-84**		
1	Kollam	81765	344	4207	84544	356	4211	85178	319	3745	75018	223	2973
2	Pathanamthitta										28807	79	2742
3	Alappuzha	63114	294	4658	62118	295	4749	62118	367	5908	46907	180	3837
4	Kottayam	51115	188	3678	50751	200	3941	50786	226	4450	50914	153	3005
5	Idukki	16617	43	2588	17371	44	2533	17371	45	2591	16523	40	2421
6	Ernakulam	60881	327	5371	62317	344	5520	62916	332	5277	62038	264	4255
7	Trichur	54030	347	6422	57312	381	6648	57312	355	6194	58929	322	5464
8	Palakkad	22954	80	3485	22916	77	3360	23688	80	3377	23186	63	2717
	GKR	350476	1623	4344	357329	1697	4423	359369	1724	4506	362322	1324	3427
	Kerala	651370	3008	4618	666618	3006	4509	674378	3184	4721	682281	2602	3814

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Table 2.6.3. Contd...

Sr. No.	District	1984-85			1985-86			1986-87			1987-88		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	68927	275	3990	68769	272	3955	70599	340	4816	76172	306	4017
2	Pathanamthitta	25926	124	4783	27521	160	5814	26158	132	5046	29403	121	4115
3	Alappuzha	45699	282	6171	48702	277	5688	49126	253	5150	54292	242	4457
4	Kottayam	48179	192	3985	49033	217	4426	49118	202	4113	48384	184	3803
5	Idukki	15036	44	2926	17585	71	4038	16188	42	2595	17880	61	3412
6	Ernakulam	55678	363	6520	59632	338	5668	59251	308	5198	65244	337	5165
7	Trichur	62438	297	4757	60366	369	6113	61200	312	5098	69715	376	5393
8	Palakkad	25504	76	2980	26349	108	4099	25681	57	2220	29051	76	2616
	GKR	**347387**	**1653**	**4514**	**357957**	**1812**	**4975**	**357321**	**1646**	**4279**	**390141**	**1703**	**4122**
	Kerala	**687483**	**3453**	**5023**	**704682**	**3377**	**4792**	**706107**	**3173**	**4494**	**775365**	**3346**	**4315**
		1988-89			**1989-90**			**1990-91**			**1991-92**		
1	Kollam	81754	395	4832	76752	383	4990	77874	364	4674	75454	343	4546
2	Pathanamthitta	30274	143	4724	28752	128	4452	27505	145	5272	26850	135	5028
3	Alappuzha	57052	274	4803	61088	307	5026	66664	295	4425	65254	306	4689
4	Kottayam	50828	212	4171	48360	212	4384	47217	195	4130	46012	217	4716
5	Idukki	17918	67	3739	17351	74	4265	14864	63	4238	16356	72	4402
6	Ernakulam	68988	440	6378	65798	419	6368	66264	346	5222	64359	370	5749
7	Trichur	74198	515	6941	77452	529	6830	80856	465	5751	84789	546	6440
8	Palakkad	31076	100	3218	34468	111	3220	38153	130	3407	37090	137	3694
	GKR	412088	2146	4851	410021	2163	4942	419397	2003	4640	416164	2126	4908
	Kerala	816880	4215	5160	832174	4358	5237	870022	4232	4864	863060	4641	5377
	India										1529000	10080	6593

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Table 2.6.3. Contd...

Sr. No	District	1992-93			1993-94			1994-95			95-96S		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	76658	398	5192	76661	397	5179	81528	430	5274	81034	481	5936
2	Pathanamthitta	25635	141	5500	22597	137	6063	25807	128	4960	23712	142	5989
3	Alappuzha	67501	307	4548	64478	297	4606	68495	347	5066	67030	336	5013
4	Kottayam	44992	203	4512	41531	204	4912	40765	176	4317	40333	160	3967
5	Idukki	17298	85	4914	16374	79	4825	16676	71	4258	17510	75	4283
6	Ernakulam	65201	432	6626	63900	414	6479	61241	389	6352	62502	370	5920
7	Trichur	85600	634	7407	87118	588	6749	86206	614	7122	85138	539	6331
8	Palakkad	39514	163	4125	43703	182	4164	45503	166	3648	48336	183	3786
	GKR	422399	2363	5353	416362	2298	5372	426221	2321	5125	425595	2286	5153
	Kerala	877010	5124	5843	882290	5192	5885	910960	5336	5858	914370	5155	5638
	India	1538000	11241	7309	2E+06	11975	7324	2E+06	13300	7760	1833000	12952	7066

Source : Directorate of Economics and Statistics

Table 2.6.4

District wise Area, Production and Productivity of Rice in GKR

(Area in ha, Production in MT & Productivity in Kg/ha)

Sr. No.	District	1978-79			1979-80			1980-81			1981-82		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	50815	81499	1604	49895	80984	1623	50055	82189	1642	50406	83369	1654
2	Pathanamthitta	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Alappuzha	75501	135561	1795	80059	151277	1890	82466	144858	1757	88606	173162	1954
4	Kottayam	37449	65663	1753	32928	61805	1877	31948	58478	1830	34428	64603	1876
5	Idukki	8832	15784	1787	7826	14997	1916	9261	15503	1674	8957	16108	1798
6	Ernakulam	100165	150424	1502	101155	146519	1448	102500	144601	1411	100884	148995	1477
7	Trichur	115787	153033	1322	110654	154508	1396	110314	147571	1338	115511	155473	1346
8	Palakkad	174413	349326	2003	178761	381561	2134	183634	373782	2035	180878	385389	2131
	GKR	562962	951290	1681	561278	991651	1755	570178	966982	1670	579670	1027099	1748
	Kerala	799238	1272743	1592	793266	1299695	1638	801699	1271962	1587	806851	1339393	1660
		1982-83			**1983-84**			**1984 -85**			**1985-86**		
1	Kollam	49601	85846	1731	47880	69737	1456	37563	58929	1569	34794	60835	1748
2	Pathanamthitta	NA	NA	NA	NA	NA	NA	17439	35920	2060	14498	27715	1912
3	Alappuzha	83862	149768	1786	79050	152797	1933	73610	140514	1909	56045	111971	1998
4	Kottayam	34596	83544	2415	34801	70027	2012	31990	66572	2081	31884	58104	1822
5	Idukki	9249	20625	2230	8072	13863	1717	8475	17401	2053	8251	16845	2042
6	Ernakulam	96010	149818	1560	86732	119054	1373	89183	149199	1673	84804	142756	1683
7	Trichur	107711	149393	1387	103391	155121	1500	102540	147381	1437	95215	151936	1596
8	Palakkad	173158	365211	2109	168034	339365	2020	166312	350470	2107	160855	306980	1908
	GKR	**554187**	**1004205**	**1888**	**527960**	**919964**	**1716**	**527112**	**966386**	**1861**	**486346**	**877142**	**1839**
	Kerala	**778490**	**1306197**	**1678**	**740086**	**1207916**	**1632**	**730379**	**1255902**	**1720**	**678281**	**1173051**	**1729**

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Table 2.6.4 Contd...

Sr. No	District	1986-87			1987-88			1988-89			1989-90		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	32824	54741	1668	30227	53496	1770	27876	45974	1649	31074	59093	1902
2	Pathanamthitta	13130	24456	1863	14102	33490	2375	13537	30092	2223	13949	31921	2288
3	Alappuzha	67838	117799	1736	60763	123122	2026	64404	123723	1921	64534	145133	2249
4	Kottayam	33603	67907	2021	29854	66062	2213	28661	60978	2128	30063	71175	2368
5	Idukki	7085	14962	2112	5368	10657	1985	5206	11222	2156	4914	11554	2351
6	Ernakulam	80817	131063	1622	79818	119810	1501	71266	118566	1664	69801	120101	1721
7	Trichur	89527	143297	1601	84176	130887	1555	78862	122894	1558	74451	124698	1675
8	Palakkad	154864	209976	1356	144665	266049	1839	142293	273758	1924	146739	328812	2241
	GKR	**479688**	**764201**	**1747**	**448973**	**803573**	**1908**	**432105**	**787207**	**1903**	**435525**	**892487**	**2099**
	Kerala	**663803**	**1133786**	**1708**	**604082**	**1032605**	**1709**	**577557**	**1012558**	**1753**	**583389**	**1141231**	**1956**
		1990-91			**1991-92**			**1992-93**			**1993-94**		
1	Kollam	30513	58385	1913	27619	46086	1669	28460	54576	1918	26775	50265	1877
2	Pathanamthitta	14234	33226	2334	13153	30517	2320	12892	33826	2624	12191	29852	2449
3	Alappuzha	60675	131663	2170	55872	116089	2078	53344	123178	2309	50781	110870	2183
4	Kottayam	26257	62719	2389	23855	55166	2313	25448	60798	2389	24696	59860	2424
5	Idukki	5078	10953	2157	4851	10932	2254	4397	9188	2090	3648	7651	2097
6	Ernakulam	63078	102689	1628	65001	109484	1684	66158	113927	1722	61287	101346	1654
7	Trichur	74038	129287	1746	69065	121723	1762	67151	119337	1777	63508	109626	1726
8	Palakkad	145687	324907	2230	147066	344738	2344	146095	335646	2297	139769	316947	2268
	GKR	**419560**	**853829**	**2071**	**406482**	**834735**	**2053**	**403945**	**850476**	**2141**	**382655**	**786417**	**2085**
	Kerala	**559450**	**1086578**	**1942**	**541327**	**1060350**	**1959**	**537608**	**1084878**	**2018**	**507832**	**1003938**	**1977**
	All India	**Not Available**			**42649000**	**74678000**	**1751**	**41775000**	**72867000**	**1744**	**4.3E+07**	**80298000**	**1888**

Contd...

Table 2.6.4 Contd...

Sr. No	District	1994-95			1995-96			1996-97			1997-98		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	25202	46829	1858	23252	45370	1951	22223	42237	1901	20023	36051	1800
2	Pathanamthitta	11045	24984	2262	10860	27210	2506	10985	23690	2157	8267	18534	2242
3	Alappuzha	54864	99240	1809	44132	121047	2743	41447	85192	2055	43220	95128	2201
4	Kottayam	25006	56102	2244	24878	55609	2235	20200	43728	2165	13754	29029	2111
5	Idukki	4696	10098	2150	4660	10817	2321	5099	10578	2075	4068	8468	2082
6	Ernakulam	60018	101048	1684	56533	101951	1803	53968	93352	1730	46152	74234	1608
7	Trichur	62144	114060	1835	58703	110698	1886	51544	104966	2036	40977	82991	2025
8	Palakkad	140066	313768	2240	135630	280405	2067	128359	294065	2291	120809	262494	2173
	GKR	**383041**	**766129**	**2010**	**358648**	**753107**	**2189**	**333825**	**697808**	**2051**	**297270**	**606929**	**2030**
	Kerala	**503290**	**975065**	**1937**	**471150**	**953026**	**2023**	**430826**	**871361**	**2023**	**387122**	**764610**	**1975**
	India	**42814000**	**81814000**	**1911**	**42837000**	**76975000**	**1797**	**4.3E+07**	**81312000**	**1879**	**Not available**		

Source: Directorate of Economics and Statistics

Table.2.6.5

Yearly District wise Area, Production and Productivity of Rubber in GKR from 1978-79 to 1995-96

(Area in ha, Production in MT & Productivity in Kg/ha)

Sr. No.	District	1978-79			1979-80			1980-81			1981-82		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	34933	24060	689	34674	24651	711	38890	25561	657	38890	25984	668
2	Pathanamthitta	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Alappuzha	3875	1730	446	4030	2687	667	4273	2771	648	4273	2767	648
4	Kottayam	55931	32187	575	55805	35373	634	63232	36145	572	63232	36842	583
5	Idukki	15802	10140	642	16069	10764	670	17449	11140	638	17449	11487	658
6	Ernakulam	21311	11421	536	21488	13551	631	23334	13929	597	23334	13934	597
7	Trichur	8950	6156	688	8963	6978	779	9386	6739	718	9386	6083	648
8	Palakkad	9347	4313	461	9372	4386	468	11084	4516	407	11084	4380	395
	GKR	**150149**	**90007**	**577**	**150401**	**98390**	**651**	**167648**	**100801**	**605**	**167648**	**101477**	**600**
	Kerala	**214415**	**123677**	**577**	**215474**	**136619**	**634**	**237769**	**140333**	**590**	**237769**	**139455**	**587**
		1982-83			**1983-84**			**1984-85**			**1985-86**		
1	Kollam	38666	26812	693	34253	20486	598	30208	20046	664	36033	19817	550
2	Pathanamthitta				16674	9973	598	22098	14319	648	28343	15041	531
3	Alappuzha	4814	2917	606	3447	2062	598	5580	3199	573	3768	2722	722
4	Kottayam	62454	39681	635	72396	43299	598	78739	49207	625	83644	50271	601
5	Idukki	24285	14543	599	21938	13121	598	28794	17780	617	31063	14711	474
6	Ernakulam	25316	15639	618	27580	16498	598	34319	21727	633	37769	19419	514
7	Trichur	9445	6283	665	10760	6437	598	11019	7507	681	9493	6412	675
8	Palakkad	13866	5435	392	10800	6463	598	13013	6879	529	14769	7150	484
	GKR	**178846**	**111310**	**601**	**197848**	**118339**	**598**	**223770**	**140664**	**621**	**244882**	**135543**	**569**
	Kerala	**256283**	**152662**	**596**	**271200**	**162212**	**598**	**311976**	**188900**	**605**	**330315**	**184700**	**559**

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Table 2.6.5. Contd...

Sr. No.	District	1986-87			1987-88			1988-89			1989-90		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	37288	21418	574	30186	22125	733	31560	24226	768	34241	27563	805
2	Pathanamthitta	28709	17416	607	32990	19343	586	34794	20693	595	38213	23548	616
3	Alappuzha	3831	2948	770	3459	3108	899	3492	3444	986	3223	3881	1204
4	Kottayam	88853	54583	614	101727	57074	561	104254	61221	587	104105	68556	659
5	Idukki	27734	15913	574	32076	16543	516	34396	17540	510	37759	21939	581
6	Ernakulam	43057	21816	507	51302	23863	465	54940	26554	483	57527	30609	532
7	Trichur	10048	6580	655	8992	7617	847	8784	8451	962	7778	9710	1248
8	Palakkad	17334	8143	470	16843	8866	526	19325	10667	552	20872	12819	614
	GKR	**256854**	**148817**	**596**	**277575**	**158539**	**642**	**291545**	**172796**	**680**	**303718**	**198625**	**782**
	Kerala	**347814**	**202129**	**581**	**358957**	**216562**	**603**	**379666**	**238414**	**628**	**396474**	**275397**	**695**
		1990-91			**1991-92**			**1992-93**			**1993-94**		
1	Kollam	30076	32092	1067	31146	29623	951	32819	31346	955	34067	34315	1007
2	Pathanamthitta	43715	25681	587	47705	38691	811	50492	41902	830	45857	45616	995
3	Alappuzha	2901	4370	1506	2781	2470	888	2569	2538	988	3517	2804	797
4	Kottayam	107937	73854	684	108851	89895	826	110997	96650	871	107647	105198	977
5	Idukki	34595	24479	708	36772	29248	795	35785	31721	886	36628	34286	936
6	Ernakulam	60913	34148	561	63406	13308	210	65757	47324	720	54270	53395	984
7	Trichur	6861	11001	1603	6753	20152	2984	7571	10592	1399	12264	12639	1031
8	Palakkad	24045	14660	610	24893	15312	615	25531	15786	618	24773	18389	742
	GKR	**311043**	**220285**	**916**	**322307**	**238699**	**1010**	**331521**	**277859**	**908**	**319023**	**306642**	**934**
	Kerala	**411615**	**307521**	**747**	**425768**	**343109**	**806**	**444096**	**368646**	**830**	**437100**	**408311**	**934**

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Table 2.6.5 Contd...

Sr. No.	District	1994-95			1995-96		
		Area	Production	Productivity	Area	Production	Productivity
1	Kollam	34771	36773	1058	35347	38821	1098
2	Pathanamthitta	46122	49924	1082	47063	52974	1126
3	Alappuzha	3543	2973	839	3573	3135	877
4	Kottayam	108433	113225	1044	109582	120946	1104
5	Idukki	37041	36540	986	37240	38356	1030
6	Ernakulam	54803	58206	1062	55247	62159	1125
7	Trichur	12493	13790	1104	12254	15513	1266
8	Palakkad	25428	20414	803	26031	22571	867
	GKR	**322634**	**331845**	**997**	**326337**	**354475**	**1062**
	Kerala	**443300**	**442830**	**999**	**448988**	**474555**	**1057**

Source: Directorate of Economics and Statistics

Table2.6.6

Yearly District wise Area, Production and Productivity of coffee in GKR from 1978-79 to 1995-96

(Area in ha, Production in MT and Productivity in kg/ha)

Sr. No.	District	1976-77			1977-78			1978-79			1979-80		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	78	16	205	107	40	374	109	41	376	378	282	746
2	Pathanamthitta	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Alappuzha	6	1	167	19	7	368	19	7	368	63	30	476
4	Kottayam	1305	259	198	1240	468	377	1252	472	377	902	673	746
5	Idukki	3546	705	199	4542	1712	377	4587	1729	377	5134	3712	723
6	Erkulam	280	55	196	172	65	378	174	66	379	172	128	744
7	Trichur	24	5	208	33	12	364	33	12	364	33	25	758
8	Palakkad	1965	788	401	1643	1380	840	1659	1394	840	2264	810	358
	GKR	**7204**	**1829**	**225**	**7756**	**3684**	**440**	**7833**	**3721**	**440**	**8946**	**5660**	**650**
	Kerala	**40502**	**15030**	**371**	**52644**	**27645**	**525**	**53345**	**28019**	**525**	**57949**	**30176**	**521**
		1980-81			**1981-82**			**1982-83**			**1983-84**		
1	Kollam	378	220	582	378	355	939	378	171	452	264	70	265
2	Pathanamthitta	NA	NA	NA	NA	NA	NA	NA	NA	NA	122	NA	NA
3	Alappuzha	63	23	365	21	20	952	21	10	476	15	4	267
4	Kottayam	902	525	582	958	901	941	953	433	454	986	262	266
5	Idukki	5134	2895	564	4827	4537	940	4783	2167	453	4874	1297	266
6	Erkulam	172	100	581	247	232	939	247	112	453	247	66	267
7	Trichur	33	20	606	33	30	909	33	15	455	33	9	273
8	Palakkad	2264	656	290	2351	1085	462	2351	1075	457	2351	760	323
	GKR	**8946**	**4439**	**510**	**8815**	**7160**	**869**	**8766**	**3983**	**457**	**8892**	**2468**	**275**
	Kerala	**57949**	**23540**	**406**	**57949**	**33655**	**581**	**57905**	**21785**	**376**	**62368**	**9465**	**152**

Contd....

Table 2.6.6 Contd...

Sr. No.	District	1984-85			1985-86			1986-87			1987-88		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	207	NA	NA	380	160	421	380	160	421	202	143	708
2	Pathamthitta	180	NA	NA	NA	NA	NA	NA	NA	NA	176	126	716
3	Alappuzha	16	NA	NA	23	10	435	23	10	435	23	16	696
4	Kottayam	990	NA	NA	1171	445	380	1171	445	380	1166	825	708
5	Idukki	4875	NA	NA	5770	2440	423	5770	2440	423	5667	4011	708
6	Erkulam	274	NA	NA	274	166	606	274	166	606	274	194	708
7	Trichur	33	NA	NA	32	14	438	32	14	438	32	23	719
8	Palakkad	2291	NA	NA	2292	969	423	2292	969	423	2291	1622	708
	GKR	**8866**	**NA**	**NA**	**9942**	**4204**	**446**	**9942**	**4204**	**446**	**9831**	**6960**	**709**
	Kerala	**64009**	**NA**	**NA**	**65641**	**23550**	**359**	**65641**	**23550**	**359**	**65637**	**22925**	**349**
		1988-89			**1989-90**			**1990-91**			**1991-92**		
1	Kollam	202	NA	NA	378	NA	NA	378	NA	NA	NA	NA	NA
2	Pathanamthitta	176	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Alappuzha	23	NA	NA	23	NA	NA	23	NA	NA	NA	NA	NA
4	Kottayam	1166	NA	NA	1385	NA	NA	1385	NA	NA	NA	NA	NA
5	Idukki	5667	NA	NA	10834	NA	NA	10834	3990	368	12588	2250	179
6	Erkulam	274	NA	NA	279	NA	NA	274	NA	NA	NA	NA	NA
7	Trichur	32	NA	NA	32	NA	NA	32	NA	NA	NA	NA	NA
8	Palakkad	2291	10470	4570	2292	5205	2271	2292	860	375	2290	1050	459
	GKR	**9831**	**10470**	**4570**	**15223**	**5205**	**2271**	**15218**	**4850**	**372**	**14878**	**3300**	**319**
	Kerala	**65637**	**47425**	**723**	**75057**	**21250**	**283**	**75057**	**20910**	**279**	**84016**	**20040**	**239**

Contd....

Table 2.6.6 Contd...

Sr. No.	District	1992-93			1993-94			1994-95			1995-96		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	NA	NA	NA	NA	NA	NA	NA	NA	NA	9	NA	NA
2	Pathanamthitta	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Alappuzha	NA	NA	NA	NA	NA	NA	NA	NA	NA	10	NA	NA
4	Kottayam	NA	NA	NA	NA	NA	NA	NA	NA	NA	824	NA	NA
5	Idukki	12580	3511	279	13058	8320	637	13058	8320	637	11908	9100	764
6	Erkulam	NA	NA	NA	NA	NA	NA	NA	NA	NA	274	NA	NA
7	Trichur	NA	NA	NA	NA	NA	NA	NA	NA	NA	32	NA	NA
8	Palakkad	2290	639	279	2291	1460	637	2291	1460	637	2291	2100	917
	GKR	**14870**	**4150**	**279**	**15349**	**9780**	**637**	**15349**	**9780**	**637**	**15348**	**11200**	**840**
	Kerala	**69130**	**36170**	**523**	**82348**	**46240**	**562**	**82348**	**46240**	**562**	**82348**	**45000**	**546**

Source: Directorate of Economics and Statistics

Table 2.6.7

Yearly District wise Area, Production and Productivity of Tea in GKR from 1978-79 to 1995-96

(Area in ha, Production in MT, Productivity in kg/ha)

Sr. No.	District	1976-77			1977-78			1978-79		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	2021	851	421	2007	852	425	2007	807	402
2	Pathanamthitta	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Alappuzha	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	Kottayam	2333	664	285	2327	844	363	2315	657	284
5	Idukki	24063	34340	1427	24023	37506	1561	24053	34219	1423
6	Erkulam	30	NA	NA	30	NA	NA	30	NA	NA
7	Trichur	438	913	2084	438	971	2217	438	995	2272
8	Palakkad	662	1275	1926	662	1389	2098	662	1334	2015
	GKR	**29547**	**38043**	**1229**	**29487**	**41562**	**1333**	**29505**	**38012**	**1279**
	Kerala	**36161**	**41644**	**1152**	**36112**	**51983**	**1439**	**36090**	**47365**	**1312**
		1979-80			**1980-81**			**1981-82**		
1	Kollam	2012	921	458	2004	875	437	1653	797	482
2	Pathanamthitta	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Alappuzha	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	Kottayam	2268	485	214	2268	367	162	2230	283	127
5	Idukki	24124	39197	1625	24156	37460	1551	23967	34871	1455
6	Erkulam	30	NA	NA	30	NA	NA	30	NA	NA
7	Trichur	442	1148	2597	441	1002	2272	447	912	2040
8	Palakkad	665	1305	1962	665	1219	1833	665	1187	1785
	GKR	**29541**	**43056**	**1371**	**29564**	**40923**	**1251**	**28992**	**38050**	**1178**
	Kerala	**36126**	**52434**	**1451**	**36164**	**50176**	**1387**	**35625**	**45467**	**1276**

Contd...

Table 2.6.7 Contd...

Sr. No.	District	1982-83			1983-84			1984-85		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	1552	681	439	687	215	313	681	174	256
2	Pathanamthitta	NA	NA	NA	740	NA	NA	734	188	256
3	Alappuzha	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	Kottayam	2137	289	135	2011	361	180	2009	421	210
5	Idukki	23838	34413	1444	23834	33360	1400	23804	41335	1736
6	Erkulam	2	NA	NA	2	NA	NA	2	NA	NA
7	Trichur	447	903	2020	447	692	1548	447	1296	2899
8	Palakkad	665	1349	2029	665	1114	1675	665	1374	2066
	GKR	**28641**	**37635**	**1213**	**28386**	**35742**	**1023**	**28342**	**44788**	**1237**
	Kerala	**35205**	**45439**	**1291**	**35021**	**44214**	**1262**	**34976**	**56329**	**1611**
		1985-86			**1986-87**			**1987-88**		
1	Kollam	600	200	333	600	222	370	600	166	277
2	Pathanamthitta	775	259	334	762	281	369	762	210	276
3	Alappuzha	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	Kottayam	2009	386	192	2009	170	85	2009	48	24
5	Idukki	23640	39514	1671	23609	38017	1610	23601	39864	1689
6	Erkulam	2	NA	NA	2	NA	NA	2	NA	NA
7	Trichur	447	1387	3103	447	1344	3007	447	1466	3280
8	Palakkad	665	1402	2108	665	1453	2185	685	952	1390
	GKR	**28138**	**43148**	**1290**	**28094**	**41487**	**1271**	**28106**	**42706**	**1156**
	Kerala	**34760**	**52628**	**1514**	**34639**	**50335**	**1453**	**34642**	**51952**	**1500**

Contd...

Table 2.6.7 Contd...

Sr. No.	District	1988-89			1989-90			1990-91		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	1362	412	302	1362	310	228	1362	423	311
2	Pathanamthitta	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Alappuzha	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	Kottayam	2007	67	33	2007	101	50	2009	324	161
5	Idukki	23589	56111	2379	23551	52476	2228	23557	46697	1982
6	Erkulam	2	NA	NA	2	NA	NA	2	NA	NA
7	Trichur	451	1613	3576	456	1537	3371	466	1503	3225
8	Palakkad	684	1945	2844	681	1689	2480	681	1697	2492
	GKR	**28095**	**60148**	**1827**	**28059**	**56113**	**1671**	**28077**	**50644**	**1634**
	Kerala	**34618**	**71133**	**2055**	**34605**	**65066**	**1880**	**34616**	**60638**	**1752**
		1991-92			**1992-93**			**1993-94**		
1	Kollam	1362	470	345	1362	254	186	1270	NA	NA
2	Pathanamthitta	NA	NA	NA	NA	NA	NA	91	254	2791
3	Alappuzha	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	Kottayam	2025	215	106	2036	214	105	2063	210	102
5	Idukki	23541	51125	2172	23337	40023	1715	23424	47568	2031
6	Erkulam	2	NA	NA	2	NA	NA	2	NA	NA
7	Trichur	466	1614	3464	466	1284	2755	486	1444	2971
8	Palakkad	688	1746	2538	744	1607	2160	825	1959	2375
	GKR	**28084**	**55170**	**1725**	**27947**	**43382**	**1384**	**28161**	**51435**	**2054**
	Kerala	**34623**	**66080**	**1909**	**34488**	**54435**	**1578**	**34793**	**61488**	**1767**

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Table 2.6.7 Contd...

Sr. No.	District	1994-95			1995-96		
		Area	Production	Productivity	Area	Production	Productivity
1	Kollam	1258	425	338	1258	343	273
2	Pathanamthitt	91	NA	NA	91	NA	NA
3	Alappuzha	NA	NA	NA	NA	NA	NA
4	Kottayam	2063	141	68	1947	148	76
5	Idukki	23435	47530	2028	23402	49473	2114
6	Erkulam	2	NA	NA	2	NA	NA
7	Trichur	496	1553	3131	505	1557	3083
8	Palakkad	825	2000	2424	829	1986	2396
	GKR	**28170**	**51649**	**1598**	**28034**	**53507**	**1588**
	Kerala	**34745**	**60715**	**1747**	**34605**	**64802**	**1873**

Source: Directorate of Economics and Statistics

Table.2.6.8

District wise Area, Production and Productivity of Pepper in GKR

(Area in ha, Production in MT & Productivity in Kg./Ha)

Sr. No.	District	1978-79			1979-80			1980-81			1981-82		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	10550	3123	296	9946	3620	364	9832	3441	350	9801	2784	284
2	Pathanamthitta	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Alappuzha	4614	1047	227	4493	1173	261	4843	1007	208	4816	968	201
4	Kottayam	13620	1076	79	12739	1388	109	12786	1777	139	12868	1686	131
5	Idukki	12026	1304	108	10841	2244	207	12264	1852	151	12182	2010	165
6	Ernakulam	7409	1660	224	6752	1837	272	6652	1264	190	6811	1117	164
7	Trichur	3527	977	277	3727	552	148	4010	690	172	4036	537	133
8	Palakkad	1352	314	232	1471	197	134	1532	170	111	1546	187	121
	GKR	**53098**	**9501**	**206**	**49969**	**11011**	**214**	**51919**	**10201**	**189**	**52060**	**9289**	**171**
	Kerala	**106743**	**26331**	**247**	**105817**	**28903**	**273**	**108073**	**28519**	**264**	**108242**	**27511**	**254**
		1982-83			**1983-84**			**1984-85**			**1985-86**		
1	Kollam	10196	2712	266	7457	1723	231	7515	1394	185	7886	2979	378
2	Pathanamthitta				3905	738	189	4276	970	227	4681	1524	326
3	Alappuzha	4816	535	111	3860	513	133	3644	846	232	3642	648	178
4	Kottayam	12286	2211	180	12646	2390	189	11762	933	79	11705	1074	92
5	Idukki	12182	1888	155	12209	2234	183	12819	1778	139	21417	4837	226
6	Ernakulam	6532	882	135	6665	1560	234	6191	547	88	6307	1083	172
7	Trichur	4173	826	198	4073	823	202	3780	677	179	3739	566	151
8	Palakkad	1546	240	155	1523	174	114	1665	263	158	1736	486	280
	GKR	**51731**	**9294**	**171**	**52338**	**10155**	**184**	**51652**	**7408**	**161**	**61113**	**13197**	**225**
	Kerala	**107476**	**24526**	**228**	**106143**	**24549**	**231**	**108835**	**17350**	**159**	**121565**	**33121**	**272**

Contd....

Table 2.6.8 Contd...

Sr. No.	District	1986-87			1987-88			1988-89			1989-90		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
1	Kollam	7166	1509	211	7761	2961	382	8116	2432	300	8198	3589	438
2	Pathanamthitta	4255	1201	282	4908	2018	411	5148	1454	282	5578	2154	386
3	Alappuzha	3353	1046	312	2775	872	314	2977	553	186	2848	695	244
4	Kottayam	11385	1570	138	10014	1441	144	10278	1145	111	10210	1724	169
5	Idukki	28931	4958	171	32794	13300	406	35050	16745	478	39107	18947	484
6	Ernakulam	6233	874	140	7324	1770	242	7429	1048	141	7251	1108	153
7	Trichur	3876	977	252	4481	1275	285	4711	573	122	5472	857	157
8	Palakkad	1507	216	143	2051	375	183	2243	220	98	2448	311	127
	GKR	**66706**	**12351**	**206**	**72108**	**24012**	**296**	**75952**	**24170**	**215**	**81112**	**29385**	**270**
	Kerala	**128865**	**30378**	**236**	**146081**	**46819**	**321**	**157006**	**43241**	**275**	**167104**	**54135**	**324**
		1990-91			**1991-92**			**19892-93**			**1993-94**		
1	Kollam	8101	2912	359	7869	2389	304	8164	2529	310	9002	2798	311
2	Pathanamthitta	5409	1585	293	4884	1708	350	5117	1814	355	4466	1501	336
3	Alappuzha	2316	274	118	2018	233	115	1947	205	105	1727	197	114
4	Kottayam	10912	2002	183	10546	1742	165	9704	1568	162	8783	1712	195
5	Idukki	34759	14096	406	38070	14437	379	39163	14195	362	38962	13263	340
6	Ernakulam	6977	1276	183	6725	1264	188	6963	1351	194	6038	1202	199
7	Trichur	5657	1070	189	5747	958	167	5596	972	174	5171	800	155
8	Palakkad	2754	345	125	3024	382	126	3359	407	121	3749	491	131
	GKR	**76885**	**23560**	**232**	**78883**	**23113**	**224**	**80013**	**23041**	**223**	**77898**	**21964**	**223**
	Kerala	**168507**	**46802**	**278**	**178126**	**50309**	**282**	**183478**	**49666**	**271**	**184410**	**49845**	**270**
	India				**184000**	**52000**	**283**	**189000**	**50800**	**269**	**191000**	**51300**	**269**

Contd....

Table 2.6.8 Contd...

Sr. No.	District	1994-95			1995-96		
		Area	Production	Productivity	Area	Production	Productivity
			1994-95			1995-96	
1	Kollam	8148	2731	335	9130	2748	301
2	Pathanamthitta	4792	1599	334	4718	1701	361
3	Alappuzha	2008	274	136	1982	405	204
4	Kottayam	7906	1018	129	7687	1378	179
5	Idukki	42858	17065	398	45011	22551	501
6	Ernakulam	6799	1291	190	7010	1311	187
7	Trichur	4983	745	150	5222	721	138
8	Palakkad	3206	369	115	3460	451	130
	GKR	**80700**	**25092**	**223**	**84220**	**31266**	**250**
	Kerala	**186720**	**59256**	**317**	**191596**	**68568**	**358**
	India	**193000**	**60700**	**315**	**198000**	**NA**	**NA**

Source: Directorate of Economics and Statistics

Table 2.6.9

Area, Production and Productivity of Cardamom in Kerala, Karnataka and Tamilnadu

	1989-90			1992-93		
States	**Area (1000 ha)**	**Production (1000 MT)**	**Productivity (Kg/ha)**	**Area (1000 ha)**	**Production (1000 MT)**	**Productivity (Kg/ha)**
Kerala	44.01 (33.91)	1.9	56	43.34 (31.89)	2.57	81
Karnataka	30.93 (19.90)	0.75	38	32.88 (25.25)	1.2	48
Tamilnadu	6.17 (4.36)	0.45	102	6.13 (4.00)	0.48	120
Total	81.11 (58.17)	3.10	53	82.39 (61.14)	4.25	70

Table 2.6.10

Area, Production and Productivity of Vegetables, Fruits and Banana in GKR and Kerala during 1978-79 and 1995-96

Food Items	GKR			KERALA		
	Area (ha)	Production (MT)	Productivity (kg/ha)	Area (ha)	Production (MT)	Productivity (kg/ha)
1978-79						
Chillies	71	63	887	791	719	909
Drumstic	7151	NA	NA	14931	NA	NA
Vegetables excluding tubers	174863	NA	NA	343041	NA	NA
Mango	32789	127575	3693	61498	267231	4345
Jack	30621	123999	4013	59899	251140	4193
Banana	8104	105634	12781	13518	171493	12686
Other plantains	25112	313504	12431	39824	488178	12258
Pineapple	3390	NA	NA	5938	NA	NA
Pappaya	NA	NA	NA	NA	NA	NA
1995-96						
Chillies	227	243	1070	427	495	1159
Drumstic	8952	11146	1163	21452	23120	1078
Vegetables excluding tubers	53226	NA	NA	85122	NA	NA
Mango	35200	96115	5250	81874	253911	3101
Jack	31895	129760	4081	79186	288931	3649
Banana	14259	198835	14492	26267	362919	13817
Other plantains	27704	142481	5280	46594	229493	4925
Pineapple	5865	51837	8464	7490	63800	8518
Pappaya	6893	32272	4626	13243	57479	4340

Source : Directorate of Economics and Statistics

Table.2.6.11

District-wise Percentage Distribution of Operational Holdings according to Holding Size Classes in GKR, Kerala and India in 1990-91

Districts	Holding Size Classes (ha)							All sizes	Total Number
	Marginal (<1 ha)			Small (1 - 2 ha)	Semi medium (2 - 4 ha)	Medium (4 - 10 ha)	Large (>10 ha)		
	< 0.02	0.02 - 0.5	0.5 - 1						
Kollam	13.64	77.02	6.37	2.47	0.43	0.06	0.01	100	479220
Pathanamthitta	8.72	72.31	11.64	5.76	1.29	0.21	0.07	100	247629
Alappuzha	11.33	79.34	5.91	2.5	0.75	0.15	0.02	100	398589
Kottayam	11.24	67.42	10.29	7.33	2.97	0.64	0.11	100	344646
Idukki	16.98	47.62	16.98	14.02	3.52	0.69	0.19	100	242396
Ernakulam	17.55	70.74	6.2	3.96	1.31	0.22	0.02	100	509862
Trichur	11.75	75.28	8.14	3.71	0.97	0.13	0.02	100	509339
Palakkad	11.46	67.63	9.21	7.07	3.6	0.98	0.05	100	431721
GKR	**12.83**	**69.67**	**9.34**	**5.85**	**1.86**	**0.39**	**0.06**	**100**	**3163402**
Kerala	**11.72**	**72.23**	**8.61**	**5.18**	**1.80**	**0.40**	**0.06**	**100**	**5419189**
India			**58.07**	**18.3**	**13.56**	**8.1**	**1.97**	**100**	**97730000**

Source: Agricultural Census, 1990-91 Directorate of Economics and Statistics

Table.2.6.12

District-wise Percentage Distribution of Total Area of Operational Holdings in the Different Holding Size Groups in GKR, Kerala and India in 1990-91

District	Holding Size Classes (ha)							All sizes	Total area
	Marginal (<1 ha.)			Small (1 - 2 ha)	Semi medium (2 - 4 ha)	Medium (4 - 10 ha)	Large (>10 ha)		
	<0.02	0.02 - 0.5	0.5 - 1						
Kollam	0.91	52.66	22.73	15.32	5.55	1.59	0.24	100	93946
Pathanamthitta	0.37	35.42	24.68	23.28	9.89	3.42	2.94	100	82470
Alappuzha	0.77	46.49	20.80	16.74	9.68	4.24	1.28	100	80727
Kottayam	0.36	23.19	18.63	25.60	18.75	8.59	4.88	100	141871
Idukki	0.35	15.94	21.78	32.12	15.30	6.65	7.86	100	136983
Ernakulam	1.03	34.70	20.45	22.61	14.47	4.90	1.84	100	118527
Trichur	0.69	38.86	24.42	21.22	10.48	2.82	1.51	100	119973
Palakkad	0.37	21.38	16.24	23.85	22.55	12.31	3.30	100	179720
GKR	**0.61**	**33.58**	**21.22**	**22.59**	**13.33**	**5.57**	**2.98**	**100**	**954217**
Kerala	**0.46**	**29.70**	**18.65**	**21.17**	**14.08**	**6.26**	**9.68**	**100**	**1801823**
India			**13.18**	**15.58**	**22.32**	**28.68**	**20.25**	**100**	**163910000**

Source: Agricultural Census, 1990-91 Directorate of Economics and Statistics

Table 2.6.13

Intensity of Cropping in Different Districts of GKR and Kerala : 1960-61 to 1992-93

Sr. No	District	Net Sown Area (ha)	Total Cropped Area	Intensity of Cropping (%)
1	Kollam	143116	218826	153
2	Pathanamthitta	99585	127792	128
3	Alappuzha	105027	162580	155
4	Kottayam	181175	235778	130
5	Idukki	187161	207121	111
6	Ernakulam	182229	251100	138
7	Trichur	154692	211748	137
8	Palakkad	218456	351517	161
	GKR	**1271441**	**1766462**	**139**
	Kerala	**2249593**	**3046471**	**135**

Source : Agricultural Statistics, 1992-93

Table 2.6.14

Source Wise Net Area Irrigated : 1995-96

Area in ha

District	Govt. Canals	Private Canals	Govt. Tanks	Private Tanks	Govt. Wells	Private Wells	Minor & Lift Irriga-tion	Other Sourc -es	Total	% to the Total Area
Kollam	315	17	20	108	16	1010	174	327	1987	0.79
Pathanamthitta	940	83	5	64	29	431	1,010	2864	5426	2.02
Alappuzha	2224	106	823	14907	771	1210	2082	10283	32406	23.82
Kottayam	1934	174	220	198	18	334	760	5536	9174	4 18
Idukki	1025	200	34	407	10	179	382	2841	5078	0.99
Ernakulam	21123	396	274	2,258	227	10,114	7307	8807	50506	21.46
Trichur	19059	756	462	10310	174	19711	4665	15948	71085	23.74
Palakkad	49231	241	190	5006	56	11579	1802	5143	73248	16.69

Source: Directorate of Economics & Statistics

Table 2.6.15

Details of Minor Irrigation Projects

Sr. No.	Name of the Scheme	District	Type of Tank	Ayacut Area (ha)
1.	Ayiravallikonam	Kollam	Tank	40
2.	Pathikkottu *Chira*	Kollam	Tank	25
3.	Ponakannur	Kollam	Tank	60
4.	Kundamon *Chira*	Kollam	Tank	50
5.	Kadali *Chira*	Trichur	Tank	72
6.	Chullikkottu kadavu	Trichur	Tank	20
7	Edatharapady	Pathanamthitta	VCB	12.5
8.	Manakuppa	Pathanamthitta	VCB	13
9.	Chemplavu	Kottayam	lift	40

Table 2.6.16

Major Food Items in Kerala- Requirement and Availability

Food Item	Per Capita Requirement (g/week)	Total Requirement (1000 MT)		Total Availability (1000 MT)	
		1991	1996	1991	1996
Rice	2249	3403	3637	1087	953
Other cereals	228	345	369	4	6
Pulses	108	163	175	16	15
Tapioca	245	371	396	3803	2602
Vegetables	499	755	807	#143	#154
Milk	521	788	843	1690	2246
Sugar	192	291	311	0	0
Tea	20	30	32	61	65
Coffee	8	12	13	21	22
Gur	19	29	31	52	51
Fish	308	466	498	607	581
Meat	60	91	97	117	138
Cooking Oil	59	89	95	--	--
Eggs (million)	*0.56	847	905	1550	1991
Coconut (million)	*0.93	1407	1504	4232	5906

Vegetable: pine apple, sweet potato, papaya and drum stick
* Egg and Coconut in numbers

Table 2.6.17

District-wise Livestock Population (1987)

Livestock	District						
	Alapuzha	Ernakulam	Idukki	Kottayam	Pathana-mthitta	Thrissur	GKR
Cattle	199824	323854	192311	276044	219985	263691	1475709
Buffaloes	5347	18507	20863	5972	4646	43692	99027
Goats	86373	116382	74000	126040	68367	132842	604004
Sheep	2746	944	2258	1333	1413	1072	9766
Pigs	306	15900	38610	42013	1311	3959	102099
Others	3724	6034	3707	7395	2863	4774	28497
Total Live Stock	**298320**	**481621**	**331749**	**458797**	**298585**	**450030**	**2319102**
Total Poultry	**1290625**	**1849277**	**688331**	**1572041**	**974546**	**1723459**	**8098279**

Table 2.6.18

Details of District-wise Livestock Population (1987)

Sr. No.	Livestock	Alappuzha	Ernakulam	Idukki	Kottayam	Pathanam-thitha
1.	Cattle	5347*	-	-	276044	219985
a	Crossbreed	-	-	-	-	-
	Male	-	21041	16709	-	-
	Female	-	155328	105528	-	-
	Breedable	-	90692	65555	-	-
b.	Nondescript	-	-	-	-	-
	Male	-	21608	11485	-	-
	Female	-	127177	58499	-	-
	Breedable	-	71020	35888	-	-
2.	Buffalo	-	-	-	5973	4646
	Male	-	6886	3571	-	-
	Female	-	11621	16586	-	-
	Breedable	-	71020	11188	-	-
3	Sheep	2746	-	-	1333	1413
	Male	-	944	2258	-	-
	Female	-	25034	19089	-	-
4.	Fowls	-	-	-	1572041*	924006
	Desi	3724	1321874	607961	-	-
	Improved	1012722	301642	67034	-	-
5	Goats	86373	91348	54916	126040	68367
6	Pigs	306	15897	43610	42013	1311
7	Ducks	274179	180389	8747	-	47677
8	Dogs	67284	127146	113070	-	71793
9	Rabbits	3313	-	-	-	5055
10	Donkey	-	-	-	-	3
11	Others	3724	-	-	7395	2863

5347* includes cattle and buffalo both; 1572041* includes fowls and ducks both

- Data not available

Source : Secondary data collected by CESS

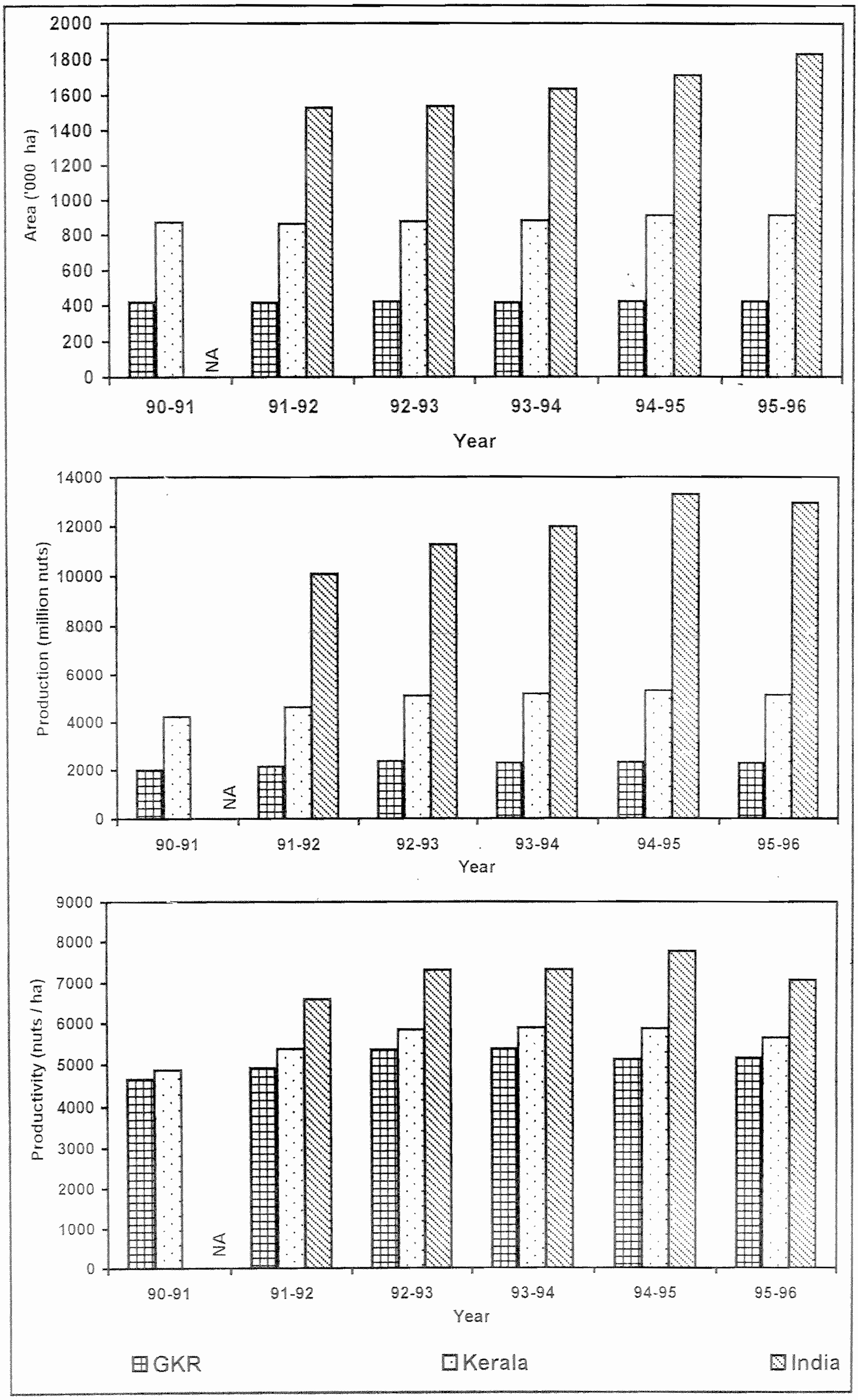

Fig. 2.6.1 : Yearly Area, Production and Productivity of Coconut in GKR, Kerala and India

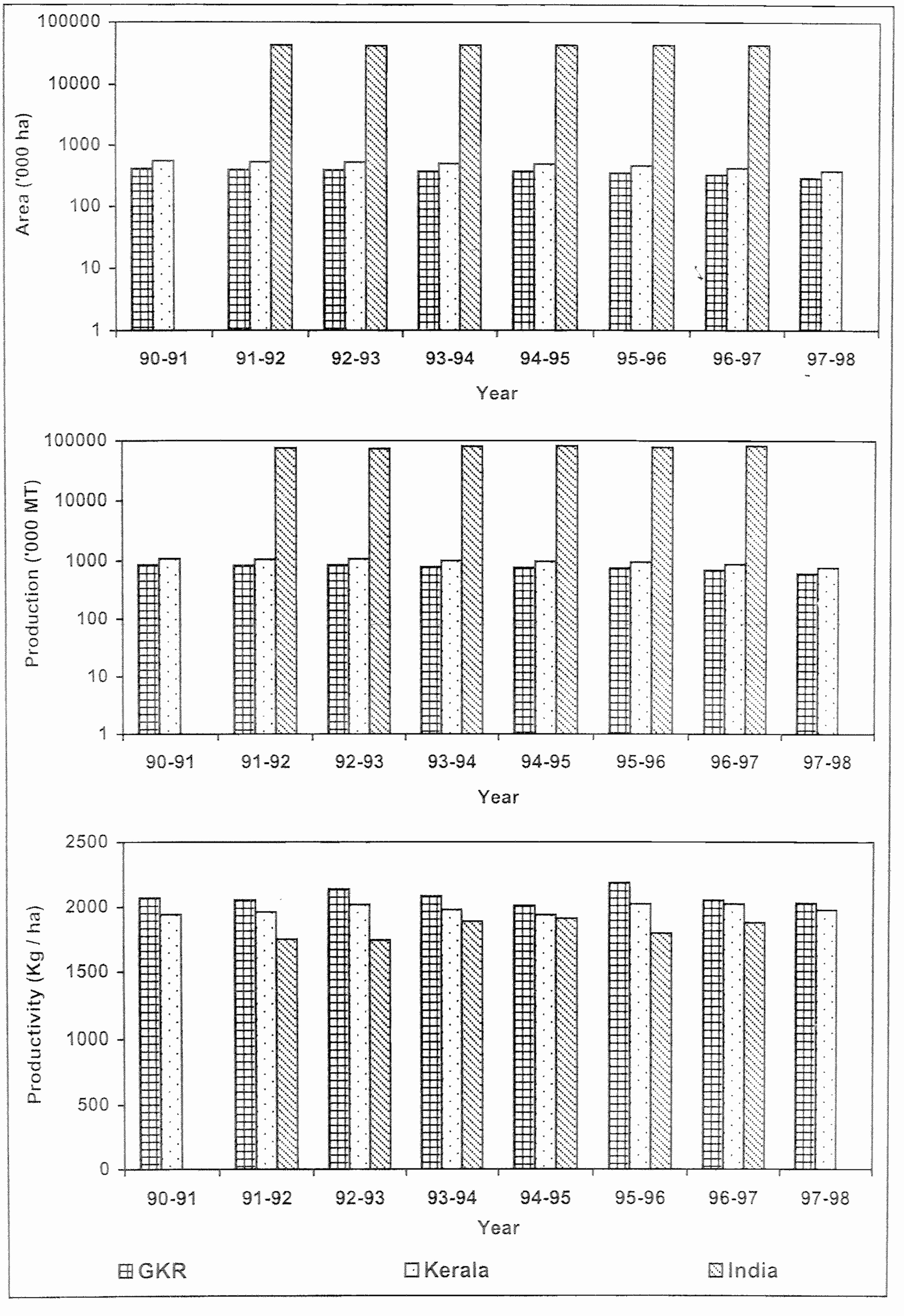

Fig. 2.6.2 : Yearly Area, Production and Productivity of Rice in GKR, Kerala and India

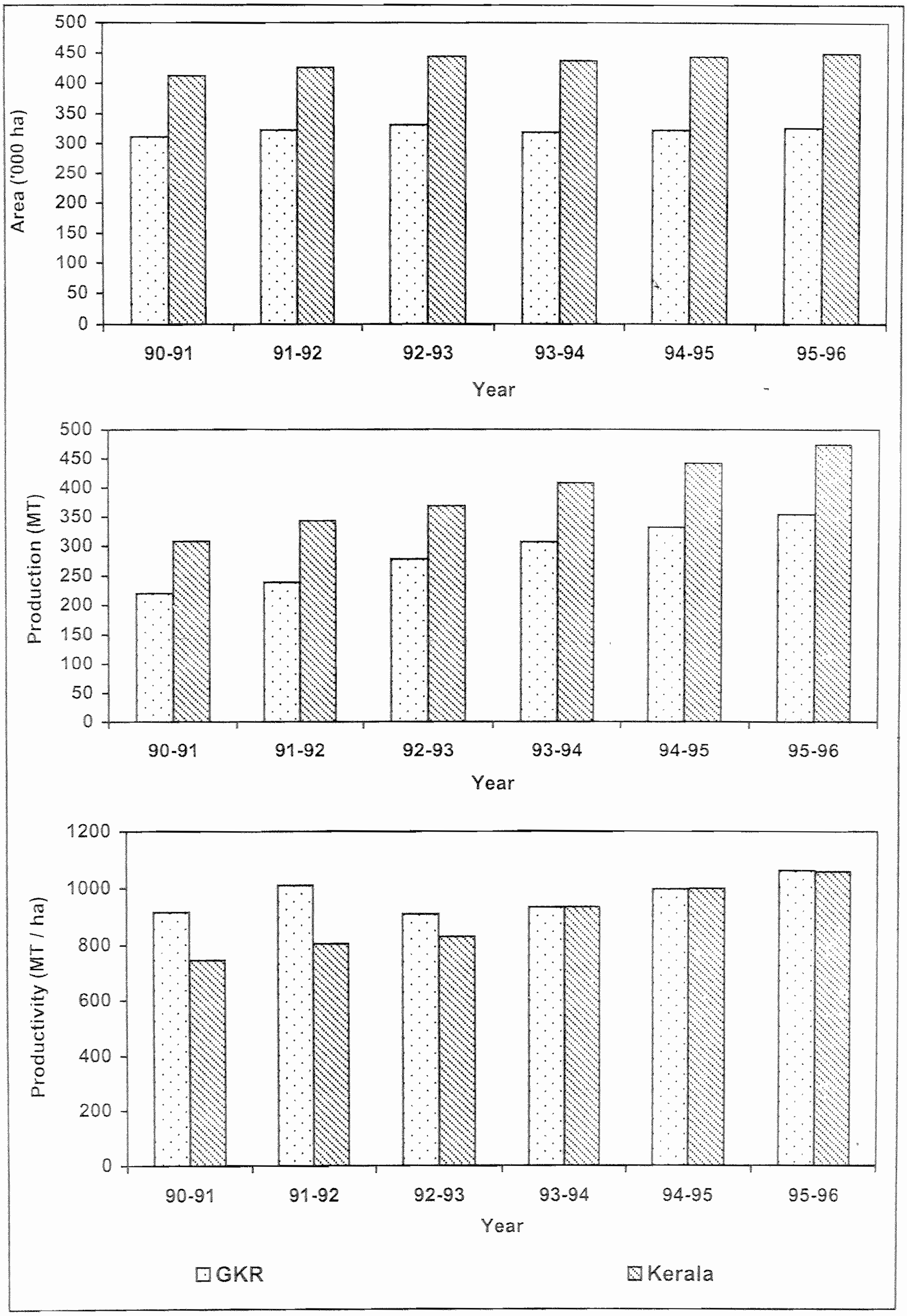

Fig. 2.6.3 : Yearly Area, Production and Productivity of Rubber in GKR and Kerala

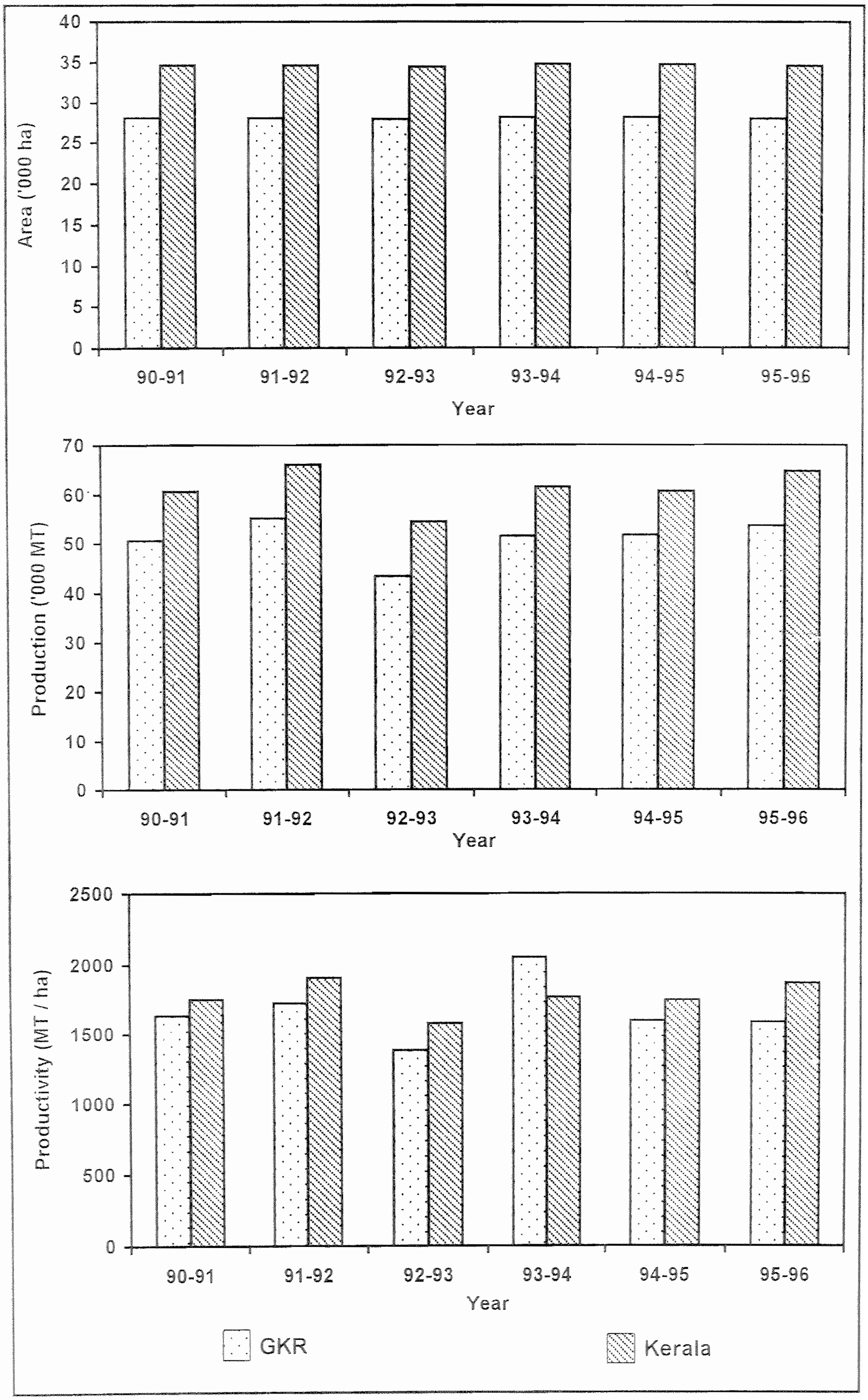

Fig. 2.6.4 : Yearly Area, Production and Productivity of Coffee in GKR and Kerala

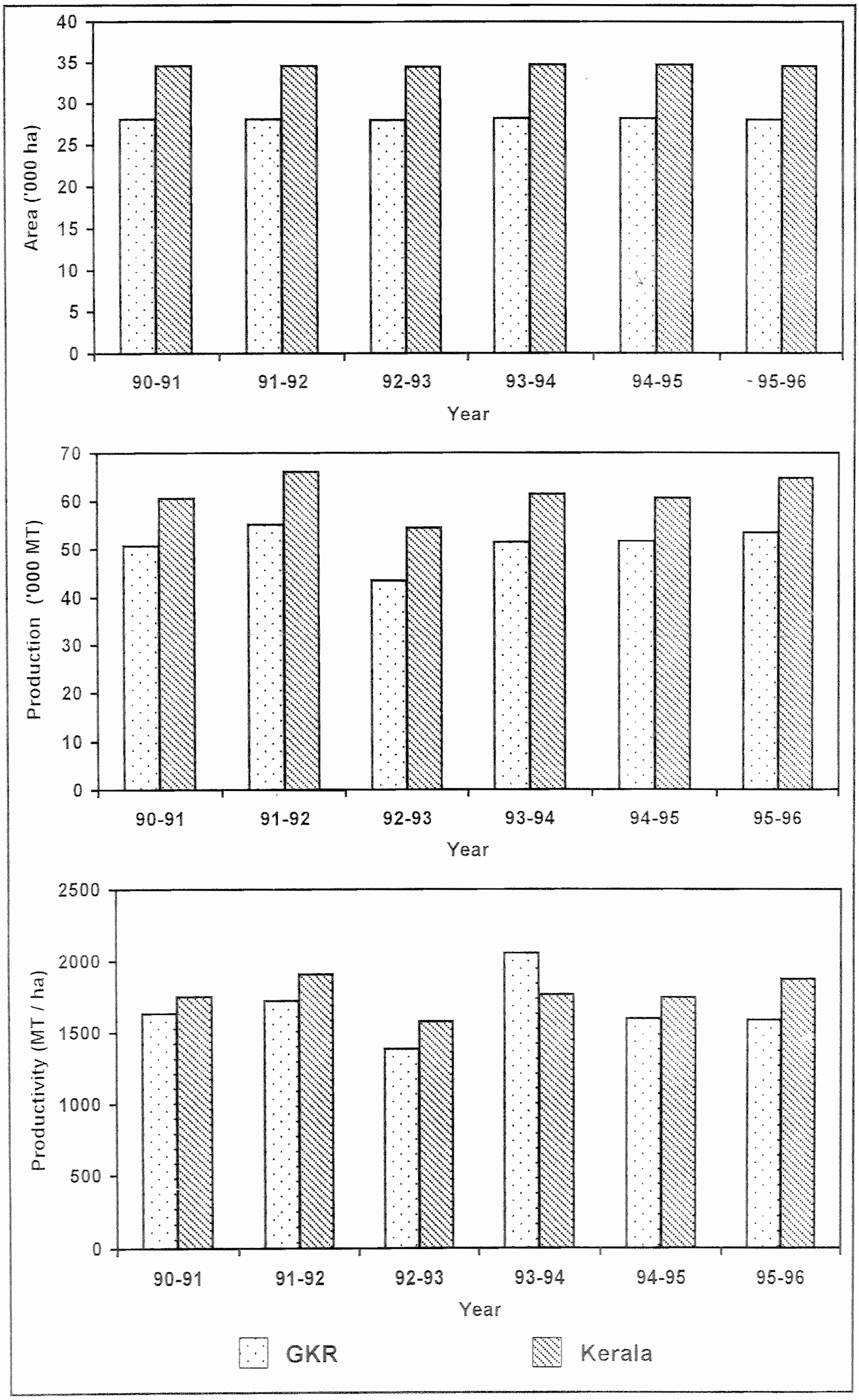

Fig. 2.6.5 : Yearly Area, Production and Productivity of Tea in GKR and

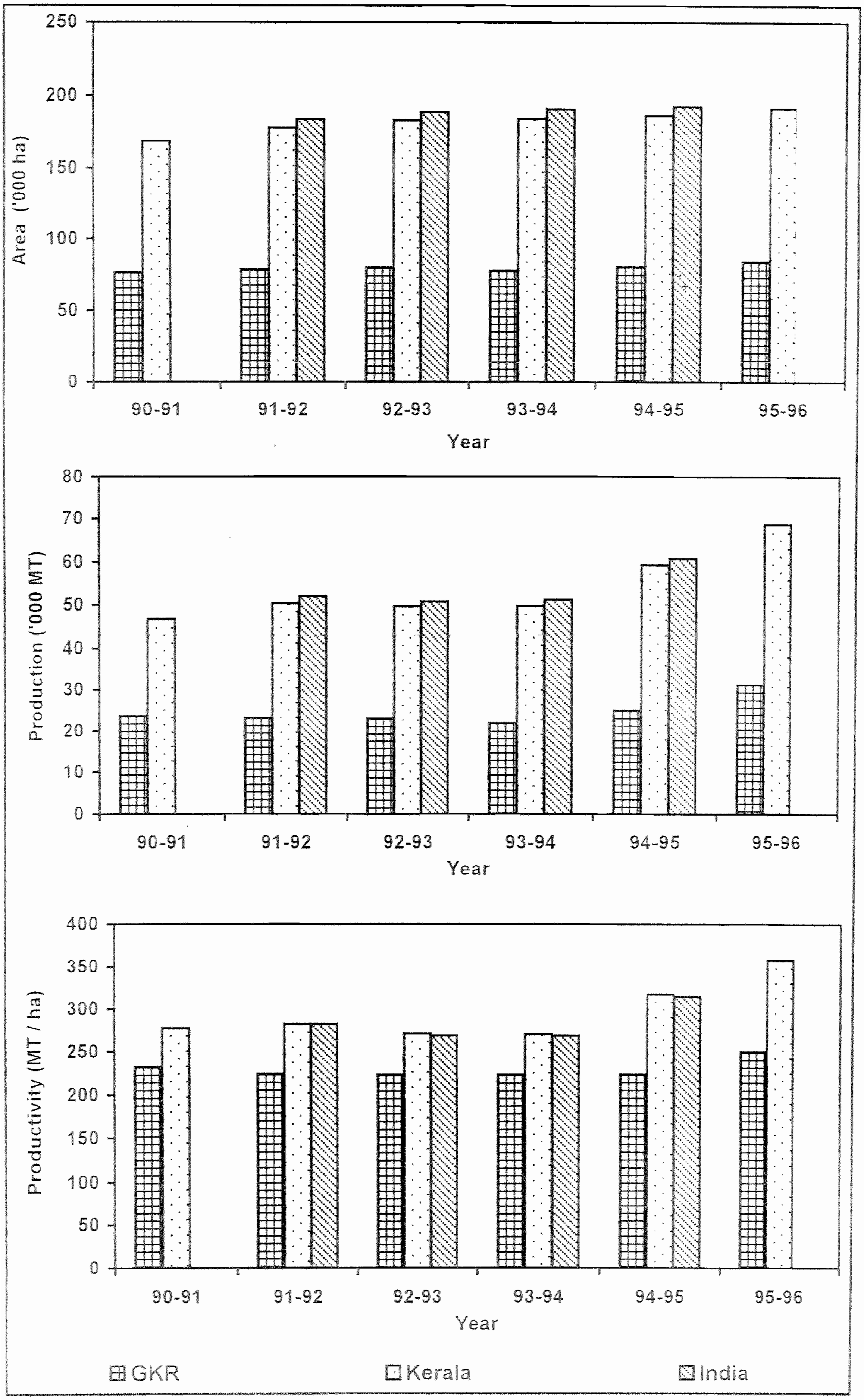

Fig. 2.6.6 : Yearly Area, Production and Productivity of Pepper in GKR, Kerala and India

2.7 Energy Base in Kerala

2.7.1 Conventional Energy Sources

Kerala State is relatively poor in energy generation, as it doesn't have any known reserves of coal, oil or natural gases, and the main source of electricity is hydroelectric power only. Details of energy generation and consumption in Kerala and in the study area (GKR) are summarized in **Table 2.7.1** during the years 1996-99. Perusal of the table indicates that GKR produces about 94-98% of total power generated in the State, whereas it consumes only 34-43% of the total power consumed in the State.

Data available exclusively for GKR is limited; hence data on various aspects pertaining to electricity generation, consumption, distribution etc. are presented for whole of the State.

Electricity generation in Kerala presented in **Table 2.7.2** indicates that the State is solely dependent on hydro electricity generation. Only recently (1997-98), an 82 MW thermal power plant is added to the total electricity generations. Gross generation of electricity increased by about 47% in 15 years time from 1980-81 to 1995-96.

Prime mover wise installed power generation capacity as on March 31st 2000 is indicated in **Fig. 2.7.1**. The total electricity described as sum of the total of hydro and thermal electricity, is about 2116 MW, of which about 83% (1753 MW) is hydro electricity. Remaining 17% (363 MW) thermal electricity is the summation of oil and gas based power generations only, as Kerala is devoid of any coal resources.

The total exploitable potential of hydro-energy taking into account the environmental limitations has been estimated between 10,000-15,000 MU whereas the demand by the year 2002 would be more than 20000 MU. There is a marked change in the power generation as well as consumption pattern in Kerala during the last decades. Details of growth of power system in Kerala from 1951 to 1994 are given in **Table 2.7.3,** which indicates that there has been a continuous growth in power generation and transmission distribution facilities. In Kerala, power generation capacity has increased from 38 MW in 1951 to 1484 MW in 1994. Similarly, per capita consumption has also increased about 16 times in 43 years from 13 KwH (1951) to 211 KwH (1994). Number of distribution transformers also increased from 324 to 21141 during the same period.

Year wise details of installed capacity of power generation through utilities and non-utilities are given in **Figs. 2.7.2** and **2.7.3** respectively, which show steady growth in both the types of capacity power generation. However, utilities power generation is nearly 10 times more than the non-utlities.

Year wise gross power generation (utilities) presented in **Fig. 2.7.4** indicate in general uniform power generation, however maximum gross power generation of 6626 million KwH, was achieved during the year 1995-96. Gross power generation through non-utilities in Kerala showed an uneven growth in the power generation from 1990-91 to 1993-94, which again declined in 1994-95 and then showed an increasing trend (**Fig. 2.7.5**).

Details of Kerala power system in the last decade given in **Table 2.7.4** indicates that total installed capacity (as on March 31, 1998), was 1776 MW, whereas annual per capita power consumption was 240 KWH. Energy loses were observed in the range of 18-21%.

Details of various power projects as on 31.03.1998 in Kerala with respect to their installed capacity (MW), firm power (MW) and power generation (MW) are given in **Table 2.7.5**. Out of total power generation (1776 MW) capacity, Idukki district alone generates about 63% (1120 MW), through 6 power projects. Pathanamthitta district generates about 17% (300 MW), whereas Ernakulam district produces only 9% (160 MW). In terms of total energy generation (in MW), district Idukki generated 2884 MW per annum, about 55.6% of the total power generation (5189 MU) in Kerala.

In the year 1997-98, Karala's first diesel power plant at Brahmapuram (installed capacity of 106.6 MW), near Kochi along with two hydel stations; Lower Periyar Hydro Electric Project (180 MW) and Madupatty small hydroelectric station (2 MW) both in Idukki district were commissioned. With the commissioning of the above three projects, the installed capacity enhanced to 6743.66 MU. Owing to the shortage of installed capacity and power availability, load shedding and power cut were continuing through out the year.

Details on energy generation from own power houses and received from other states and from joint and central plants over last two decades are summarized in **Table 2.7.6**. Availability of power from other sources has significantly reduced the gap between power availability and demand. Details on energy consumption in various sectors, like domestic, commercial, agriculture, low and medium tension, high tension public services and other consumers are summarized in **Table 2.7.7**. Energy consumption is continuously increasing maximum being in the domestic sector (**Fig. 2.7.6**), railways uses least amount of electricity.

Sector-wise annual energy consumption rate in the study area during 1994-99 as given in **Table 2.7.8** indicates that energy consumption has increased gradually but continuously in domestic and commercial sectors. Energy consumption for other purposes, like public lighting, irrigation and dewatering, public water works etc. has been fluctuating over the years, similarly, energy consumption in industrial sector has been fluctuating during different years.

Irrespective of energy consumption, energy sales in Kerala have been fluctuating. Percent change in total sales is found to grow from 3.8% in 1980-81 to 11% in 1985-86 than to 4.2% in 1995-96 and then increased to 10% in 1997-98 (**Table 2.7.9**). Energy sales to other states and exports have been found to be continuously decreasing from 1695 MU in 1980-81 to just 21 MU in 1997-98. Transmission, transformation & distribution losses are observed to be high

The details of primary sources of energy for lighting and cooking purposes are given in **Table 2.7.10,** which also gives a comparative account of use of different fuels in rural and urban areas in Kerala and on all India basis. The fuels used for cooking in urban area are coke, coal, gas, natural oil and kerosene, whereas firewood chips and dung cake are used mostly in rural areas. Fuel used for lighting in urban area is electricity (72.8%) in Kerala, which is slightly higher to the all India value of 71.8%. In rural areas, mostly Kerosene (62.5%) is used in Kerala, which is much less than the all India value of 74.6%. Contrary to the above, firewood use in much higher in Kerala in urban as well as rural areas.

Projected energy requirement and peak load in the next 5 years 2001 to 2005 is given in **Fig. 2.7.7**, which shows an increasing trend in energy requirement to the tune of 7.5% to 8.5%. The peak load shows a growth of 7.5% to 9.3% Status of power demand and its supply in the year 2002 is given in **Table 2.7.11** alongwith the details of sources of power generation to meet the demand Estimated demand by the year 2002 is about 3500 MW, which is proposed to be met by different ongoing units and various new units to be installed in the state.

Details on petroleum consumption of major petroleum products viz. LPG, Naphtha, Petrol, Kerosene, Diesel, etc. in Kerala are given in **Table 2.7.12** since 1980 to 1999. A constant increase in the consumption of LPG, motor gasoline, kerosene, high-speed oil and petroleum products are observed.

A comparison of marketing retail outlets for petroleum products in Kerala against the neighbouring states like AP, Karnataka & Tamilnadu and northern States like Punjab and Delhi is given in **Table 2.7.13** since 1991. Increase in the total number of retail outlets is about 11-14% in all the states except Delhi, where it is about 36% in past decade (1991-2000).

2.7.2 Non-Conventional Energy Sources

Renewable energy can play a very vital role particularly in the third World Countries like India, where a chronic power deficit continues that demands for regular installation of new conventional power generating systems. Energy needs of our rural population (75% of the total) could be met using non conventional energy options, which offer an opportunity for sustainable, self retain and equitable development and provide tangible benefits of land reclamation, local employment and reduction of gas emissions.

The energy landscape has been altered by the recent emergence of natural gas as the most rapidly growing energy source. Recent developments are turning wind power, solar energy and a host of other renewable resources into economically viable energy options. Govt. of India has attached significant importance to the development and promotion of renewable energy. India is one of the few countries in the world to have drawn up a comprehensive strategy and action plans and set specific goals for renewable power-generation based capacity additions. The goals have been redefined and increased from 600 MW to 2000 MW power generation. In addition, the establishment of the Indian Renewable Energy Development Agency and the announcement of fiscal incentives and financial packages have placed renewable energy sources on the commercialization roadway.

The biogas programme has traditionally been the single largest programme accounting for over half of the allocated funds. Other individual programmes received less than 10% of the total funding provided to the renewable sector. Improved coolestones have enjoyed a fair amount of success and acceptability among rural households. Among other technologies, wind farms have emerged as a viable power option. Wind farms of over 800 MW capacities are operational showing an average reliability of 98% with a capacity utilization factor as high as 30%. India is likely to be the second largest wind power producing country with the growing interest of the private sector. Small hydro has evolved as another promising option. Almost 110 MW have been harnessed from 148 small hydro stations / projects. The gasifier programme in India was launched in 1986 and so far 1000 wood-based systems have generated 3.7 MW. Biogas gasifiers offer significant potential to meet rural energy needs. Among solar thermal technologies, water-heating systems for industrial applications and solar cookers are gaining popularity.

The non-conventional energy sources can broadly be classified into the following categories; Solar, Wind, Wave, Biomass, and Biogas.

2.7.2.1 Solar Energy

Solar energy is high quality energy, and is available in abundance. The total flow of solar energy through the earths natural system is some 10,000 times greater than the present flow of energy through man's machines. Even the one percent influx that generates the great atmospheric pressure systems which drive the winds, and which in turn generate the waves, is some 180 times as large as man's rate of energy use. Though, on an average, the photosynthetic process is less than 2.0% efficient, even photosynthetic production creates 10 times as much energy as man uses. The details of solar energy fluxes are:

Solar Radiation intercepted by the Earth	175,000 TW
Solar Radiation absorbed by the Earth	110,000 TW
Solar Energy involved in Evaporation	40,000 TW
Solar Energy used in the generation of the atmospheric pressure system	1,800 TW
Solar energy involved in Direct Sensible Heating	68,000 TW
Solar Energy utilized in Photosynthesis	100 TW
Man's Rate of Energy use, 1980	1,065 TW

As per WMO report, the solar constant (the intensity of subject on top of the atmosphere) is 1370 W/m^2 and the Earth's albedo (the percentage of incident sunlight reflected back into space) is 32%.

Global solar radiation based on sunshine duration can be calculated as:

$$G/ETR = a+b\,(n/N)$$

Where.

G = Total global radiation
n = Daily duration of sunshine, hrs
ETR = Daily toal of extra terrestrial solar radiation on a horizontal surface
a & b = Regression constants
N = Maximum possible duration of sunshine, hrs

Direct manifestations of solar energy in the form of direct-beam or diffuse radiation may be utilized to produce heat or secondary froms of energy, such as electricity or synthetic fuels. Indirect manifestations of solar energy, as they appear in the wind, waves, ocean-thermal gradients, photosynthesis may also be harnessed usefully.

Solar Generated Thermal Energy

Solar energy in the form of direct-beam radiation lends its effectively to the productions of heat. The maximum temperature attainable is approximately 5600^0C

Low-Temperature Heat : The technology for generation of low-temperature heat (less than 100^0C) from sunlight is fairly mature. The basic system consists of a flat plate collector, liquid or air heat transfer medium, with or without storage facility. The simple applications of solar energy to water heating and space conditioning are unlikely to displace more that 2.5% or worlds primary energy requirements.

Solar-Thermal Electric Conversion : STEC Power plants can come from a few hundred MW (electric) down to far smaller size units.

Photoelectric Energy Conversion : Solar radiant energy may be converted to direct current electricity, typically by means of suitably constructed thin layers of silicon. The advantages are many; there need to be no moving parts; lifetimes can exceed 100 years (although cell performance degrades continuously), little skill for maintenance, both direct beam and diffused sunlight can be used effectively.

Details of different types of devices used applying non-conventional energy sources (mainly solar energy) in different districts of GKR are summarized in **Table 2.7.14**. Fixed Chulha, Portable Chulha, Kerosene Stove, Solar Lantern and Pressure cookers are main items contributing non-conventional energy systems.

2.7.2.2 Wind Energy

Wind Energy Parameters

The power (P) due to the kinetic energy of wind, with a constant speed (V) passing through an area (A), is given by; $P = 1/2\, \rho\, AV^3$ where ρ is the density of air and P is expressed in watts or kilowatts. The equation can be written as $P=K.AV^3$, where K varies with the system of units used. Values of K in terms of the units of P and V are given below, where ρ is taken as 1.29 kg/m^3 and the unit for area is m^2.

Power (P)	Wind Speed (V)	Constant (K)
Kilowatts	m/s	0.000645
Kilowatts	km/hr	0.0000137
Watts	m/s	0.645
Watts	km/hr	0.0137

Power density (P_d) or the power per unit area normal to the wind is given by; $P_d = 1/2\, \rho V^3$ and is expressed either in W/m^2 or kW/m^2.

The mean power density (P_d in kW/m^2) in a month is given by; $P_d = 0.00001073\, \rho \sum V^3_1 / N_m = 0.00001073\, \rho V^3_1$, where, V^3_1 is the mean of the cubes of hourly wind speeds during the month, N_m is the number of hours during the month, ρ is in kg/m^3 and V_1 in kmph.

Energy content of wind

The energy content (in kWH/m^3) of the wind per m^2 for any specific period is given by; $P_d = 0.00001073\, \rho \sum V_1^3$ where V_1 is the hourly wind speed in kmph for hour i, which ranges from 1 to 744 for a month of 31 days, and ρ is the mean air density in kg/m^3.

The energy content of the wind for a month, in each of the years, is obtained by summing KAV^3 over the total number of hours in the month and the energy content of the wind of the year is obtained by summing the energy content of the wind for each of the twelve months of the year. The maximum power that can be extracted by a wind energy conversion system is only 59.3% of the power in the wind, and even this limit is never reached in practice.

Energy pattern factor

The energy pattern factor (EPF) for a particular site and period of time is defined as a ratio of the actual energy available in the wind for the month to the energy calculated from mean monthly wind speed.

i.e. = mean power density for the month/ mean power density at the monthly mean speed

$$= \frac{1/2\rho\sum V^3/N_m}{1/2\rho\, V_m^3} = \frac{\sum V^3/N_m}{V_m^3}$$

where, V_i is the hourly speed during the month, N_m is the number of hourly wind speed values during the month and $V_m = \sum V_i/N_m$

In the equation, the numerator is always greater than the denominator hence the energy pattern factor always exceeds one. EPF is a function of the mean wind speed V_i, which in turn is a function of the average interval T for durations less than a year. Hence, the EPF is a function of T as well. It is also related to the turbulent intensity at a site. In the atmospheric layers close to the ground, the size of turbulent eddies is unaffected by the average gust speed. Thus EPF decreases with an increase in V_t.

For a given region, the concept of the EPF is useful in calculating the available energy in the wind from the knowledge of the annual mean speed. It is also useful while choosing a location with limited wind data, because long term data from neighboring stations can be correlated with on-site short term measurements.

EPF.,. the annual energy pattern factor is given as a ratio of mean power density for the year to the mean power density at the mean annual speed

$$EPF_A = (\Sigma V_1^3/N_A)/V_A^3$$

Summation being over all the hourly wind speeds for the year, N_A being the number of hourly with speed values during the year. If the mean monthly / annual wind speed at a station is known, then the mean power density at the station can be obtained by using EPF_m/EPF_A for a nearby station.

Mean power density in this case is $EPF_m.1/2\rho V_m^3$ for the month and $EPF_A.1/2\rho V_A^3$ for the year. The mean energy content of the wind is $N_m.EPF_m.1/2\rho V_m^3$ for the month and $N_A.EPF_A.1/2\rho V_A^3$ for the year.

Distribution of wind power over different speed intervals

The distribution of wind power over different speed intervals is determined from its percentage frequency distribution. For a particular speed interval, say, 15-16 kmph, if FF_m, FF_A are the percentage frequencies for a particular month and for the year, then P_m and P_A, the values of the mean monthly and annual power density for this speed interval, are given by

$$P_m = 0.01073\, \rho m\, (15.5)^3 \times FF_m$$
$$P_A = 0.01073\, \rho_A\, (15.5)^3 \times FF_A$$

where, P_m and P_A are the mean monthly and annual air densities in kg/m^3. P_m and P_A are in W/m^2.

2.7.2.3 Waves Energy

Wave motions in a liquid have two properties in common with all types of waves, firstly, energy is being propagated from one point to another; secondly, the disturbance travels through the medium without giving the medium as a whole any permanent displacement.

The energy of a water wave is independent of wave period or wavelength. The only wave parameter, which determines waves energy content, is the wave height. The energy increases as the square of height. A wave twice as high as its neighbour carries four times the energy. The power per unit crest length P, of a wave is the rate at which it transports its energy. Mathematically it is the product of the energy per unit area, E, carried by the waves and the group velocity Vg, which is the speed at which the energy waves travel.

$$P = E * Vg$$

On a worldwide basis, the total energy in the waves of all the seas is about $5X10^{17}$ joules spread over 3.6 X 10^{14} m^2. If we take a wave period T=10s as a reasonable average period then Vg can be calculated

$C^2 = \lambda^2 / T^2 = g\lambda / 2\Pi$
For deep water waves, $\lambda = gT^2 / 2\Pi$
then, $C = gT / 2\Pi$

But for deep water waves, Vg = (½)C, so that Vg for 10s period waves is about 9 m/s. Thus, 10^4 watts power is being dissipated, on average, along each metre of the worlds shoreline. The shoreline of the entire earth is about 500000 km so that there is continues power dissipation of about $5X10^{-2}$ W along world's shorelines.

The most developed wave energy extraction device is Masuda buoy, in which air is compressed by the motion of waves driving a turbine to produce power (50-60 kW). But in 1978 Japanese launched their full-scale wave turbine prototype power plant with three 125 kW generators.

2.7.2.4 Biomass Energy

Plentiful renewable resources are available in the agro-processing centres (rice husk, bagasse, molasses, coconut shell, groundnut shell, maize cobs, potato waste, coffee waste, whey), farms (rice straw, cotton sticks, jute sticks), animal sheds (cow dung, poultry excreta), forests (bark, chips, shavings, sawdust), municipal waste (city refuse, sewage) and industrial waste (distillery effluents/spent wash, textile waste, plastic waste). The increase in productivity as a result of green revolution has affected not only the production of main products but also the generation of residues. The percent of residues generated by rice, sugarcane, coconut, groundnut, cotton, jute and maize during 1981-82 is significantly substantial (**Table 2.7.15**).

There are a variety of agricultural residues available in the countryside,, which find use as fuel. An average heat potential of some of these residues is given in **Table 2.7.16**. Perusal of the data reveals the following variations;. moisture 4.3-15%, ash content 1-33% and calorific value 3000-4700 kcal/kg. These values indicate that these resource materials can hope to meet a substantial portion of the heat energy of the rural sector using efficient thermo-chemical or biological conversion devices.

The energy value of industrial wastes with rubber, bus and auto-tyres leather scrap is much higher than energy from forestry and agricultural residues (**Table 2.7.17**). Therefore, these technologies can prove profitable for processing industrial wastes, mainly heavy plastics and tyres.

Generation electricity from of biomass is possible at varying scales, viz., small scale (5-100 kW), medium-scale (1-10 MW) and large-scale (50 MW) or biogas plants of few m^3 capacity Unlike solar, wind or micro hydro electric systems, modern biomass energy systems could be set up in virtually in any location where plants can be grown or domestic animals are reared. According to WEC (1993) report, under the minimum case scenario biomass is the most important renewable resource and is projected to account for 45% of the total renewable energy to world energy by 2020.

The potential for MW - scale biomass electricity generation and liquid fuel systems, not be ignored since there could be significant economic benefits to farmers who own degraded lands. Potential of 16000 - 32000 MW of installed capacity is shown to be feasible by dedicating only 5% of India's geographical area, depending on the efficiency of conversion. For one MW system, biomass feedstock needs to come from a radius of only 8km, at a productivity of 8 MT/ha/year assuming conversion efficiency of 8%.

For convenience, it is assumed that 0.5^*/capita/year will be used for electricity generation and for liquid fuel generation. Assuming conversion at 18% and 36% efficiency for 0.5 of wood, the potential of electricity generation using producer gas route is 384 KwH and 768 KwH capita/year respectively. The methanol fuel production potential using 0.5 MT/capita/yr of lingo-cellulose feedstock via thermal-chemical route is 217 kg/capita/yr.

2.7.2.5 Biogas

By far the most promising alternative is biogas from dung, which is no longer given much impact as more sophisticated; technologies are floating around the market place. The technology is cost-effective and the know-how is relatively simple allowing local variations and what is most important can be repaired in-situ, without many spare parts and by local villagers who are trained.

Thus, biogas very well qualifies, as an energy source for meeting cooking and lighting energy needs in rural India. Estimates indicate that biogas generated by cattle dung available in the country would be equivalent to nearly 195 billion KwH annually of equivalent 24 billion litres kerosene. At present, biogas available from more than 2 million family size plants (1-4 m^3 capacities) is generally used for cooking & lighting.

Animal dung, a form of agricultural waste forms about 8-10% of the total energy consumption in the rural sector. Out of a total estimated production of 324 MMTPA of dung (air dry), about 73 MMTPA has been estimated to be burnt for energy purposes. The quantity of dung available varies from 0.04 kg/day in case of hens to 15.00 kg/day in case of buffaloes thus depending upon the weight and age of the animals. Similarly, there also exists a good deal of variation in the disposal rates of dung from one area to another. The disposal rates depend upon climate and the availability of firewood. Kerala, Karnataka, Andhra Pradesh and Tamil Nadu which are all coastal areas and the climate is warm and humid, the percentage of dung thrown into manure pits is high. In

Punjab and Northeastern States, the proportion of dung thrown into Manure pits is comparatively less. In these states, a fairly high percentage of the total dung collected is converted into dung cakes for fuel purposes. The dung utilized for other purposes such as construction of 'Kucha' houses form a very meager percentage of the total dung collection.

Table 2.7.1

Power Generation and Consumption in the Study Area and Kerala

Area	Usage of Power (MU)	Year		
		1996-97	1997-98	1998-99
Kerala (Total)	Generation	5503	5189	7600
	Consumption	8799	9425	10964
Study Area (GKR)	Generation	5302	4889	7460
	Consumption	3152	4076	3791
	% Generation of Total	96.35	94.24	98.16
	% Consumption of Total	35.82	43.25	34.57

Table 2.7.2

Electricity Generation in Kerala

Year	Installed Capacity (MW)			Gross Generation (Million KwH)			
	Total	Thermal	Hydro	Total	Thermal	Hydro	% Change
1980-81	1012	-	1012	5242	-	5242	2.4
1985-86	1309	-	1309	5362	-	5362	9.8
1990-91	1477	-	1477	5491	-	5491	8.2
1995-96	1492	-	1492	6626	-	6626	0.8
1997-98	1771	82	1689	5183	115	5068	-5.9

Total electricity = Thermal + Hydro electricity

Source : Energy, Centre for monitoring Indian economy

Table 2.7.3

Details of Growth of Kerala Power System

Particulars	1951	1961	1980	1990	1994
Installed Capacity, MW	38	133	1012	1477	1484
Annual sales, MU	140	518	4318	4794	6234
Per Capita Consumption. KWH	13	30	96	164	211
EHT lines. Ckm	911	1900	4404	5760	6018
EHT S/S. Nos.	12	22	86	130	150
HT lines, Ckm	1067	5449	13348	19627	23455
LT lines, Ckm	992	8899	47606	95938	119935
Distribution Transformers, Nos.	324	2898	10821	16394	21141
Annual Revenue in Crore Rs.	**0.58**	**3.11**	**91.25**	**270**	**548**

Source : Secondary data collected by NEERI

Table 2.7.4

Growth of Kerala Power System in the last Decade (1992, 1997 and 1998)

Sr. No.	Particulars	Status		
		31.3.1992	31.3.97	31.3.98
1	Installed Capacity, MW	1477	1508	1776
2	Maximum Demand, MW			
	a) System	1267	1572	1786
	b) Internal	1309	1235	1337
3	Generation Per Annum, MU	5326	5503	5189
4	Import Per Annum, MU	1856	3298	4236
5	Export per Annum, MU	2.17	1.97	0.000
6	Energy Sales Per Annum, MU	5596	7021	7715
7	Energy losses (% of energy available)	21	20	18
8	Per capita Consumption, Kwh/annum	192	224	240

Source : Secondary data collected by NEERI

Table 2.7.5

Details of Power Projects in Kerala (as on 31-3-1998)

Sr. No.	Districts	Name of Projects	Installed Capacity (MW)	Firm Power (MW)	Annual Power generation 1997-98 (MU)
1	Ernakulam	Brahmapuram	75	36	337
2	Ernakulam	Brahmapuram	85	-	113
3	Idukki	Pallivasal	37	32	212
4	Idukki	Sengulam	48	21	139
5	Idukki	Neriamangalam	45	27	287
6	Idukki	Panniyur	30	17	149
7	Idukki	Idukki	780	230	1842
8	Idukki	Lower Periyar	180	56	255
9	Kollam	Kallada-Mini	15	6	50
10	Palakkad	Kanjikod Wind Farm	2	-	2
11	Pathanamthitta	Sabarigiri	300	138	1089
12	Thrissur	Peringalkuthu	32	20	200
13	Thrissur	Sholayar	54	27	237
14	Thrissur	Madupetty	2	-	1
15	Thiruvananthapuram	Peppara	3	-	5
16	Wayanad	Kuttiady	75	28	243
	Sub Total		**1764**	**639**	**5161**
17		Maniyar	12	4	28
	Grand Total		**1776**	**643**	**5189**

Source : KSEB

Table 2.7.6

Electricity Availability in Kerala from Different Sources

Million KwH

Year	Net Generation (Own Power Houses)	Energy from Joint & Central Plants	Energy from other States & Imports	Energy Availability	% Change in Energy Availability
1980-81	5203	-	32	5234	2.0
1985-86	5332	-	236	5568	11.8
1990-91	5461	1360	-	6821	10.3
1995-96	6600	2747	-	9347	5.0
1996-97	5482	3427	-	8909	-4.7

Source: Energy, Centre for monitoring Indian Economy (April 2001).

Table 2.7.7

Details of Power Utilizations in Different Sectors

Million KwH

Year	Dom.	Com.	Agr.	Low & Medium Tension	High Tension	Public Services	Railways	Others
1980-81	450	192	80	223	1711	81	-	18
1985-86	889	371	101	280	1998	107	-	20
1990-91	1638	511	208	356	2362	195	-	4
1995-96	2799	707	322	535	2731	198	-	48
1997-98	3799	670	341	534	2003	291	9	37

Dom. - Domestic; Com.- Commercial; Agr. - Agriculture
Source: Energy, Centre for Monitoring Indian Economy (April 2001)

Table 2.7.8

Sector wise Status of Energy Sales in the Study Area

Sector	Status of Energy Sales (MU)				
	1994-95	**1995-96**	**1996-97**	**1997-98**	**1998-99**
Domestic	1113.2	1118.8	1475.6	1612.8	1617.2
Commercial	264.1	288.0	326.0	351.6	455.2
Public Lighting -	48.6	51.8	51.2	74.4	57.1
Irrigation & Dewatering	182.2	147.0	161.3	144.7	131.5
Public Water Works	9.8	15.3	12.2	15.3	19.6
Industrial					
LT	339.6	233.2	297.2	294.5	296.9
HT	1488.1	1414.3	796.4	1544.	1164.8
EHT	22.4	28.0	34.9	43.7	54.6
Total	**3466.2**	**3296.2**	**3155.7**	**4081.3**	**3796.8**

Source : Secondary data collected by NEERI

Table 2.7.9

Details of Electricity Consumption in Kerala

Million KwH

Year	Total Sales	Sales to Ultimate Consumers	Sales to Other States & Exports	T & D Losses	% Change in Total Sales
1980-81	4451	2756	1695	784	3.8
1985-86	4132	3757	375	1436	11.0
1990-91	5296	5274	22	1525	8.8
1995-96	7340	7340	-	2007	4.2
1997-98	7705	7684	21	1822	10.0

Source : Energy, Centre for Monitoring Indian Economy (April 2001)

Table 2.7.10

Primary Sources of Energy for Cooking and Lighting

Per 1000 households

Fuel Type	Kerala		All India	
	Urban	Rural	Urban	Rural
Cooking				
Coke / Coal	419	6	107	19
Firewood & Chips	659	944	374	789
Gas. Coal or Natural oil	179	17	223	8
Gobar gas	-	1	1	3
Dung Cake	2	-	31	138
Char Coal	-	-	3	-
Kerosene	71	16	192	15
Electricity	6	1	5	1
Others	69	15	64	27
Lighting				
Kerosene	264	625	269	746
Electricity	728	370	718	238
Others	8	5	13	16

Source : Energy, Centre for monitoring Indian Economy (March 2000)

Table 2.7.11

Status of Demand and Supply of Power by the Year 2002 AD

Details	MW	MU
Present demand (unsuppressed) 1995-96	2160	11393
Present supply 1995-96	1850	9000
Shortage	310	2393
Estimated demand by 2002	3469	18654
Sources to meet this demand:		
1. On-going schemes	480	1709
2. N.T.P.C. Kayamkulam	350	2100
3. CRL	500	2500
4. KSEB Large Thermal	400	2000
5. KSEB Small Thermal	200	1000
6. Small hydro, gassifier etc.	100	300
7. IPPs(Small)	200	800
8. IPPs(Large)	500	3000
Total	2730	**13709**
Grand Total – Generation	4580	**22400**
Less: 16% for T & D loss and 20% reserve	3680	**18816**

Table 2.7.12

Petroleum Consumption of Major Petroleum Products in Kerala

(1000 MT)

Year	LPG	Naphtha	Petrol	Kero-sene	HSD	LSD	FO	LSHS	Petroleum Products (Refineries)
1980-81	7	191	88	130	352	11	217	64	1117
1985-86	28	163	124	188	485	9	83	111	1322
1990-91	81	185	148	262	690	11	181	154	1911
1995-96	134	170	206	292	1180	9	181	203	2634
1998-99	189	383	259	301	1262	6	232	191	3136

Source : Energy, Centre for monitoring Indian Economy (April 2001)

Table 2.7.13

State-wise Marketing Retail Outlets of Petroleum Products

(Number)

State / Union Territory	1991-92	1992-93	1993-94	1994-95	1996-97	1997-98	1998-99	1999-00
Kerala	699	700	713	726	747	747	749	776
Andhra Pradesh	1193	1195	1212	1242	1266	1270	1304	1364
Karnataka	926	928	944	975	1007	1010	1020	1063
Punjab	947	946	959	1001	1024	1029	1035	1058
Tamilnadu	1408	1408	1430	1467	1508	1514	1546	1591
Delhi	241	244	250	270	288	290	305	329

Source : Energy, Centre for Monitoring Indian Economy (April 2001)

Table 2.7.14

District wise Data Relating to Non-Conventional Energy System since Inception up to 30-3-1999

Name of Devices	Alappuzha		Ernakulam		Idukki		Kottayam		Pathanamthitta		Thrissur	
	Pattana-kkad	Hari-ppad	Mula-mthuruthy	Kotha-mangalam	Elam-desam	Idukki	Kaduthuru-thy	Kanjira-ppally	Parakkode	Ranni	Olluk-kara	Puzha-kkal
Community Chulha	268	1082	121	56	24	154	95	5	260	1	280	187
Fixed Chulha	11582	13260	5018	2276	1911	9472	7289	1688	8247	644	1602	8171
Portable Chulha	11676	11805	8534	1454	3029	14994	4651	1776	2120	3705	2640	9755
Electronic Choke	2808	3120	3686	2011	1306	2086	3145	2083	2899	2069	4183	3518
Kerosene stove	9338	7175	8520	5880	3336	5424	6793	4164	5963	3192	6257	5751
Solar domestic Light	12	21	45	7	51	135	38	17	96	20	17	19
Solar street light	5	4	7	5	2	20	2	2	18	8	12	13
Solar Lantern	2632	1803	1535	1947	595	1458	2097	1217	1509	1767	1959	2052
Solar television			1	0		2			6		1	2
SPV Pump	6	6	12	3		3	14	3	5		8	9
Solar Water Heater	6		12	4		3	57		6	2	28	60
Solar Radio Module	21		89	111	41	56	44	124	28	14	31	124
SPV Module	47		20	24	126	168	63	16	11	65	63	62
Solar Still			0	0					1		0	2
Solar Cooker	8	8	19	7		3	93	9	7	14	78	16
CFL with ele. Choke	3624	3150	6813	6374	1616	2959	4987	1951	12133	6121	3815	9225
Wind mill											0	0
Pressure Cooker	9897	8320	7937	6235	4124	5050	5801	4859	5547	5060	4406	6789
Frictionless foot valve	94		10				25	0			0	0
CFL tube only	99		73	9	10	33	15	15	25	408	13	60
Power plant											0	0
Reduser for chulha	701	420	2233	584			109	18		38	1042	591
Exhibition	18	26	12	2	1	13	30	0	16	1	2	10
Awareness programme	20	72	21	10	10	6	43	0	24	11	56	21
User education Programme	45	75	70	6	5	20	0	0	75		152	33
Demonstration Kit		2	18			9	0	0		5	7	0

Table 2.7.15

Potential Availability of Rice Husk, Bagasse, Coconut Shell, Groundnut Shell, Cotton Stalks in Kerala (1981-82)

Agricultural Waste	Area	Production	Rice Husk	%of the Total
Rice Husk	787.7	1246.9	415.6	2.3
Bagasse*	7.8	460.8	153.6	0.2
Coconut Shell	667.8	3057.2	611.4	54.5
Groundnut Shell	13.0	11.2	3.7	0.1
Cotton Stalks	5.2	8.3*	15.6	0.1

(* = 000 bales of 175 kg)

Table 2.7.16

Heat Potential of Agricultural Wastes

Agricultural Waste	Moisture (%)	Ash Content (%)	Calorific Value (Kcal/kg)
Paddy Straw	10.6	20.1	3000
Rice husk	9.6	19.5	3440
Mango leaves	9.8	18.0	3390
Groundnut Straw	12.1	1.3	4200
Cow dung	8.5	21.7	3290
Cow dung cake	4.3	33.2	3140
Sugarcane bagasse	15.0	1.0	3800
Wheat straw	9.2	18.0	3800
Cotton Sticks	12.0	13.5	3300
Maize stalks	11.5	14.2	4700
Maize cobs	8.6	13.8	3500
Bajra stalks	11.2	17.5	3850
Gram straw	9.2	13.2	3950
Mash straw	7.8	13.4	3920
Masoor straw	10.1	12.8	3810
Moong straw	10.3	12.6	3820

Source : Secondary data collected by NEERI

Table 2.7.17

Fuel Values of Industrial, Forestry and Agricultural Wastes

Type of Waste / Residue	Heating Value (Kcal/kg)
Industrial wastes	
Rubber	6800
Bus & auto tyres	9900
Leather scrap	5500
Polyethylene	10900
Polyvinyl chloride	9600
Forestry Residues	
Wood wastes	2500-3850
Bark	2500-2850
Agricultural Residues	
Bagasse	2000-3600
Rice Hulls	2850-3600
Nut Hulls	4200
Corn Cobs	4400-4600

Source : Secondary data collected by NEERI

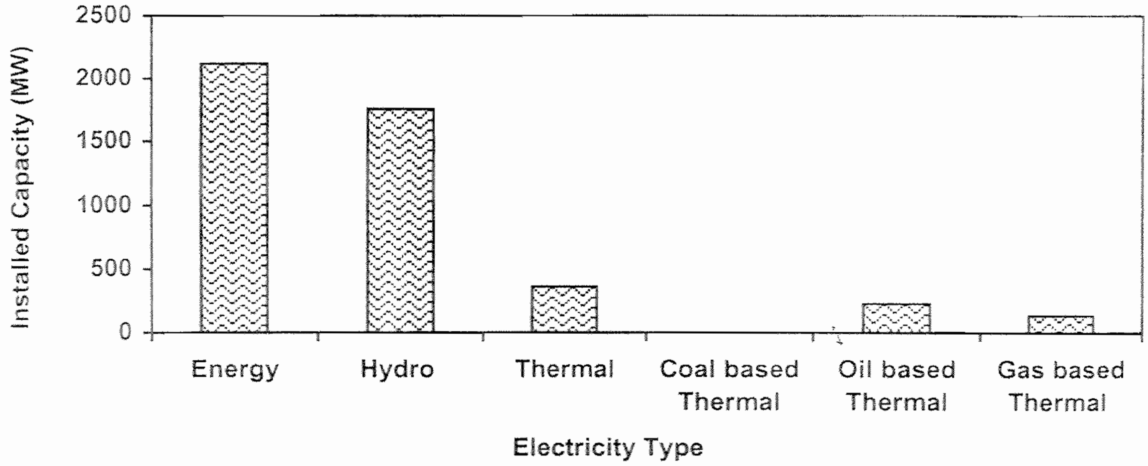

Fig. 2.7.1 : Prime Moverwise Installed Power Generation Capacity in Kerala (as on 31st March 2000)

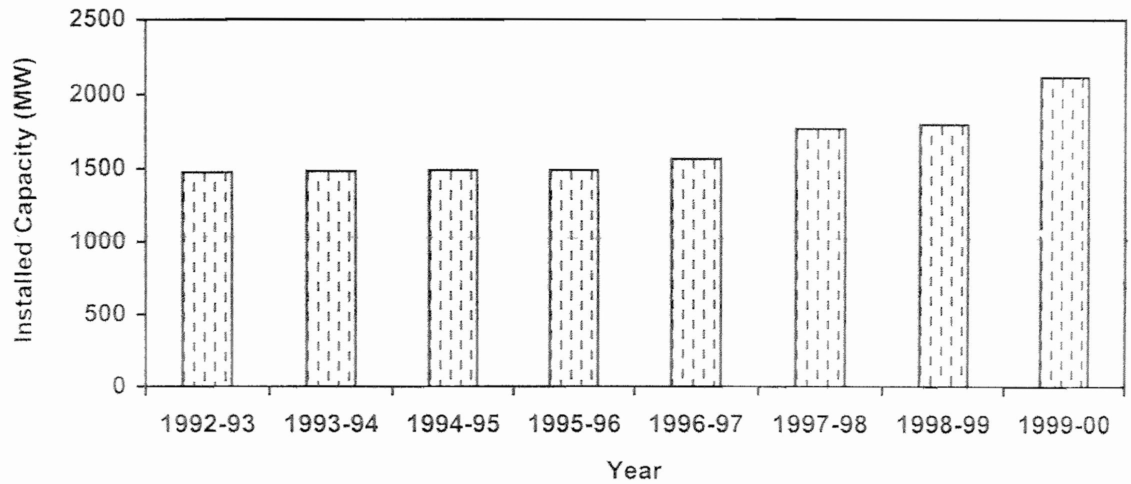

Fig. 2.7.2 : Yearwise Installed Power Generation Capacity in Kerala (Utilities)

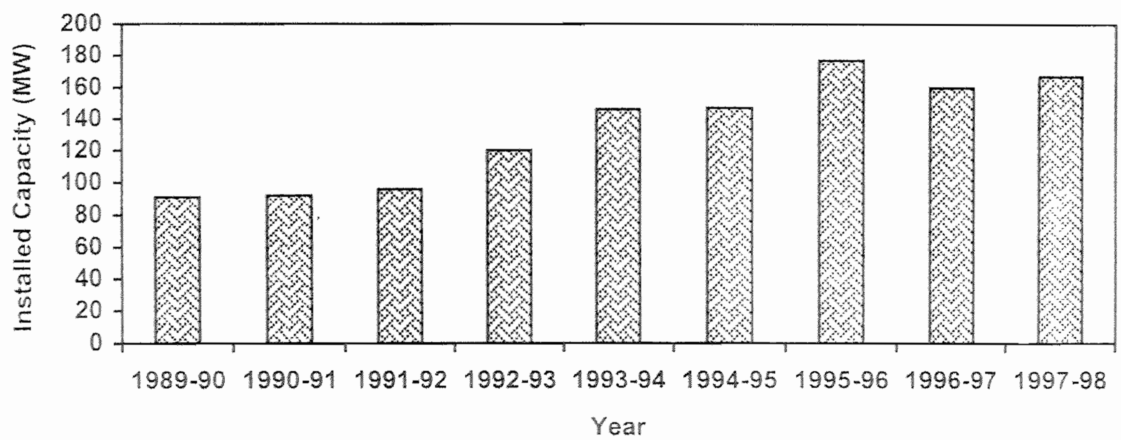

Fig. 2.7.3 : Yearwise Installed Power Generation Capacity in Kerala (Non-Utilities)

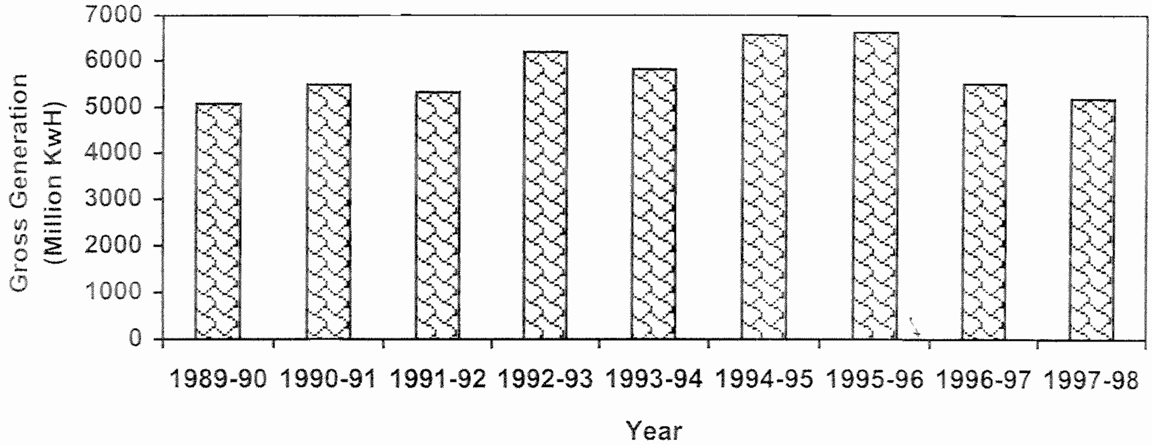

Fig. 2.7.4 : Yearwise Gross Power Generation in Kerala - (Utilities)

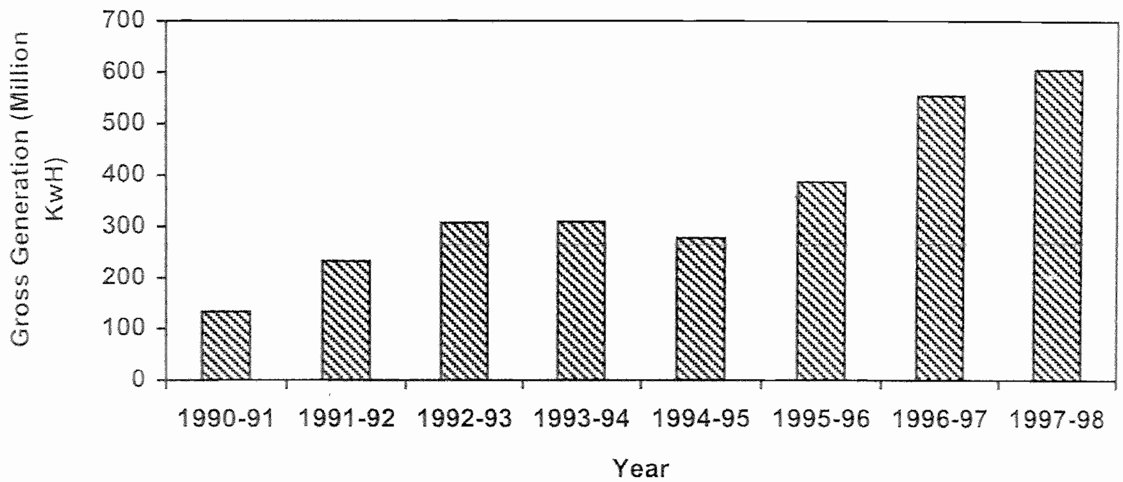

Fig. 2.7.5 : Yearwise Gross Power Generation in Kerala (Non - Utilities)

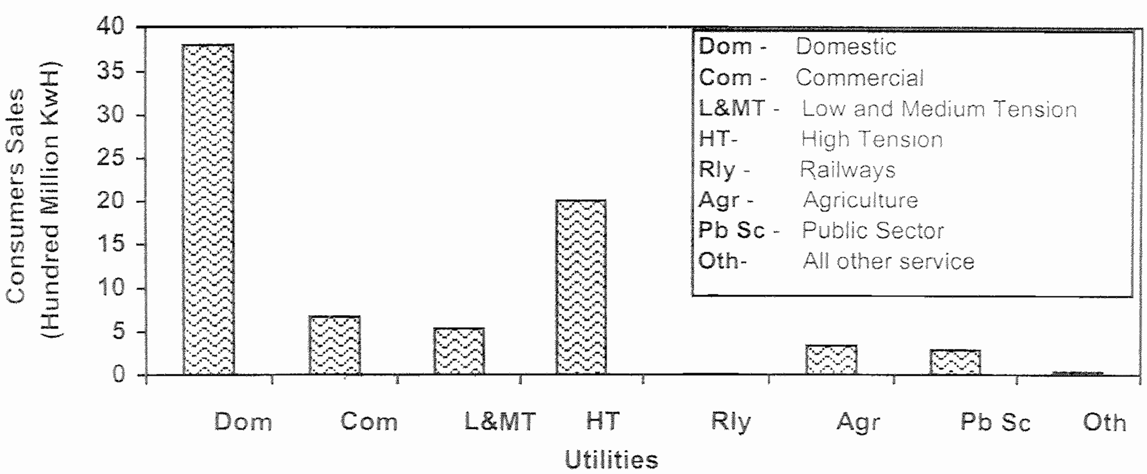

Fig. 2.7.6 : Electricity Sales in Kerala (as on 31st March, 1998)

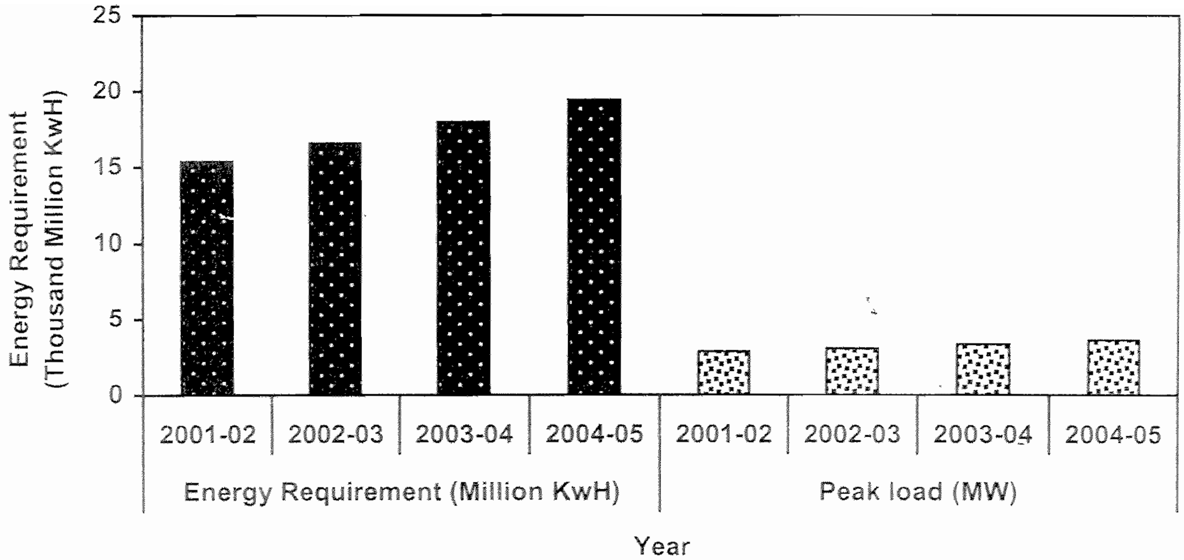

Fig. 2.7.7 : Projected Energy Requirement and Peak Demand in Kerala

2.8 Transformational (Industrial) Resources

The resources required for transformation of natural resources into usable products such as industry, energy generation and technologies are grouped as transformational resources. This section presents the details of industrial resources with special emphasis on the economics, products, production and resource use in the industrial sector. The discussion on the small-scale industries and large and medium scale industries in the project area is presented below

2.8.1 Small Scale Industries

The secondary data on small-scale industries (SSIs) in GKR were collected from the Panchayat development reports. District-wise details of SSIs registered as on 31-3-1991 given in **Table 2.8.1** indicates that there were 37027 units in GKR. The total investment on all these units was around Rs.400 crores. By the end of March 1998, the total number of SSIs in GKR increased to 90689 with the total investment increasing to about Rs.1286 crores.

There are 22204 SSIs in GKR. Ernakulam district has a maximum of 43.65% SSIs in Idukki district has a minimum of (3.6%). Alappuzha, Kottayam and Pathanamthitta districts have 31.89%, 14.4% and 6.5% SSIs respectively. District wise status of working SSIs as on March 31st 1998 given in **Table 2.8.2** indicates that there were 2204 SSIs declared as sick units and 588 units were revived in GKR.

The SSIs of GKR can be grouped into 42 product-wise types. 19.3% of the total numbers of SSIs in GKR are coir and coir products industries **(Table 2.8.3)**.

About 99% of coir based SSIs (4227) are in Alappuzha district. These are in the northern blocks of the district, namely Aryad, Kanjikuzhi and Pattanakkad blocks. Vembanad Lake is the main open water body in these blocks. The coir industry in Alappuzha district survives on water from Vembanad Lake. Reports indicate that the quality of life situation in this industrial area (coir industry) is very low due to poor quality of water and air, especially as a result of coconut husk retting and disposal of wastes. District wise distribution of different sector industries is given in **Table 2.8.4**, which shows that the mechanical / general engineering industries ranks second, next in number to coir and coir products based SSIs. This group comes to around 9.86% of the total number of SSIs in GKR. About 77% of the engineering based SSIs are in Ernakulam district.

2.8.2 Large and Medium Scale Industries

The secondary data on the break up of medium and large-scale industries in GKR as on 31st March 1998 is given in **Table 2.8.5**. It shows that there are 262 large and medium scale industries in GKR. Out of this, 205 (78%) are in the private sector. State sector has 24 units, central sector has 11 units and 16 units are owned by joint sector. Majority (55.34%) of these medium and large scale industries are in Ernakulam district, followed by Thrissur district with 18%, Alappuzha with 12%, Kottayam with 8% and the remaining are in Idukki and Pathanamthitta districts.

District wise distribution of large and medium scale industries with details of production capacity, annual turnover and raw material used is given in **Table 2.8.6** and discussed below.

Alappuzha District

Primary data on 41 large and medium scale industries are available which include 11 sea food, 11 coir, 5 metal, 2 glass and milk, and one each of allopathic medicines, foreign liquor, electronic, brick, cattle feed, match stick, ice and oxygen gas industries. The metal industries come first with the annual turnover of Rs. 1052.71 crores. These industries bring raw materials from outside the State. Seafood industries come second with Rs. 266.53 crores of annual turnover. They use marine resources, like shrimp, prawn, crabs, fish etc. from local sources. Coir industry is the third important type with Rs. 108.31 crores of annual turnover from 11 units. The raw materials are consumed from local sources. Other industries, which consume local resources, are glass and brick industries.

Ernakulam District

Data on the economics, products, production and raw materials for 103 large-scale industrial units and one cluster of 20 units of rice industries in Ernakulam district is available.

Rubber based units are the second largest type by number. There are 16 units with annual production of 2.09 MMT and Rs. 80.11 crores of annual turnover. Crude latex from (within) the state is being consumed by these industries. But petroleum-refining industries form the largest group by annual turnover. Cochin Refineries Ltd. with 6.9 MMTPA of production and Rs. 3917.75 crores annual turnover is the largest of its kind. Two fertilizer industries with 0.32 MMTPA production and Rs. 1313.5 crores of annual turnover is the next important type of industry in this district. Metal industries (12 units) using bauxite, aluminium, carbon steel etc. have Rs.1294.16 crores of annual turnover Chemical industries using lime shell, carbon, common salt, benzene, copper, LPG, rock phosphate etc. have Rs.708.07 crores of annual turnover Twenty rice mills are present in the northern part of the district as a cluster and they have Rs.60.96 crores of annual turnover.

Idukki District

Large-scale units consuming herbal plants for the production of ayurvedic medicines form the major type of industries. The annual production is 1729 MT with Rs.10.97 crores of annual turnover. Electronic units with Rs.5.17 crores form another type of industries in Idukki district.

Kottayam District

Rubber based industries are the largest group by number and annual turnover. There are 4 units with a total annual turnover of Rs.2262.51 crores. Latex and rubber are the raw materials used by these industries. Food, paper and cement industries are the other types of industries in Kottayam district.

Thrissur District

Thrissur district falling under GKR has only one large industries manufacturing IMFL (Indian made foreign liquor) industry with Rs. 2.5 crores annual turnover.

Economic status (profit/loss) of major Government companies viz., Cochin Refineries, Cochin Shipyard, FACT, Hindustan Newsprint Ltd., IRE Ltd. etc. in GKR is projected in **Table 2.8.7** during the period 1987-88 to 1991-92. Except Cochin Shipyard Ltd., most of the industries registered a profit during this period.

2.8.3 Transformational Resources: Fisheries

Fish Processing

In Kerala, water bodies suitable for fish culture are in abundance, but even 1% of their production potential is not exploited. In Kerala, around 12,500 ha of low-lying intertidal lands are used as traditional filtration fields mainly to exploit the shrimp resources naturally available in estuarine waters. District wise break up is given in **Table 2.8.8**.

It is a well-established fact that commercially important penaeid prawns enter the backwater system at their early life stages and spend 5-6 months in this area before returning to sea. This habit of the shrimps is made use of for impounding and periodically harvesting them from the low-lying fields. This type of prawn fishing is called 'Prawn filtration' which is still prevalent in the low-lying areas situated adjacent to the backwater of Kerala.

There are 2 types of fields where traditional filtration is practiced i.e., seasonal (95%) and perennial (5%). In seasonal fields, fishery operation is restricted to post-monsoon months after the harvest of paddy (Pokkali Krishi) whereas in the perennial fields, it is carried out throughout the year.

Traditional paddy cum prawn farming is being carried out in West Bengal, Kerala, Karnataka and Goa. One crop of paddy during the rainy season (low saline period) and one crop of prawn during summer season are cultivated in the low-lying coastlands in these states. Under this farming system, after the harvest of paddy, the juveniles of prawns and fishes in the incoming tides are trapped in the brackish water fields and harvested at fortnightly intervals. There is no control over the quality or quantity of the seed material, stocked in this system. The juvenile prawns do not get sufficient time to grow and therefore, the production is very low.

The average production of shrimp from the traditional fields was estimated to be around 600 kg/ha/season, which works out to almost a total production of 7000 MT/year from all the traditional filtration fields of Kerala. Since neither culture practice nor management is involved in the traditional filtration system, the shrimp production from these fields have always remained the same without showing any notable variations. The major percentage of catch from these fields comprises low valued shrimps mostly of juvenile size suitable for PUD packing.

In Kerala, the extent to which the prevailing traditional filtration system hinders the overall growth of shrimp production from the culture fields when compared to the performance of AP state, where only scientific farming prevails is clear from the data given in **Table 2.8.9.**

Although traditional filtration fields are often described as environmentally benign, however some negative impacts on the natural resources are also observed. The major drawbacks of the traditional filtration system are:

- Indiscriminate fishing of the undersized juveniles of commercially important shrimp, before attaining maturity
- Carnivorous and predatory species like eels, murrels, catfishes, Lates spp., Megalops spp. and crabs, which enter the trap along with the shrimp juveniles form a threat to the shrimp larvae in the filtration fields
- Only an average 0.5 m water column remains in the pond. Due to this, oxygen depletion during nighttime is a common phenomenon
- pH shows lower values during early hours due to the acidic nature of soil on many occasions
- Silt level is very high as the operation of filtration starts immediately after paddy harvest, without any preparation. Hence the soil fertility is not conducive for release of nutrients, which in turn helps to produce phytoplankton and zooplankton
- Under utilization of land due to low productivity
- Catch composition indicates that the low valued *M. dobsoni* contributes 58.9% of the total shrimp catch and fetches the lowest mean price of Rs 20/kg.

Details on the productivity of Shrimps with its price given in **Table 2.8.10** indicates that P. indicus has highest price (90 Rs. /kg), with lowest price of M. dobsoni giving highest production.

A minimum of 3-4 months growth phase is required for these shrimps in the brackish water, before they enter the marine ecosystem. If the above-mentioned number of shrimps migrate back to sea and are caught while fishing, then the total revenue would be about Rs. 320 crores **(Table 2.8.11)**.

Even though the loss of revenue worked out appear to be sizeable, such a difference in figures will never occur in practice, as several factors like death by predation, natural factors etc. by which a considerable number of shrimps which enter the marine ecosystem are lost and also the time period required for the shrimp to attain marketable size in the sea are overlooked. Thus by taking into consideration the number of shrimp caught from the sea as same as that obtained from the traditional field, the figures worked out may be exaggerated (**Table 2.8.12**)

Fish culture programme in Kerala was run by Fisheries Dept. and associated institutions. But due to the lack of participation by common people, fish production was very minimal. The knowledge that even technically complex matters can be run successfully with people's participation has paved way for Janakeeya Matsya Krishi which was started in 1998, details of which are given in **Table 2.8.13**. Janakeeya Matsya Krishi programme involves propaganda regarding fish culture, technical education, location and preparation of water bodies production and distribution of fish seed, fish culture, harvesting and marketing with people's participation under the supervision of local administrative bodies. Under Janakeeya Matsya Krishi, the major fish species cultured are: -

- **In saline water bodies: -** Estuarine fishes like *Etroplus suratensis*, *Liza parsia*, *Chanos chanos* etc. and prawns like *P.monodon*, *P.indicus* etc.
- **In fresh water areas:** - Shrimps like Macrobrachium rosenbergii and species like *Labeo rohita*, *Catla catla*, *Ctenopharyngodon idella* which reach harvestable size in a short time.

Details of Janakeeya Matsya Krishi Programme Conducted in Kottayam District

Janakeeya Matsya krishi programme in Kottayam district is mainly concentrated in Kottayam, Changanachery and Vaikom taluks, where around 6000 fishermen are trained. According to the survey conducted, about 500 ha of brackish water area is suitable for fish farming in Kottayam. Fish productions by capture and culture in Kottayam district for the years 1996-97, 1997-98, 1998-1999 is given in **Table 2.8.14**.

Even though the Ministry of Agriculture has established BFFDA and FFDA (**Table 2.8.15**) to promote aquaculture activities in the state by meeting 50% of the cost of the projects and assist fish farmers in their activities, the services rendered by these agencies are not found to be satisfactory. Further in Kerala, intensive prawn culture farms have been set up, even though in a restricted manner, with the financial support from ADAK.

The boom in the foreign market that occurred in 80s triggered the intensive prawn farming in Kerala. In 90s expecting a huge profit, experiments were done to conduct scientific prawn culture in all brackish water paddy fields in Kerala. These intensive culture operations upset the environmental balance, which resulted in diseases and heavy loss in the years 1991, 1994 and 1995. The modern intensive prawn farming cannot be conducted along with the Pokkali paddy cultivation. In the traditional paddy cum prawn culture, neither insecticides nor chemical manure are used. But in the intensive prawn culture, one or two selected sp. of prawns are reared by providing artificial feed and only prawn culture can be carried out in these fields.

As paddy cultivation in Kerala is not economically feasible, more and more farmers are switching on to intensive prawn farming with technical assistance from agencies like ADAK. Paddy-cum-prawn culture is carried out in 10,937 ha of Pokkali fields. The intensive farming by which prawn is cultivated throughout the year has resulted in the scarcity of prawn eggs and seeds, and the disappearance of fishes like Clarius, Lates etc. from the Pokkali fields.

As compared to the fresh water fisheries, the brackish water fisheries in the State are relatively better organized. However, there is no proper management of the fisheries of this region. The brackish waters, besides supporting a lucrative fishery, form an ideal nursery ground for several fishes and crustaceans. In recent years, because of increasing demand for fishes, particularly for prawns from the export trade these has been considerable increase in fishing effort in the capture fisheries of this region. Several gears operating in this region are carrying out large-scale exploitation of juvenile prawns and fishes.

Such unrestricted exploitation of juvenile stocks adversely affects the fisheries of this area as well as the adjacent sea, as the recruitments to these regions are interdependent. This is particularly so in the case of prawn fishery, which form one of the important fisheries of the state and one of the main sources of its economy. Besides this, reclamation of the brackish water areas for agro-industrial and urbanization programmes is also adversely affecting the fishery. In view of this, appropriate conservation and management measures have become an imperative need for the rational exploitation of the resources of this region, rather than the expansion of the fishery. The status of aquaculture in Kerala can be summarized as follows: -

- Traditional prawn filtration fields are getting destroyed
- Paddy cum prawn culture is disappearing because subsidies are available only for intensive culture
- With the advent of intensive culture, mangrove areas which are important as breeding grounds of fishes and crustaceans are being destroyed
- Prawn farmers are resorting to destructive harvesting technologies
- Government agencies are still not able to develop an environment friendly, economically feasible scientific culture practice for prawns and fishes.

Development of scientific fresh and brackish water fish culture would greatly help to solve the unemployment problems acutely faced at present in the state.

- The concept of desalination could be attempted in Cochin region by utilizing the intermediate saline waters of the Cochin backwaters

- Utilization of unpolluted estuarine waters towards aqua farming
- Tidal /freshwater flow currents for energy generation.

The Cochin backwater and its immediate neighbourhood are governed and administered by a large number of authorities / ministries / departments. The activities of these bodies are conflicting at times or the administrative steps taken to fulfil policy objectives do not care much about the environment. The composite and diversified activities of these authorities have unfortunately not been able to co-ordinate and implement healthy environmental practices. An estuarine management authority with comprehensive powers will have to be constituted to find a solution for the above. Some of them are:

- Augmented drinking water supply schemes and replacement of existing dilapidated pipelines. Consideration has to be given to the population growth and related demands
- Proper provision has not been made to keep the sewerage and canals clean. It is necessary that proper water flow is maintained in the drainage systems to avoid blocking and there by flooding of low lying areas with storm water and domestic waste water
- In recent years, a number of tragedies have occurred due to sporadic fire resulting in loss of properties. One of the inadequacies for fire fighting has been reported as the non-availability of water, pressure tubing, local wells or ponds, ground storage tanks etc. Without incurring much expenditure, monsoonal runoff in the estuary may be diverted and stored at nodal points to meet fire-fighting requirements
- No declared policy exists as of date on the sharing of water resources. Since drinking water and its supply has the top priority, existing industries and those, which are likely to come up, will have to identify and quantify their water requirements and recycle oppurtunities
- Vector and water borne diseases and control is closely linked to the hygienic conditions of the cities. Thorough flushing of sewage canals, open canals, waste dumping grounds, processing units, treatment plants are prerequisites in attaining better human (health) quality index. In Kochi the larval population is minimum in drains and canals during the rainy months due to flushing or flooding. Their contribution during the rest of the season is high, accounting for over 90% of the total mosquito production from all sources. The next major breeding source is septic tanks. There are over 1.2 lakhs septic tanks in Kochi corporation area and most of them are heavy breeding places of mosquitoes. Backwater pools, ponds, channels, pits and ditches of mangrove forests are the major mosquito breeding grounds for *Culex sitiens*. The aquatic weeds *Eichornia, Pistia*, etc. are the host plants of *Mansonia* species. A total of 35 species of mosquitoes belonging to eight genera have been listed from Kochi city. The mosquito menace in Kochi city is mainly due to the night biting mosquito species such as *Culex quinquefasciatus*, *Culex sitiens*, *Armigeres subalbatus*, *Mansonia* species and *Anopheles* species. The important day biting mosquitoes are *Aeded albopictus*. The approach to

mosquito control in the city is that of drainage cleaning, maintenance of septic tanks, providing proper water flow in the canals, avoiding water stagnation, use of mosquito larvicides and weed control

- Non-degradable plastics as well as large quantities of garbage pile up in specified locations. No mechanism exists at present for the effective removal and disposal of the same.

2.8.4 Agro based Industries

Coir Industry

About 46% of area in GKR is under coconut and about 44% of total production of coconut in Kerala comes from GKR. No wonder, the coir yarn and coir production industry assumes the greatest importance in the industrial sector of GKR, especially, in the coastal districts. More than 2 lakh workers are engaged in this traditional industry, out of which females far outnumber the males. One important feature is that more than 50% of workers are engaged in the cooperative sector. Out of 682 cooperative coir societies, in the State, 435 are in GKR. It is of high export value.

During 1997-98, the coir and coir products brought in Rs.240 crores through various products; coir fibre, coir mats and matting, geotextiles, rubberized coir, coir pith etc. One interesting feature in the export products is the growing demand of pith in European market, which is replacing peat for its more efficient moisture absorbing capability.

The coir industry of Kerala is undergoing a fast phase of modernization with machines for spinning of yarn and extraction of fibre. As part of modernization, the State Govt. is implementing an "Integrated Coir Development Project" with the financial assistance of Government of India for setting up 200 spinning units and 100 defibering mills in the Cooperative sector.

COIRFED is the apex federation of primary coir cooperative societies engaged in the manufacturer of coir and coir products. Centre for Development of Coir Technology (C-DOCT) has developed a product, 'silver', which is bio-degradables and cost-effective. It is fast catching up with the market, earning Rs.313 lakhs in 1997-98. Thousands of people are engaged in coconut oil production, being practiced as a cottage industry. The 'KERA' brand of coconut oil produced by the KERAFED has become the most popular edible oil in Kerala, known for its purity and quality.

Khadi and Village Industries and Handicraft Industries

Khadi and Village Industries Board is the main agency to implement the khadi and village industries programme in the State. There are six Village Industries Federations working under the Board for different products like cottage match, agarbathy, rubber based products, processing of cereals and pulses, bee-keeping, fruits and vegetable preservation, lime product, cane and bamboo, ayurvedic medicines etc. The total value of sales of these products was about Rs.65 crores during the year 1997-98 for the State and approximately Rs 30 crores for the GKR. It provides employment opportunity for about 50,000 people in the State and about half of the number is in GKR

Surabhi is sponsored by the State Government for the development of handicrafts industry through cooperative sector. Bamboo Corporation and Handicrafts Corporation are other State agencies engaged in the promotion of handicraft industry. The Kerala Agro-industries Corporation manufactures a wide range of fruit products under the brand name 'JYOTHI' and marketed.

The Oil Palm India Ltd. is a joint venture of the Government of Kerala and Government of India. It has about 3646 ha of oil palm estates in Kollam. Steps have been taken for setting up a modern mill in Kollam District and a seed garden at Thodupuzha for the production of hybrid seeds.

Plantation Industry

The Plantation Corporation of Kerala Ltd. has 9 rubber estates. In addition to rubber, it has cashew and oil palm estates. The oil palm estate is located near Kalady. In addition to rubber processing factories, a rubber wood-processing factory has also been started. The Corporation provides employment to 6000 persons.

Rubber Board, Spices Board and Tea Board

These Boards are the links between the planters and the buyers, promoting the highly rewarding agro-business in the State, in general, and the GKR in particular.

The Rubber Board functions at Kottayam under the Ministry of Commerce of the Government of India. The activities of the Board are classified under eight departments viz., Administration, Financial Accounts, Rubber production, Training, Research, Processing & Product Development, Statistics & Planning and Technical Consultancy. Field service is rendered through Zonal Supervisory Regional and Field Officers spread all over the country. Liaison Officers are at Ahmedabad, Bangalore, Bombay, Calcutta, Jullunder City. Kanpur, Madras and New Delhi.

The Spices Board helps in brining together the international buyers of spices with the Indian exporters. The Board also facilitates constant dialogues between international organisations and Indian spice export bodies. The Board also publishes monthly magazines in different languages for the benefit of farmers, exporters and traders.

The functions of Tea Board are to promote development of tea industry for which specific measures are to be taken regarding regulation of production and extend cultivation of tea; improvement of quality; promotion of cooperative efforts among growers and manufactures; undertaking scientific, technological and economic research and maintaining demonstration farms and manufacturing stations; assisting in the control of insects and disease affecting tea; regulation of sale and export; training in tea testing; increasing the consumption of tea in foreign countries; registering and licensing manufactures, brokers, tea waste dealers and persons engaged in the business of blending tea, improving marketing facilities etc.

Sericulture

It is only ten years since the sericulture activity started in the State. At present, around 2023 ha area is under mulberry cultivation involving around 7500 farmers. All the districts of GKR have mulberry cultivation. The total cultivated area of GKR comes 505 ha, producing 26.4 MT of cocoon, engaging about 1951 farmers.

Table 2.8.1

District-wise Details of Small Scale Industries in GKR

District	No. of SSI Units Promoted by				Total Investment (Rs. in Lakh)	Trunover (Rs. in Lakh)	Employment Provided (Nos.)
	SC/ST	Women	Others	Total			
as on 31.03.1991							
Alappuzha	124	720	5730	6574	4313	45236	38249
Ernakulam	353	517	9637	10507	16979	36265	53520
Idukki	157	407	1580	2144	1108	5540	7678
Kottayam	121	749	6571	7441	6970	-	31202
Pathanamthitta	185	734	1221	2140	698	4280	9717
Thrissur	309	558	7354	8221	9887	749	36578
GKR	**1249**	**3685**	**32093**	**37027**	**39956**	**92070**	**176944**
as on 31.03. 1998							
Alappuzha	486	2756	13289	16531	174392	63398	87220
Ernakulam	848	3291	20308	24447	47127	201951	121863
Idukki	360	1588	3137	5085	4766	11687	17708
Kottayam	423	3198	14863	18484	18993	49970	66874
Pathanamthitta	581	1986	5261	7228	6052	13428	29390
Thrissur	1105	2289	15520	18914	34239	81318	80648
GKR	**3803**	**15108**	**72378**	**90689**	**128618**	**421752**	**403703**

Source : Secondary data collected by KSSP

Table 2.8.2

Working Status of Small Scale Units (as on 31.03.1998)

District	Total No. of Units	No. of Units Identified As			Units Revived by DIC (during 1997-98)
		Sick	Registered	Revived	
Alappuzha	16531	365	182	176	NIL
Ernakulam	24447	1128	205	204	1
Idukki	5085	61	40	23	NIL
Kottayam	18484	274	239	91	NIL
Pathanamthitta	7828	162	52	46	2
Thrissur	18914	214	112	48	4
GKR	90689	**2204**	830	**588**	7

Source : Secondary data collected by KSSP

Table 2.8.3

% Participation of Different type of Industries

Type of Industry	Share (%)
Coir And Coir Products	19.30
Mechanical / General Engineering	9.86
Repair and Servicing	7.99
Flour Mills / Rice Mills / Cattle Feeds	7.07
Food & Catering / Curry Powder	5.87
Wood / Forest Industries	5.80
Bricks / Tiles / Pottery	5.74
Readymades / Tailoring	5.16
Rubber Based	3.30
Vegetable Oil / Edible Oil / Oil Extraction	3.04
Other Groups	26.87

Table 2.8.4

% Participation of Different Units in SSI

District	Total No. of SSI	Largest Group with %	2nd Largest Group with %	3rd Largest Group with %
Alappuzha	7079	Coir & Coir Products 59.70	Brick / Tiles / Pottery 6.10	Poultry / Cattle Feeds / Meat & Fish 5.80
Ernakulam	9692	Mech. / Gen. Engineering 17.40	Repair & Servicing Industries 17.26	Food / Curry Powder / Pappad 8.97
Idukki	797	Automobile / Body Building 21.83	Flour Mills / Cattle Feeds 11.29	Service Stations / Misc. 9 70
Kottayam	3196	Rubber Based 11.14	Wood / Forest Based 11.10	Mech./ Gen. Engineering 10.23
Pathanam-thitta	1440	Flour Mills / Cattle Feeds / Rice Mills 13.40	Wood / Forest Based 9.03	Printing / Photography 8.90

Source : Secondary data collected by KSSP

Table 2.8.5

District-wise Break up of Medium and Large Scale Industries in GKR (as on 31.03.1998)

District	Central Sector	State Sector	Cooperative Sector	Joint Sector	Private Sector	Total
Alappuzha	1	6		3	21	31
Ernakulam	8	8	1	4	124	145
Idukki			1	1	9	11
Kottayam		2	2		17	21
Pathanamthitta		1	1	1	5	8
Thrissur	2	7	1	7	29	46
GKR	**11**	**24**	6	16	205	**262**

Source : Secondary data collected by KSSP

Table 2.8.6

District-wise Distribution of Product, Production, Economies & Raw Materials of Industries

Products (No. of Industry)	Production	Turnover (Crore Rs.)	Raw Materials
Alappuzha District			
Sea Food (11)	27.5 Crores MT	266.53	Shrimp, Prawn, Crab, Fish Etc.
Coir (11)		108.31	Coir, Dyes, Chemicals
Metal (5)		1052.71	Steel, Bronz etc.
Textiles (2)		12.05	Cotton
Glass (2)		37.97	Soda Ash, Glass Fibre
Match Stick (2)		46	Wood
Foreign Liquor (1)	10 Lakh Cases	36	Spirit
Milk (1)		17	Milk
Gas –Oxygen (1)	291457 MT	60	Oxygen
Sand Lime Bricks, Fly Ash Bricks, Lime		1.5	Lime Shell, Sand, Coal
Allopathic Medicines (1)		7.11	Paracetamol, Amoxylin

Contd...

Table 2.8.6. Contd...

Products (No. of Industry)	Production	Turnover (Crores)	Raw Materials
Ernakulam District			
Metal (12)		1294.16	Bauxite, Aluminium, Carbon Steel, Gun Metal, Tin Plates etc.
Textiles (2)	445837 kg	28.29	Cotton
Sea Food (5)	78928.5 MT	42.98	Shrimp, Prawn, Cuttle Fish etc
Industrial Oxygen Acetylene (1)	840478 m^3	3.18	Calcium Carbide
Electronics (8)	-	145.7	Metalcomponents, Ceramic Base, Lamination Materials
Fertilizer (2)	319934 MT	1313.5	Naphtha, Sulphur
Ayurvedic Medicines (1)	-	3.5	Herbal Plants
Bamboo Ply (1)	26.79 lakh	10	Bamboo
Spices (4)	2527 MT	100.18	Pepper, Chilli, Spices
Food (4)	-	55.92	Wheat, Sugar etc.
Rubber (16)	2.09 MMT	80.11	Rubber Scrap, Latex
Chemical Industries (12)	0.155 MMT	708.07	Limeshell, Carbon, Common Salt, Benzene, Copper, Lpg, Polyt-Hene, Rock Phosphate
Paper (4)		8 84	Waste Paper
Essential Oil (2)		19.25	Mustard Seed, Coconut
Plastic (4)		28.6	Poly Carbonate
Ceramics (2)		30.98	Bone Ash, China Clay
Petroleum Oil (1)	6.90 MMT	3917.75	Naphtha, Kerosene, Crude Oil
Rice Mill Units (20)		60 96	Paddy
Tea/Coffee (2)		236.52	Tea/Coffee
Total (103)			
Idukki District			
Ayur. Medicines (1)	1729 MT	10.97	Herbal Plants
Electronics (1)		5 17	
Kottayam District			
Food (3)		4 47	Wheat
Rubber (4)		2262.51	Latex, Rubber
Paper (2)	108914 MT	250.27	Reed, Bamboo, Wood
Cement (1)	29943 MT	34.04	Limeshell, Clay
Thrissur District			
Foreign Liquor		2.5	Extra Neutral Alcohol

Source : Secondary data collected by KSSP

Table 2.8.7

Economic Status of Government of India Companies in GKR

(Rs. in Lakhs)

Name of Company	1987-88	1988-89	1989-90	1990-91	1991-92
Cochin Refineries Ltd., Cochin	+1954	+4156	+8226	+9684	+9804
Cochin Shipyard Ltd., Cochin	-2586	-2638	-2771	-2097	-1492
Fact, Aluva	+1290	+597	+26	+2361	+2900
Hindustan Newsprint Ltd., Kottayam	-175	+200	+2036	+3102	+3801
Indian Rare Earths Ltd.	NA	+367	-60	-53	+14
Hindustan Insecticides Ltd., Aluva	-27	+97	+37	-60	+9
Modern Food Industries (I) Ltd , Cochin	+68*	+34*	+40	+53	+65
H.M.T. Ltd., Kalamassery, Kochi	+20*	+30*	-280	+265	+844
Balmer Lawrie and Company Ltd., Aroor	-86	+8	-107	-66	+24
Hindustan Organic Chemicals Ltd., Cochin	+43	+205	+472	+2859	NA

(+) : Net Profit; (-) : Loss

Table 2.8.8

District-wise Break-up of Shrimp Filtration Fields in GKR / Kerala

District	Area (ha)
Trivandrum	Nil
Kollam	24
Alappuzha	475
Kottayam	15
Ernakulam	10597
Thrissur	898
Malappuram	Nil
Calicut	Nil
Kannur	501
Kasargode	Nil
Total	12511

Table 2.8.9

Trend of Shrimp Farming in Andhrapradesh and Kerala

Year	Andhra Pradesh		Kerala	
	Area under Culture (ha)	Estimated Production (MT)	Area under Culture (ha)	Estimated Production (MT)
1991-92	8100	9700	13145	9500
1992-93	9500	12000	13400	9750
1993-94	19500	36000	13860	11500
1994-95	34500	34000	14100	12000
1995-96	50000	27140	14657	9000
1996-97	60249	30577	14658	8225
1997-98	66290	34075	14595	7290
1998-99	66249	44858	13180	7660

Estimated Potential area in AP : 1,50,000 ha; and in Kerala : 65,000 ha

Source : Secondary data collected by CUSAT

Table 2.8.10

Average Catch of Each Species in the Traditional Filtration System

Species	Catch Quantity (kg/ ha)	Total No. of Shrimps (Nos./ha)	Average Price (Rs./ kg)	Total Value (Rs./ha)
P. indicus	260	24528	90	23400
M. dobsoni	288	480000	20	5760
M. monoceros	51	20400	40	2040
Total				Rs 31200

Table 2.8.11

Revenue Generated from Marine Ecosystem

Species	Average Weight (g)	Production from Traditional Fields		Average Price (Rs./Kg)	Total Revenue (Rs.)	Loss of Revenue due to Traditional Fields	
		(No./ha)	Total Quantity (Kg)			(Rs./ha)	Total (Rs. Crore)
P. indicus	22	24528	540	225	121410	98010	120
M. dobsoni	7	480000	3360	50	168000	162240	194
M. monoceros	10	20400	204	75	15300	13260	15

Source : Data collected by CUSAT

Table 2.8.12

District Wise Details of Traditional Prawn Filtration Fields and Brackish Water Fish/ Prawn Culture Farms in Vembanad Lake

District	Area of Traditional Prawn Filtration Fields (ha)	Area of Culture Farms-Public and Private (ha)	Total Area (ha)
Ernakulam	10597.01	131.46	10728.47
Kottayam	15.38	48.61	63.99
Alappuzha	475.35	9.24	484.59

Table 2.8.13

Details of Janakeeya Matsya Krishi Programme Conducted in Kottayam

Year	Supervising Dept.	Fish species Utilized	No. of Fish Seed Deposited	Place of Culture
1997	Fisheries	M. rosenbergii	130000	Kumarakom, Thiruvarppu
1998	District Panchayat	*M. rosenbergii*	234700	T.V. puram, Chembu, Thalayolaparam
1998	-do-	*Labeo rohita*	103200	Illickal, Thiruvarppu
1998	-do-	*Cirrhinus mrigala*	60000	Thalappalam, Erattupetta
1998	-do-	*M.rosenbergii*	140250	Kaduthuruthy, Kallara, Thiruvarppu
1998	-do-	*Cirrhinus mrigala*	70000	Kidangoor, Chayakadavu
1999	ADAK	*M. rosenbergii*	10000	Kumarakom Boat jetty
1999	-do-	*E. suratensis*	5000	-do-
1999	-do-	*M. rosenbergii*	37500	Palakadavu, Thalayolaparambu
1999	-do-	*Labeo*	66000	Meenachil, Illickal, Thiruvarppu
1999	-do-	*M. rosenbergii*	75824	Samickal jetty Vechoor
1999	-do-	*-do-*	179240	Neendur, Thiruvarppu
1999	-do-	*Labeo*	137360	Kallara
1999	-do-	*M. rosenbergii*	88720	Thalayazham
1999	-do-	*-do-*	77717	T.V.Puram
1999	-do-	*Labeo*	100000	Muvattupuzha, Vadayar
1999	-do-	*M. rosenbergii*	155400	Maniyamparampu, Arppookara
1999	-do-	*Etroplus*	28000	-do-
1999	-do-	*M.rosenbergii*	57600	Kallara

Source : Secondary data collected by CUSAT

Table 2.8.14

Fish Production by Capture and Culture in Kottayam District

Species	Fish Production (MT)		
	1996-97	1997-98	1998-99
Fish Production by Capture			
M. rosenbergii, Penaeids	300	310	320
Etroplus suratensis	340	335	350
L. parsia, Mugil cephalus	325	310	289
Ophiocephalus	516	537	560
Tachysurus	300	247	225
Tilapia	390	450	468
Chanos chanos	30	40	45
Johnius sp.	168	180	185
Scylla serrata	30	35	40
V. cyprinoids	180	160	148
Others	360	420	425
Total	**2939**	**3024**	**3055**
Fish Production by Culture			
Catla catla	100	245	460
Rohita	75	225	356
Cyprinus	22	28	60
Ctenopharyngodon idella	24	180	240
Mrigal, silver carp	5	12	18
Total	**226**	**690**	**1134**

Table 2.8.15

Govt. Agencies Setup to Augment Prawn Culture Activities in the State

Name	Nature of Duties
Prawn hatchery CIBA, Narakkal	Production of seeds of *P. indicus*
MPEDA's shrimp project complex, Vallarpadam	Production of seeds of *P. monodon* and *P. indicus*
Brackish water Fish Farmers Development Agency (BFFDA)	Development and promotion of prawn farming
Fish Farmers Development Agency (FFDA)	Development of inland fish production and culture
Agency for Development of Aquaculture in Kerala (ADAK)	To encourage Aquaculture activities

2.9 Human Resources

2.9.1 District-wise Population / Work Force

In 1981 and 1991 censuses, the whole population was divided into three categories, namely; main workers, marginal workers and non-workers. The main worker is defined as a person whose main activity is participation in any economically productive work by his physical or mental activities and who had worked for 183 days or more. Work involved not only actual work, but effective supervision and direction of work. A marginal worker is defined as a person whose main activity is participation in any economically productive by his physical or mental activity for less than 183 days. A non-worker is defined as a person who had not done any work at any time.

The workers are classified into four categories, namely; cultivators, agricultural labourers, those engaged in household industry and other workers. A cultivator is a person who is engaged either as employer, single worker or family worker in cultivation of land owned or held from government or held from private persons or institutions for payment in money. Cultivation includes supervision or direction of cultivation. A person who works in another person's land for wages in money, or share should be regarded as an agricultural labourer. The person has no risk in the activities but merely works on another person's land for wages.

Household industry is defined as an industry by the head of the household himself/herself and/or by the members of the household at home or within the village in rural areas and only within the precincts of the house where the household lives in urban areas. Other workers include the workers who are not cultivators or agricultural labourers or in household industry. Factory workers, plantation workers, those in trade, commerce, business, transport, mining, construction, political or social work, all government servants, municipal employees, teachers, priests etc. come under this group.

Table 2.9.1 shows the details of work force in all the districts of GKR. Ernakulam has maximum number of main workers and Pathanamthitta has minimum. Marginal workers are maximum in Alappuzha and minimum in Pathanamthitta district. Thus Alappuzha and Ernakulam districts are rich in human resources as compared to other districts.

District wise distribution of main workers, marginal workers, non-workers and those seeking work among the non-workers are summarized through **Tables 2.9.2 to 2.9.7** under the different age group categories. Data in the above table is given as total and for rural and urban areas respectively for each district.

2.9.1.1 Alappuzha District (Table 2.9.2)

Out of the total population of about 20 lakhs in Alappuzha district, 69.5% live in rural areas. About 65.91% of the total population is non-workers and in that only 17.85% are job seekers. About 30.11% of the population is main workers and 4% are marginal workers. Among the main workers, highest percentage of 20.63% are in the age group of 40-49, and similarly a maximum of 16% of the marginal workers are also in the same age group. Also it can be seen that 70% of the main workers in this age group are males, where as 60.7% of the marginal workers in this age group are females. Among the non-workers 61% are females and in the non-workers seeking jobs, 56% are females.

If the rural urban difference in the number of each category of human resources is considered, it can be seen that the main workers in the rural areas of Alappuzha district is 69.4% of the total main workers, this break up is exactly similar to the rural-urban break up of population in the district. But among the marginal workers, 72.28% are in the rural region. A similar percentage of 69.43% of the non-workers are also in the rural areas. Maximum job seekers are in the age of 20-24 both in rural and urban areas.

2.9.1.2 Ernakulam District (Table 2.9.3)

About 51.25% of the population of Ernakulam district is in the rural areas. In the total population, 66.56% are non-workers, 31% are main workers and 2.44% are marginal workers. Among the non-workers 15.65% are job seekers in which 57% are females. It is also seen that in the rural and urban areas, the maximum percentage of jobseekers are in the age group 20-24. Among the main workers, the highest percentage (about 20.73) is in the age group 40-49 and in the marginal workers; the highest percentage (17.22) is in the age group of 20-24. In age group of 40-49, 77.28% of main workers, and in the age group of 20-24, 56.88% of marginal workers are males. But among the non-workers, majority (63.57%) are females. In the non-workers seeking jobs 57% are females Majority of main workers (53%) and marginal workers (63%) are in the rural areas where as 50.1% of the non-workers are from urban areas in the district.

2.9.1.3 Idukki District (Table 2.9.4)

In Idukki district, 95.28% of the population lives in the rural areas. The percentage of non-workers is relatively less in the district, ie. 60.29% in which 14.28% are job seekers. The highest percentage of main workers (36%) is another speciality of this district. About 36% of the total population is marginal workers. Among the main workers, the highest percentage of 18.7 is in the age group 40-49 and among the marginal workers, a maximum of 20.61% are in the age group of 20-24. About 73% of the main workers in the age group of 40-49 are males and 55.9% of the marginal workers in the age group 20-24 and 62.36% of total non-workers are females. Majority (62.37%) of the job seekers among non-workers are also females. Among the main workers 95.9%, among the marginal workers 98.7% and among the non-workers 94.7% are in the rural areas.

2.9.1.4 Kottayam District (Table 2.9.5)

In the total population of Kottayam district, 82.45% of the people are in the rural areas. About 68.8% of the population are non-workers, 29.38% main workers and 1.85% are marginal workers The percentage of job-seekers among non workers comes to 16.76 and the highest percentage of job seekers are in the age group of 20-24 both in rural and urban areas. A minimum of about 20.29% of the main workers and 16.05% of the marginal workers are in the age group of 40-49. About 80% of the main workers in the age group of 40-49 are males and about 56.83% of the marginal workers are females. Also it is to be noted that 63.97% of the total non-workers and 59.5% of the job seekers among the non-workers are also females. Majority of the main workers, marginal workers and non-workers are in the rural areas.

2.9.1.5 Pathanamthitta District (Table 2.9.6)

About 86.95% of the total population of Pathanamthitta district is in the rural areas. The percentage of non-workers is 70.28%, which is the highest of its kind in GKR. About 17% of the non-workers are job seekers. The main workers are only 27.06% of the total population and marginal workers constitute 2.66%. Among the main workers a maximum of 20.79%, and in the marginal workers a maximum of 16.83%, are in the age group of 40-49. Majority (79.29%) of the main workers are males in the 40-49 age group and majority (66.5%) in the marginal workers of the same age group are females. About 64% of non-workers are females and 60.95% of the job seekers among non-workers are also females. About 87.25% of main workers, 91% of marginal workers and 86.68% of non-workers are in the rural areas.

2.9.1.6 Thrissur District (Table 2.9.7)

In Thrissur district, 73.69% of the total population is in the rural areas. Non-workers contribute 68%, main workers 29.4% and marginal workers 2.56%. About 14.25% of the non-workers are job seekers. Among the main workers a maximum of 19.87% are in the age group 40-49. But in the marginal workers, a maximum of 16.47% are in the age group 20-24. Approximately 70.25% of the main workers in the age group 40-49 and 55.97% of marginal workers in the age group of 20-24 are males. But 62.7% of non-workers are females and 56.14% of the total number of job seekers is a females. Further, it can be seen that 74.21% of the main workers, 80.52% of the marginal workers and 73.21% of the non-workers reside in the rural areas.

The main workers are classified further into ten groups such as cultivators, agricultural labourers, and workers in sectors like live stock, forestry and fisheries, mining and quarrying, manufacturing, processing servicing and repairs in household industry, manufacturing and servicing other than household industry, constructions, trade and commerce, transport, storage and communication and others. Industrial classification of main workers is given in **Table 2.9.8** along with their availability in the districts of GKR.

The percentage of distribution of main workers of each sex into broad industrial categories in different districts as per 1991 census data is given in the **Table 2.9.9**. In Alappuzha, Kottayam, Pathanamthitta and Thrissur districts of GKR, the maximum percentage of main workers are agricultural labourers, where as in Ernakulam those engaged in unspecified other services, dominate others and in Idukki district, those engaged in livestock, forestry, hunting etc. are the major group of main workers. The highest percentage of cultivators is in Pathanamthitta district and lowest percentage is in Thrissur district.

The sex ratio among total population, total workers, main workers and each category of main workers, marginal workers and non workers in total rural and urban areas in the districts of GKR are given in **Table 2.9.10**. The average sex ratio in GKR is 1029 with 1031 and 1027 for rural and urban areas. The highest sex ratio is for non-workers (1699) with 1698 and 1710 for rural and urban areas. Marginal workers with 1397 and 1067 for rural and urban areas give the second highest value of 1331. With respect to the main workers, the sex ratio in GKR is 307, with 315 and 274 for rural and urban areas respectively. In the group of main workers, those workers in manufacturing, processing, servicing and repairs in household industry record the highest sex ratio. For this group, the average sex ratio in GKR is 1131. The lowest sex ratio among main workers is in the group of transport, storage and communication.

The percentage of SC/ST population in total workers, main workers, marginal workers and non-workers in the districts of GKR is given in **Table 2.9.11**. The percentage of population in total workers in GKR is 41.41. Among main workers, 37.14% and among marginal workers 4.01% are SC. The percentage of SC population is highest among non-workers (58.86). The data for ST population is almost similar to the SC population.

Comparison of the work participation rate in GKR for 1961 and 1991 is given in **Table 2.9.12**. It can be seen that there is a reduction in the work participation rate in 1961 from 33.74 to 33.28 in 1991. In 1991 Alappuzha ranks first with 34.1 and Pathanamthitta ranks last with 29.27. This gives an indication of the involvement of human resources in the economic activities.

The female work participation rate in different districts for the year 1981 and 1991 are given in **Table 2.9.13**. The average female work participation rate of 18.55 in 1981 was reduced to 17.94 in 1991. Idukki ranks first in Kerala in the female work participation rate and Kottayam are in the 12th place in Kerala with respect to female work participation rate.

The average daily wage of skilled labour in the construction sector both in rural and urban areas are given in **Table 2.9.14**. It can be seen that there is an increase in the daily wages for 1st class carpenters from Rs.49-54 to Rs.66-75 for the period 1987-88 to 1992-93 in rural areas. In the urban areas, the corresponding increase is from Rs.46-56 to Rs.69-74. In the case of first class mason, the above increase is from Rs.49-54 to Rs.66-74 in rural areas and from Rs.49-57 to 66-74 in the urban areas.

The average daily wages of carpenters and mason in 1958-59 and 1996-97 are given in **Table 2.9.15**. For GKR as a whole, the average daily wage of 1st class carpenter in rural areas is Rs.134 and Rs.138 for urban areas. For first class masons in rural areas, the average daily wage is Rs.134 and for urban areas, it is 138 in 1996-97.

The employment details available for the districts of GKR show that Ernakulam district has maximum number in all the sections of employment such as public, private, public central, public state, public local bodies and quasi-government (**Table 2.9.16**).

The details of employment for 1981, 1985, 1988, 1989, 1990, 1991 and 1992 in the case of public and private sectors, is given in the **Table 2.9.17**. From 1981 to 1992, there was 23.77% increase in the employment in public and private sectors. Except in the case of Alappuzha district, all other districts recorded increase in the number of employment in public and private sectors between 1981 and 1992. Among other districts of GKR, the percentage of increase in employment is highest in Pathanamthitta district (29.42%). Idukki with 6.4% increase in employment is the lowest.

When the public sector is considered alone (**Table 2.9.17**), it is seen that in 1992, there were 252095 employments in GKR. About 40% is from Ernakulam district alone. This is due to the relatively higher concentration of public sector organisations in Ernakulam compared to other districts. The contribution of Idukki district to this total employment is at the other extreme with only 5.74%. It can also be seen that between 1981 and 1992, there was 34.69% increase in the total employment in public sector in GKR.

As per 1992 data the total number of employment in private sector for GKR as a whole is 240900. About 27.6% of it is in Ernakulam district. In private sector, Pathanamthitta district with 5.18% contribution to the total in GKR ranks last and it has to be noted that Idukki has a substantial contribution of 24.5% in this regard. The district-wise employment details in central public sector for the year 1992 indicate that there are 32452 employees in central public sector in GKR, in which about 59% is in Ernakulam district. The lowest number is for Idukki with 4% contribution.

As per 1992 data in GKR for state public sector, there are 103060 employments in this sector. Ernakulam district with 25.64% contribution comes first and Idukki with only 8.65% contribution ranks last. Out of the 10798 employed in public sector local bodies in GKR, the highest percentage of contribution of 34.9% is from Ernakulam district and the lowest contribution of 8.6% is from Idukki.

Another sector of employment is quasi-government public sector. As per the data, the total employment in this sector in 1992 is 105785. Here also Ernakulam district has a maximum contribution of 48% and Idukki has a minimum contribution of only 3%.

The details on the employment in GKR show that Ernakulam district ranks first and Idukki ranks last in the employment, in organised sectors. This means that there exists a wide gap between districts like Ernakulam, Thrissur, Pathanamthitta and Idukki, Kottayam and Alappuzha.

2.9.2 Religious Structure of Population

The social status of any community is directly or indirectly related to their religion, and an account of the religion-wise distribution of households in GKR is considered. When GKR as a whole is considered, majority of the households (53.365) are Hindus. The percentage of Christians (37.17%) comes second and the remaining 9.47% of households are Muslims. Even though the census 1991 reports three other religions like Sikhs, Buddhists and Jains in Kerala, the survey undertaken do not identify any such households.

The religious composition of the districts of GKR can be seen from the **Table 2.9.18** and **Fig. 2.9.1**. Even though this is based on the religion of the head of households, we did not see any households with members of different religions. Hindus are majority in all the districts except Ernakulam and Thrissur In Thrissur, we have surveyed only three panchayats and generalisation may not be correct with that. But in Ernakulam no religious group is having majority, though Hindus are the major group followed by Christians. As per 1991 census the highest percentage of Christian households is in Kottayam (45.83%) and the lowest percentage of Christians is in Alappuzha district, which ranks first in the percentage of Hindus as per 1999-2000. Muslims are having highest percentage (59.72%) in Thrissur and this religion is minimum (23.23%) in Alappuzha district. The above religious composition based on the 1999-2000 primary data is similar to the secondary data from 1991 census report.

2.9.3 Social Groups

The households of GKR and districts in GKR are classified into 5 social groups based on their castes, such as SC, ST, other eligible communities (OEC), other backward communities (OBC) and others (which includes castes in the higher levels of the social hierarchy). The castes included under each social group are with reference to the list of castes under each group published by the Govt. of Kerala in the Gazette notification (**Table 2.9.19 and Fig. 2.9.2**).

2.9.4 Age-wise Classification of Population & Projections

The age structure of population arrived at from primary data is given in the **Table 2.9.20** and **Fig. 2.9.3**. It shows that in GKR a maximum of 41.09% of the population are in the productive age group of 16-35; which is followed by 28.56% in the age group 36-60. About 10.55% of the population is in the age group of above sixty. The remaining are children below the age of 15 years. The growth trend in population for different age groups is given in **Table 2.9.21**.

2.9.5 Marital Status

The percentage-wise distribution of population based on their marital status is a general indicator of the social status. In GKR 6 57% of the population are widow/widower/divorced. The percentage of widow/widower is highest (6.91%) in Pathanamthitta district and it is minimum in Idukki district. The percentage of divorced people is minimum in Idukki district and their highest percentage is in Alappuzha district (**Table 2.9.22, Fig. 2.9.4**)

Table 2.9.1

District wise Human Resources Availability in GKR

(in lakhs)

District	Population		Literacy Rate (%)	Details of Work Force			
	Total	SC/ ST		Main	Marginal	Total	% Work Participation
Alappuzha	20.10	1.93	93.87	6.03	0 80	6.83	33.98
Ernakulam	28.18	2.47	92.35	8.74	0.69	9.43	33.46
Idukki	10.78	2.07	86.94	3.90	0.39	4.29	39.80
Kottayam	18.28	1.54	95.72	5.37	0.34	5.71	31.24
Pathanamthitta	11.88	0.81	96.55	3.21	0.32	3.53	29.71
Thrissur	27.37			8.05	0.70	8.75	31.97

Source : Secondary data collected by KSSP

Table 2.9.2

Age Group wise Details of Human Resources available in Alappuzha District

Based on Total Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	2001217	975885	1025332	602604	423866	178738	79593	33162	46431	1319020	518857	800163	235432	104292	131140
5-14	363088	183779	179309	870	440	430	300	100	200	361918	183239	178679	6870	3800	3070
15-19	200818	97365	103453	16905	8975	7930	3963	1600	2363	179950	86790	93160	59510	30290	29220
20-24	213812	99527	114285	65630	43010	22620	10995	4840	6155	137187	51677	85510	81870	38040	43830
25-29	184821	88328	96493	86772	62026	24746	11850	4970	6880	86199	21332	64867	44192	17312	26880
30-34	149473	73405	76068	84144	60995	23149	9980	4000	5980	55349	8410	46939	19280	6080	13200
34-39	151861	74872	76989	91950	65237	26713	10316	4020	6296	49595	5615	43980	11510	3430	8080
40-49	20176	102254	99512	124343	87458	36885	12723	4996	7727	64700	9800	54900	8310	3390	4920
50-59	153751	73279	80472	77327	55514	21813	10085	4045	6040	66339	13720	52619	1920	950	970
60-69	137491	63659	73832	43781	31249	12532	7533	3553	3980	86177	28857	57320	1030	570	460
70-79	60325	26936	33389	8500	7030	1470	1558	918	640	50267	18988	31279	220	140	80
80-	23281	10171	13110	1572	1382	190	220	100	120	21489	8689	12800	230	110	120
Age Not Stated	4340	1990	2350	810	550	260	70	20	50	3460	1420	2040	490	180	310
15-59	1256302	609030	647272	547071	383215	163856	69912	28471	41441	639319	197344	441975	226592	99492	127100
60+	221097	100766	120331	53853	39661	14192	9311	4571	4740	157933	56534	101399	1480	820	660

Contd...

Table 2.9.2 Contd....

Based on Rural Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	1391607	677351	714256	418291	294118	124173	57526	24043	33483	915790	359190	556600	156950	69390	87560
5-14	251819	127349	124470	580	290	290	230	80	150	251009	126979	124030	4430	2560	1870
15-19	140093	67930	72163	11890	6180	5710	2733	1050	1683	125470	60700	64770	40130	20400	19730
20-24	146650	67370	79280	45490	29600	15890	7990	3590	4400	93170	34180	58990	54650	24910	29740
25-29	126267	60320	65947	59537	42450	17087	8480	3620	4860	58250	14250	44000	29170	11310	17860
30-34	102532	50022	52510	57502	41382	16120	7210	2880	4330	37820	5760	32060	12580	4150	8430
34-39	104746	51206	53540	62516	44356	18160	7380	2800	4580	34850	4050	30800	7920	2470	5450
40-49	139931	70488	69443	85211	59818	25393	9200	3530	5670	45520	7140	38380	5540	2340	3200
50-59	109313	52050	57263	54713	39480	15233	7390	2970	4420	47210	9600	37610	1260	630	630
60-69	98272	46132	52140	32590	23670	8920	5563	2713	2850	60119	19749	40370	600	320	280
70-79	43210	19480	23730	6530	5440	1090	1130	710	420	35550	1330	22220	160	100	60
80-	17444	8024	9420	1212	1112	100	160	90	70	16072	6822	9250	150	90	60
Age Not Stated	2960	1280	1680	520	340	180	60	10	50	2380	930	1450	360	110	250
15-59	869532	419386	480146	376859	263266	113593	50383	20440	29943	442290	135680	306610	151250	66210	85040
60+	158926	73636	85290	40332	30222	10110	6853	3513	3340	111741	39901	71840	910	510	400

Contd...

Table 2.9.2 Contd...

Based on Urban Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	609610	298534	311076	184313	129748	54565	22067	9119	12948	403230	159667	243563	78482	34902	43580
5-14	111269	56430	54839	290	150	140	70	20	50	110909	56260	54649	2440	1240	1200
15-19	60725	29435	31290	5015	2795	2220	1230	550	680	54480	26090	28390	19380	9890	9490
20-24	67162	32157	35005	20140	13410	6730	3005	1250	1755	44017	17497	26520	27220	13130	14090
25-29	58554	28008	30546	27235	19576	7659	3370	1350	2020	27949	7082	20867	15022	6002	9020
30-34	46941	23383	23558	26642	19613	7029	2770	1120	1650	17529	2650	14879	6700	1930	4770
34-39	47115	23666	23449	29434	20881	8553	2936	1220	1716	14745	1565	13180	3590	960	2630
40-49	61835	31766	30069	39132	27640	11492	3523	1466	2057	19180	2660	16520	2770	1050	1720
50-59	44438	21229	23209	22614	16034	6580	2695	1075	1620	19129	4120	15009	660	320	340
60-69	39219	17527	21692	11191	7579	3612	1970	840	1130	26058	9108	16950	430	250	180
70-79	17115	7456	9659	1970	1590	380	428	208	220	14717	5658	9059	60	40	20
80-	5837	2147	3690	360	270	90	60	10	50	5417	1867	3550	80	20	30
Age Not Stated	1380	710	670	290	210	80	10	10	0	1080	490	590	130	70	60
15-59	386770	189644	197126	170212	119943	50263	19529	8081	11498	197029	61664	135365	75342	33282	42060
60+	62171	27130	35041	13521	9439	4082	2458	1058	1400	46192	16633	29559	570	310	260

Table 2.9.3

Age Group wise Details of Human Resources available in Ernakulam District

Based on Total Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	2817236	1408649	1408587	873408	691339	182069	68697	34118	34579	1875131	683192	1191939	293401	126090	167311
5-14	499253	253511	245242	2677	1820	857	470	270	200	496106	251421	244685	6960	3690	3270
15-19	279140	135520	143620	27200	19190	8010	4420	2450	1970	247520	113880	133640	21270	36100	35170
20-24	320869	158545	162324	105283	81679	23604	11828	6728	5100	203758	70138	133620	106430	48720	57710
25-29	279882	137913	141969	133453	106393	25060	10199	5560	4639	138230	25960	112270	57620	21750	35870
30-34	225355	116860	108495	128282	104230	24552	7880	3680	4200	88693	8950	79743	23140	6780	16360
34-39	214270	110415	103885	129284	101555	27729	8250	3600	4650	76736	5260	71476	13641	3440	10201
40-49	291686	151808	139878	181030	139899	41131	10876	4469	6407	99780	7440	92340	8500	2760	5740
50-59	212809	106216	106593	106266	85596	21170	8140	3880	4260	97903	16740	81163	2970	1590	1380
60-69	155859	72758	83101	46173	38447	7726	4914	2361	2553	104772	31950	72822	1040	620	420
70-79	74363	33793	40570	10740	9400	1340	1300	870	430	62323	23523	38800	430	230	200
80-	34050	14760	19290	2700	2250	450	280	180	100	31070	12330	18740	490	210	280
Age Not Stated	8200	3250	4950	1320	880	440	140	70	70	6740	2300	4440	910	200	710
15-59	1824011	917277	906234	809298	638542	171256	61593	30367	31226	952620	248368	704252	283571	121140	162431
60+	264272	121311	142961	59613	50097	9516	6494	3411	3083	198165	67803	130362	1960	1060	900

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Table 2.9.3 Contd...

Based on Rural Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	1444059	722730	721329	464141	359572	104569	43898	19281	24617	936020	343877	592143	144451	61770	82681
5-14	255939	129430	126509	1830	1350	480	330	190	140	253279	127890	125889	4090	2080	2010
15-19	142570	70040	72530	14860	10230	4630	2910	1480	1430	124800	58330	66470	36510	18120	18399
20-24	165280	81780	83500	56370	42470	13900	7490	3860	3630	101420	35450	65970	53430	24320	29110
25-29	142840	71270	71570	69150	55140	14010	6300	3090	3210	67390	13040	54350	28310	10790	17520
30-34	110788	57540	53248	64945	51430	13515	4910	1900	3010	40933	4210	39723	10270	3050	7220
34-39	107015	55204	51811	66734	51104	15630	5230	1890	3340	35051	2210	32841	6021	1500	4521
40-49	145530	75249	70281	92693	69749	22944	6607	2270	4337	46230	3230	43000	3380	920	2460
50-59	109959	53519	56440	57359	44339	13020	5290	2140	3150	47310	7040	40270	1190	500	690
60-69	85318	40208	45110	30130	24990	5140	3661	1641	2020	51527	13577	37950	420	190	230
70-79	42290	19610	22680	7610	6750	860	890	620	270	33790	12240	21550	200	90	110
80-	20080	9460	10620	1730	1470	260	190	140	50	181600	7850	10310	250	120	130
Age Not Stated	4150	1980	2170	730	550	180	90	60	30	3330	1370	1960	380	90	290
15-59	923982	464602	459380	422111	324462	97649	38737	16630	22107	463134	123510	339624	139111	59200	79911
60+	147688	69278	78410	39420	33210	6260	4741	2401	2340	103477	33667	69810	870	400	470

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Table 2.9.3 Contd...

Based on Urban Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	**1373177**	**685919**	**687258**	**409267**	**331767**	**77500**	**24799**	**14837**	**9962**	**939113**	**339315**	**599796**	**148950**	**64320**	**84630**
5-14	243314	124081	119233	847	470	377	140	80	60	242327	123531	118796	2870	1610	1260
15-19	136570	65480	71090	12340	8960	3380	1510	970	540	122720	55550	67170	34760	17980	16780
20-24	155589	76765	78824	48913	39209	9704	4338	2868	1470	102338	34688	67650	53000	24400	28600
25-29	137042	66643	70399	62303	51253	11050	3899	2470	1429	70840	12920	57920	29310	10960	18350
30-34	114567	59320	55247	63837	52800	11037	2970	1780	1190	47760	4740	43020	12870	3730	9140
34-39	107255	55211	52044	62550	50451	12099	3020	1710	1310	41685	3050	38635	7620	1940	5680
40-49	146156	76559	69597	88337	70150	18187	4269	2199	2070	53550	4210	49340	5120	1840	3280
50-59	102850	52697	50153	49407	41257	8150	2850	1740	1110	50593	9700	40893	1780	1090	690
60-69	70541	32550	30991	16043	13457	2586	1253	720	533	53245	17373	34872	620	430	190
70-79	32073	14183	17890	3130	2650	480	410	250	160	28533	11283	17250	230	140	90
80-	13970	5300	8670	970	780	190	90	40	50	12910	4480	5430	240	90	150
Age Not Stated	4050	1270	2780	590	330	260	50	10	40	3410	930	2480	530	110	420
15-59	900029	452675	447354	387687	314080	73607	22856	13737	9119	489486	124858	364628	144460	61940	82520
60+	116584	52033	64551	20143	16887	3256	1753	1010	743	94688	34136	60552	1090	660	430

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Table 2.9.4

Age Group wise Details of Human Resources available in Idukki District

Based on Total Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	1078066	545872	532194	389136	285977	103159	38963	15271	23692	649967	244624	405343	92810	34920	57890
5-14	213814	106639	107175	1040	530	510	380	190	190	212394	105919	106475	6200	3050	3150
15-19	111890	54290	57600	20100	12710	7390	4020	1830	2190	87770	39750	48020	28150	13020	15130
20-24	123831	60045	63786	55137	39015	16122	8030	3540	4490	60664	17490	43174	31000	11840	19160
25-29	109571	54304	55267	64722	46530	18192	6043	2430	3613	38806	5344	33462	13720	3980	9740
30-34	84870	43760	41020	55920	40580	15340	4510	1570	2940	24350	1610	22740	5280	1010	4270
34-39	83159	43994	39165	56936	41226	15710	4578	1388	3190	21645	1380	20265	3890	640	3250
40-49	106684	56972	49712	72837	53182	19655	5300	1770	3530	28547	2020	26527	2360	590	1770
50-59	72472	37492	34980	39819	31949	7870	3713	1323	2390	28940	4220	24720	1230	350	880
60-69	46064	23855	22209	17355	15425	1930	1859	910	949	26850	7520	19330	490	150	340
70-79	19940	9940	10000	4210	3950	260	450	270	180	15280	5720	9560	250	150	100
80-	8231	4261	3970	830	730	100	70	50	20	7331	3481	3850	210	120	90
Age Not Stated	1480	750	730	230	150	80	10	0	10	1240	600	640	30	20	10
15-59	692387	350857	341530	365471	265192	100279	36194	13851	22343	290722	71814	218908	85630	31430	54200
60+	74235	38056	36179	22395	20105	2290	2379	1230	1149	49461	16721	32740	950	420	530

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Table 2.9.4. Contd...

Based on Rural Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	1027185	520308	506877	373185	272963	100222	38456	15033	23423	615544	232312	383232	87430	32850	54580
5-14	204421	101878	102543	980	500	480	380	190	190	203061	101188	101873	6070	2970	3100
15-19	106510	51660	54850	19650	12360	7290	3950	1770	2180	82910	37530	45380	26630	12250	14380
20-24	118241	57365	60876	53197	37465	15732	7950	3500	4450	57094	16400	40694	29180	11140	18040
25-29	104179	51734	52445	62142	44410	17732	5963	2410	3553	36074	4914	31160	12650	3630	9020
30-34	81160	42190	38970	54000	39090	14910	4450	1570	2880	22710	1530	21180	4860	950	3910
34-39	79115	41790	37325	54360	39110	15250	4520	1360	3160	20235	1320	18915	3700	630	3070
40-49	101266	53868	47398	69136	50218	18918	5270	1760	3510	26860	1890	24970	2230	560	1670
50-59	69113	35753	33360	38080	30470	7610	3643	1283	2360	27390	4000	23390	1170	300	870
60-69	43600	22700	20900	16590	14710	1880	1810	880	930	25200	71110	18090	460	140	320
70-79	18840	9580	9260	4040	3780	260	440	260	180	14360	5540	8820	250	150	100
80-	7800	4080	3720	780	700	80	70	50	20	6950	3330	3620	200	110	90
Age Not Stated	1450	730	720	230	150	80	10	0	10	1210	580	630	30	20	10
15-59	659584	334360	325224	350565	253123	97442	35746	13653	22093	273273	67584	205689	80420	29460	50960
60+	70240	36360	33880	21410	19190	2220	2320	1190	1130	46510	15980	30530	910	400	510

Contd...

Table 2.9.4 Contd...

Based on Urban Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	50881	25564	25317	15951	13014	2937	507	238	269	34423	12312	22111	5380	2070	3310
5-14	9393	4761	4632	60	30	30	0	0	0	9333	4731	4602	130	80	50
15-19	5380	2630	2750	450	350	100	70	60	10	4860	2220	2640	1520	770	750
20-24	5590	2680	2910	1940	1550	390	80	40	40	3570	1090	2480	1820	700	1120
25-29	5392	2570	2822	2580	2120	460	80	20	60	2732	430	2302	1070	350	720
30-34	3620	1570	2050	1920	1490	430	60	0	60	1640	80	1560	420	60	360
34-39	4044	2204	1840	2576	2116	460	58	28	30	1410	60	1350	190	10	180
40-49	5418	3104	2314	3701	2964	737	30	10	20	1687	130	1557	130	30	100
50-59	3359	1739	1620	1739	1479	260	70	40	30	1550	220	1330	60	50	10
60-69	2464	1155	1309	765	715	50	49	30	19	1650	410	1240	30	10	20
70-79	1100	360	740	170	170	0	10	10	0	920	180	740	0	0	0
80-	431	181	250	50	30	20	0	0	0	381	151	230	10	10	0
Age Not Stated	30	20	10	0	0	0	0	0	0	30	20	10	0	0	0
15-59	32803	16497	16306	14906	12069	2837	448	198	250	17449	4230	13219	5210	1970	3240
60+	3995	1696	2299	985	915	70	59	40	19	2951	741	2210	40	20	20

Table 2.9.5

Age Group wise Details of Human Resources available in Kottayam District

Based on Total Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	1828271	912860	915441	537087	443092	93995	33761	16759	17002	1257423	4530050	804414	210787	85343	125444
5-14	318169	158741	159428	1070	710	360	80	40	40	317019	157991	159028	8395	4425	3970
15-19	181010	88540	92470	13890	10240	3650	1760	1030	730	165360	77270	88090	51470	25130	26340
20-24	202901	98925	103976	59697	48397	11300	5050	3084	1966	138154	47444	90710	73613	32023	41590
25-29	173493	85103	88390	78338	65218	13120	4696	2460	2236	90459	17425	73034	38465	13715	54750
30-34	142892	74443	68449	79006	66333	12673	4270	1870	2400	59616	6240	53376	16470	4130	12340
34-39	136776	69237	67539	79205	64086	15119	4192	1742	2450	53379	3409	49970	10360	2000	8360
40-49	186731	95021	91710	108951	87191	21760	5420	2340	3080	72360	5490	66870	6690	1790	4900
50-59	144858	72060	72798	69755	58557	11197	4553	2063	2490	70550	11440	59410	2380	850	1530
60-69	109367	53810	55557	35385	31660	3725	2890	1560	1330	71092	20590	50502	1214	580	634
70-79	56504	26470	30034	8550	7870	680	630	430	200	47324	18170	29154	380	180	200
80-	27330	12910	14420	2140	1940	200	150	120	30	20540	10850	14190	490	250	240
Age Not Stated	8000	3910	4090	1100	890	210	70	20	50	6830	3000	3830	860	270	590
15-59	1168661	583329	585332	488842	400022	88820	29941	14589	15352	649878	168718	481160	199448	79638	119810
60+	193201	93190	100011	46075	41470	4605	3670	2110	1560	143456	49610	93846	2084	1010	1074

Contd...

Table 2.9.5 Contd...

Based on Rural Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	1507353	752358	754995	444786	367276	77510	30119	14703	15416	1032448	370379	662069	170622	68238	102384
5-14	261754	130575	131179	810	580	230	70	30	40	260874	129965	130909	6755	3535	3220
15-19	149760	73130	76530	11180	8290	2890	1560	910	650	137020	63930	73090	41730	20300	21430
20-24	166570	80864	85706	49400	40020	9380	4526	2730	1796	112644	38114	74530	59613	25623	33990
25-29	143337	70277	73060	65367	54127	11240	4020	2090	1930	73950	14060	59890	31490	11120	20370
30-34	117331	60830	56501	64595	54160	10435	3900	1740	2160	48836	4930	43906	13120	3240	9880
34-39	112426	57056	55370	65296	52926	12370	3620	1460	2190	43510	2700	70810	8170	1520	6650
40-49	153153	77923	75230	89183	71513	17670	4810	1990	2820	59160	4420	54740	5360	1290	4070
50-59	119453	59503	59950	57830	48740	9090	4133	1803	2330	57490	8960	58530	1880	570	1310
60-69	91029	45000	46029	30815	27570	3245	2690	1450	1240	57524	15980	41544	924	400	524
70-79	47070	21990	25080	4760	6880	580	580	390	190	39030	14720	24310	290	130	160
80-	23660	11250	12410	1840	1660	180	150	120	30	21670	9470	12200	450	240	210
Age Not Stated	7400	3600	3800	1010	810	200	60	20	40	6330	2770	3560	840	270	570
15-59	962030	479583	482447	402851	329776	73075	26569	12693	13876	532610	137114	395496	161363	63663	97700
60+	161759	78240	83519	40115	36110	4005	3420	1960	1460	118224	401170	78054	1664	770	894

Contd...

Table 2.9.5 Contd...

Based on Urban Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	**320918**	**160502**	**160416**	**92301**	**75816**	**16485**	**3642**	**2056**	**1586**	**224975**	**82630**	**142345**	**40165**	**17105**	**23060**
5-14	56405	28166	28249	260	130	130	10	10	0	56145	28026	28119	1640	890	750
15-19	31250	15410	15840	2710	1950	760	200	120	80	28340	13340	15000	9740	4830	4910
20-24	36331	18061	18270	10297	5377	1920	524	354	170	25510	9330	16180	14000	6400	7600
25-29	30156	14826	15330	12971	11091	1880	626	370	306	16509	3365	13144	6975	2595	4380
30-34	25561	13613	11948	14411	12173	2238	370	130	240	10780	1310	9470	3350	890	2460
34-39	24350	12181	12169	13909	11160	2749	572	312	260	9869	709	9160	2190	480	1710
40-49	33578	17098	16480	19768	15678	4090	610	350	260	13200	1070	12130	1330	500	830
50-59	25405	12557	12848	11925	9817	2108	420	260	160	13060	2480	10580	500	280	220
60-69	18338	8810	9528	4570	4090	480	200	110	90	13568	4610	8958	290	180	110
70-79	9434	4480	4954	1090	990	100	50	40	10	5294	3450	4844	90	50	40
80-	3670	1660	2010	300	280	20	0	0	0	3370	1380	1990	40	10	30
Age Not Stated	600	310	290	90	80	10	10	0	10	500	230	270	20	0	20
15-59	206631	103746	102885	85991	70246	15745	3372	1896	1476	117268	31604	85664	38085	15975	22110
60+	31442	14950	16492	5960	5360	600	250	150	100	25232	9440	15792	420	240	180

Table 2.9.6

Age Group wise Details of Human Resources available in Pathanamthitta District

Based on Total Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	**1188332**	**576176**	**612156**	**321595**	**265333**	**56262**	**31571**	**11387**	**20184**	**835166**	**299456**	**535710**	**143745**	**56132**	**87612**
5-14	214606	109463	105143	560	360	200	160	100	60	213886	109003	104883	6610	3410	3200
15-19	113360	55430	57930	7710	6180	1530	1560	750	810	104090	48500	55590	36040	17010	19030
20-24	118022	54512	63510	30620	24810	5810	4040	1580	2460	83362	28122	55240	46902	20102	26800
25-29	102850	47314	55536	44378	36454	7924	4720	1370	3350	53752	9490	44262	25115	7770	17345
30-34	83429	38401	45028	41101	33391	7710	3560	1040	2520	38768	3970	34798	11948	2940	9008
34-39	85732	41057	44675	45615	3700	5895	3727	1207	2520	36390	2830	33560	7900	1790	6110
40-49	123238	59927	6311	66874	53027	13847	5314	1780	3534	51050	5120	45930	5790	1740	4050
50-59	103957	49951	53976	47987	40631	7356	4490	1530	2960	51480	7820	43660	2020	750	1270
60-69	81654	40034	41620	27400	24700	2930	1470	1460	51324	13864	37460	780	380	400	400
70-79	40234	18917	21317	7570	7090	480	870	440	430	31794	11387	20407	320	170	150
80-	20550	9750	10800	1550	1470	80	170	110	60	18830	8170	10660	120	50	70
Age Not Stated	3180	1440	1740	230	200	30	30	10	20	2920	1230	1690	200	20	180
15-59	730558	346622	383966	284285	231513	52772	27411	9257	18154	418892	105852	313040	135715	52102	83613
60+	142438	68701	73737	36520	33260	3260	3970	2020	1950	101948	33451	68527	1220	600	620

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Table 2.9.6. Contd...

Based on Rural Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	1033298	500965	532333	280581	232121	48460	28780	10230	18550	723937	258614	465323	123395	47630	75765
5-14	185824	94683	91141	450	300	150	150	90	60	185224	94293	90931	5780	2950	2830
15-19	98050	48050	50000	6620	5360	1260	1440	700	740	89990	4190	48000	31270	14740	16530
20-24	102050	47140	54910	26830	21880	4950	3640	1410	2230	71580	23850	47730	40080	17020	23060
25-29	89169	40750	48419	38334	31540	6794	4290	1200	3090	46545	8010	38535	21425	6470	14955
30-34	72547	33427	39120	35697	29077	6620	3250	970	2280	33600	3380	30220	10260	2480	7780
34-39	74980	35730	39250	39710	32200	7510	3380	1090	2290	31980	2440	29450	6930	1540	5390
40-49	106785	51887	54898	58065	46107	11958	4830	1570	3260	43890	4210	39680	4800	1370	3430
50-59	91015	43687	47328	41945	35687	6258	4090	1330	2760	44980	6670	38310	1690	620	1070
60-69	71484	35324	36160	24560	22100	2460	2710	1340	1370	44214	11884	32330	590	240	350
70-79	35264	16717	18547	6800	6390	410	800	410	390	27664	9917	17747	280	140	140
80-	18240	8790	9450	1380	1320	60	170	110	60	16690	7360	9330	100	40	60
Age Not Stated	2940	1310	1630	190	160	30	30	10	20	2720	1140	1580	190	20	170
15-59	634596	300671	333925	247201	201851	45350	24920	8270	16650	362475	90550	271925	116455	44240	72215
60+	124988	60831	64157	32740	29810	2930	3680	1860	1820	88568	29161	59407	970	420	550

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Table 2.9.6 Contd...

Based on Urban Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	155034	75211	79823	41014	33212	7802	2791	1157	1634	111229	40842	70387	20350	8502	11848
5-14	28782	14780	14002	110	60	50	10	10	0	28662	14710	13952	830	460	370
15-19	15310	7380	7930	1090	820	270	120	50	70	14100	6510	7590	4770	2270	2500
20-24	15972	7372	8600	3790	2930	860	400	170	230	11782	4272	7510	6822	3082	3740
25-29	13681	6564	7117	6044	4914	1130	430	170	260	7207	1480	5727	3690	1300	2390
30-34	10882	4974	5908	5404	4314	1090	310	70	240	5168	590	4578	1688	460	1228
34-39	10752	5327	5425	5905	4820	1085	347	117	230	4500	390	4110	970	250	720
40-49	16453	8040	8413	8809	6920	1889	484	210	274	7160	910	6250	990	370	620
50-59	12942	6294	6648	6042	4944	4098	400	200	200	6500	1150	5350	330	130	200
60-69	10170	4710	5460	2840	2600	240	220	130	90	7110	1980	5130	190	140	50
70-79	4970	2200	2770	770	700	70	70	30	40	4130	1470	2660	40	30	10
80-	2310	960	1350	170	150	20	0	0	0	2140	810	1330	20	10	10
Age Not Stated	240	130	110	40	40	0	0	0	0	200	90	110	10	0	10
15-59	95992	45951	50041	37084	29662	7422	2491	987	1504	56417	15302	41115	19260	7862	11398
60+	17450	7870	9580	3780	3450	330	290	160	130	13380	4260	9120	250	180	70

Table 2.9.7

Age Group wise Details of Human resources Available in Thrissur District

Based on Total Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	**2737311**	**1312683**	**1424628**	**804738**	**587948**	**216290**	70068	31330	38738	**1862505**	**693405**	**1169100**	**265470**	**116430**	**149040**
5-14	5253434	264311	259123	3620	2240	1380	380	190	190	519434	261881	257553	9190	5270	3920
15-19	283874	137120	146254	35884	23030	12854	5330	2720	2610	242660	111370	131290	71000	36050	34950
20-24	305649	143199	162450	104041	76331	27710	11538	6458	5080	190070	60410	129660	90520	40770	49750
25-29	249889	117599	132290	119578	91318	28260	9810	4550	5260	120501	21231	98770	45720	16590	29130
30-34	199072	96047	103025	110752	82810	27942	8201	3317	4884	80119	9920	70199	20930	6370	14560
34-39	182175	86365	95810	107582	76645	30937	7623	2980	4643	66970	6740	60230	11830	3730	8100
40-49	268019	127068	140951	159958	112374	47584	11420	3940	2480	96641	10754	85887	9510	4180	5330
50-59	212844	98269	114575	102609	75299	27310	8621	3460	5161	101614	19510	82104	3500	1870	1630
60-69	162417	73605	88812	47334	36981	10353	5370	2700	2670	109713	33924	75789	1430	870	560
70-79	77423	33145	44278	9980	8450	1530	1410	830	580	66033	23865	42168	520	290	230
80-	32415	13495	18920	2330	1880	450	255	165	90	29830	11450	18380	480	210	270
Age Not Stated	8960	3520	5440	1070	590	480	110	20	90	7780	2910	4870	840	230	610
15-59	1701522	805667	895855	740404	537807	202597	62543	27425	35118	898575	240435	658140	253010	109560	143450
60+	272255	120245	152010	59644	47311	12333	7035	3695	3340	205576	69239	136337	2430	1370	1060

Contd...

Table 2.9.7 Contd...

Based on Rural Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	2017095	964593	1052502	597197	429759	167438	56421	24508	31913	1363477	510326	853151	190990	84260	106730
5-14	391610	197856	193754	2810	1850	960	300	150	150	388500	195856	192644	6970	4040	2930
15-19	210117	101190	108927	27317	17240	10077	4250	2150	2100	178550	81800	96780	53110	26900	26210
20-24	225248	105028	120220	79240	56970	22270	9148	5028	4120	136860	43030	93830	64820	29360	35460
25-29	182651	84901	97750	87800	65840	21960	7860	3530	4330	86991	15531	71460	32380	11800	20580
30-34	143851	69441	74440	80601	59431	21170	6610	2630	3980	56670	7380	49290	14540	4670	9870
34-39	132777	61970	70807	78724	54970	23754	6083	2290	3793	47970	4710	43260	8140	2530	5610
40-49	194612	90988	103624	116565	80388	63177	9290	3020	6270	68757	7580	61177	6630	2890	3740
50-59	155730	72330	83400	77060	56000	21060	7000	2720	4280	71670	13610	58060	2250	1170	1080
60-69	119450	54160	65290	36540	28450	8090	4400	2140	2260	78510	23570	54940	840	420	420
70-79	57189	24469	32220	7930	6740	1190	1140	670	470	48119	17059	31060	310	120	190
80-	24330	10280	14050	1770	1410	360	240	160	80	22320	8710	13610	420	190	230
Age Not Stated	6750	2830	3920	840	470	370	100	20	80	5810	2340	3470	580	170	410
15-59	1245016	585848	659168	547307	390839	156468	50241	21368	28873	647468	173641	473827	181870	79320	102550
60+	200969	88909	112060	46240	36600	9640	5780	2970	2810	148949	49339	99610	1570	730	840

Contd...

Table 2.9.7 Contd..

Based on Urban Area

Age Group	Population			Main Workers			Marginal Workers			Non- Workers			Those Seeking Work among Non-Workers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	**720216**	**348090**	**372126**	**20541**	**158189**	**49382**	**13647**	**6822**	**6825**	**499028**	**183079**	**315949**	**74480**	**32170**	**42310**
5-14	131824	66455	65369	810	390	420	80	40	40	130934	66025	64909	2220	1230	990
15-19	73575	35930	37827	8567	5790	2777	1080	570	510	64110	29570	34540	17890	9150	8740
20-24	80401	38171	42230	24801	19364	5440	2390	1430	960	53210	17380	35830	25700	11410	14290
25-29	67238	32698	34540	31778	25478	6300	1950	1020	930	33510	6200	27310	13340	4790	8550
30-34	55191	26606	28585	30151	23379	6772	1591	687	904	23449	2540	29909	6390	1700	4690
34-39	49398	24395	25003	28858	21675	7183	1540	690	850	19000	2030	16970	3690	1200	2490
40-49	73407	36080	37327	43393	31986	11407	2130	920	1210	27884	3174	24710	2880	1290	1590
50-59	57114	25939	31175	25549	19299	6250	1621	740	881	29944	5900	24044	1250	700	550
60-69	42967	19445	23522	10794	8531	2263	970	560	410	31203	10354	20849	590	450	140
70-79	20234	8676	11558	2050	1710	34090	270	160	110	17914	6806	11108	210	170	40
80-	8085	3215	4870	560	470	90	15	5	10	7510	2740	4770	60	20	40
Age Not Stated	2210	690	1520	230	120	110	10	0	10	1970	570	1400	260	60	200
15-59	456506	219819	236697	193097	146968	46129	12302	6057	6245	251107	66794	184313	71140	30240	40900
60+	71286	31336	39950	13404	10211	2693	1255	725	530	56627	19900	36727	860	640	220

Table 2.9.8

Industrial Classification of Main Workers

Sr. No.	Category	Alappuzha	Ernakulam	Idukki	Kottayam	Pathanamthitta
I	Cult	48009	81257	75829	84327	83027
II	Agri. Lbr	145641	137948	86420	125424	87197
III	LFF	48145	62223	137743	56901	20488
IV	M&Q	2745	342	972	2952	1756
V(a)	MPSH	58568	13757	2515	12079	3781
v(b)	MPSOH	77963	141170	12461	44273	18746
VI	Con	19956	62511	6331	18910	10132
VII	T&C	73798	133400	24613	71161	30854
VIII	TSC	31287	81131	9283	29574	14566
IX	Others	96492	151895	34065	91486	51048

Cult - Cultivators, Agri. Lbr - Agricultural Labourers, LFF - Live Stock, Forestry, Fisheries, M&Q - Mining & Quarrying, MPSH - Manufacturing, Processing, Servicing & Repairs in Household Industry, MPSOH - Manufacturing, Servicing other than Household Industry, Con -Constructions, T&C - Trade & Commerce, TSC -Transport, Storage & Communication

Source : Secondary data collected by KSSP

Table 2.9.9

Percentage Distribution of Main Workers into Broad Industrial Categories in Different Districts: 1991

District	Industrial Categories of Main Workers									
	I	II	III	IV	V(a)	V(b)	VI	VII	VIII	IX
Alappuzha	7.97	24.17	7.99	0.45	9.72	12.94	3.31	12.25	5.19	16.01
Ernakulam	9.30	15.79	7.12	0.95	1.57	16.16	7.16	15.27	9.29	17.39
Idukki	19.43	22.16	35.24	0.25	0.64	3.20	1.62	6.33	2.39	8.74
Kottayam	15.70	23.35	10.60	0.55	2.25	8.24	3.52	13.25	5.51	17.01
Pathanam -thitta	25.81	27 11	6.37	0.55	1.18	5.83	3.15	9.59	4.53	15.87
Thrissur	9.20	22 81	6.43	0.74	4.46	14.78	4.39	14 50	6.81	15.88

II - Cultivators, II - Agricultural Labourers, III - Live Stock Forestry, IV - Fisheries, V(a) - Mining and Quarrying, V(b) - Manufacturing, Processing, Servicing and Repairs in Household Industry, VI - Manufacturing, Servicing other than Housing Industry, VII - Construction, VIII - Trade and Commerce, IX - Transport, Storage and Communication

Source : Secondary data collected by KSSP

Table 2.9.10

Sex Ratio (No. of Females/1000 Males) Among the Total Population, and Various Categories of Workers in Each Districts

District	Total Rural Urban	Total Population	Total Workers (Main + Marginal)	Main Workers					Main Worker						Marginal Workers	Non Workers
				Total Main Workers	I	II	III	IV	V (A)	V (B)	VI	VII	VIII	IX		
Alappuzha	T	1051	493	422	94	625	47	143	3491	561	52	107	53	516	1400	1542
	R	1054	496	422	90	621	41	155	3658	654	36	106	49	483	1393	1550
	U	1042	486	421	136	646	62	116	3260	453	78	109	58	580	1420	1525
Ernakulam	T	1000	299	263	107	580	97	192	628	238	55	131	60	671	1014	1745
	R	998	341	291	105	605	97	214	627	360	48	111	46	628	1277	1722
	U	1002	252	234	120	468	98	128	535	160	60	142	67	701	671	1768
Idukki	T	975	421	361	116	414	602	165	369	158	63	74	49	660	1551	
	R	974	429	367	118	419	605	157	376	157	59	73	49	660	1551	
	U	990	242	226	63	282	150	318	303	165	109	80	51	648	1130	
Kottayam	T	1003	241	212	33	320	78	83	805	147	31	99	44	688	1014	
	R	1004	243	211	31	330	78	77	526	175	32	105	40	667	1048	
	U	999	493	214	69	229	87	125	722	75	27	85	53	779	771	
Pathanmthitta	T	1062	276	212	54	290	207	103	191	136	22	98	49	772	1773	
	R	1063	276	209	56	288	206	106	184	151	20	99	49	559	1813	
	U	1061	275	235	32	305	220	73	237	69	31	92	50	836	1412	
Thrissur	T	1085	413	369	169	777	128	288	1306	330	113	73	53	742	1236	
	R	1091	439	390	168	792	130	279	1506	360	114	65	58	698	1302	
	U	1069	340	312	179	647	119	345	905	275	112	87	45	825	1000	
GKR As District Average	**T**	**1029**	**357**	**307**	**96**	**501**	**193**	**162**	**1131**	**262**	**56**	**97**	**51**	**675**	**1331**	
	R	**1031**	**371**	**315**	**95**	**509**	**193**	**165**	1146	310	52	93	49	616	1397	
	U	**1027**	**348**	**274**	**100**	430	123	**184**	994	200	70	99	54	728	1067	

II - Cultivators, II - Agricultural Laborers, III - Live Stock Forestry, IV - Fisheries, V(a) - Mining and Quarrying, V(b) - Manufacturing, Processing, Servicing and Repairs in Household Industry, VI - Manufacturing, Servicing other than Housing Industry, VII - Construction, VIII - Trade and Commerce, IX - Transport Storage and Communication

Table 2.9.11

Percentage Distribution of SC/ST Population of Each Sex into Different Category of Workers in each District of GKR: 1991

District	Total Population			Total Workers (Main Marginals)			Main Workers			Marginal Workers			Non Workers		
	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
SC Population															
Alappuzha	100	100	100	41.59	49.23	34.15	35.70	44.29	27.33	5.89	4.94	6.82	58.41	50.77	65.85
Ernakulam	100	100	100	40.96	52.85	29.19	36.68	49.04	24.45	4.28	3.81	4.74	59.04	47.15	70.81
Idukki	100	100	100	47.55	53.51	41.57	44.26	50 31	38.19	3.29	3.20	3.38	52.45	46.49	58.43
Kottayam	100	100	100	36.10	50.58	21.74	33.19	47.85	18.66	2.91	2.73	3.08	63.90	49.42	78.26
Pathanam-thitta	100	100	100	38.36	51.32	25.79	34.70	48.77	21.05	3.66	2.55	4.74	61.64	48.68	74.21
Thrissur	100	100	100	42.30	51.89	33.20	38.30	48.38	28.73	4.00	3.51	4.47	57.70	48.11	66.80
GKR	**100**	**100**	**100**	**41.14**	**51.56**	**30.94**	**37.14**	**48.11**	**26.40**	**4.01**	**3.46**	**4.54**	**58.86**	**48.38**	**69.06**
ST Population															
Alappuzha	100	100	100	40.70	53.52	27.76	34.81	48.83	20.66	5.89	4.69	7.10	59.30	46.48	72.24
Ernakulam	100	100	100	38.55	52.29	23.89	36.33	50.25	21.46	2.22	2.04	2.43	61.45	47.71	76.11
Idukki	100	100	100	44.21	57.43	30.59	38.94	54.42	22.99	5.27	3.01	7.60	55.79	42.57	69.41
Kottayam	100	100	100	34.84	54.98	15.13	32.14	53.44	11.29	2.70	1.54	3.84	65.16	45.02	84.87
Pathanam-thitta	100	100	100	38.76	53.63	23.91	28.73	45.85	11.64	10.03	7.78	12.27	61.24	46.37	76.09
Thrissur	100	100	100	49.02	56.68	41.63	43.79	53.52	34.40	5.23	3.16	7.23	50.98	43.32	58.37
GKR	**100**	**100**	**100**	**41.03**	**54.76**	**27.15**	**35.79**	**51.05**	**20.41**	**5.22**	**3.70**	**6.75**	**58.99**	**45.25**	**72.85**

Table 2.9.12

District-wise Work Participation in GKR : 1961 and 1991

District	Work Participation (%)	
	1961	**1991**
Alappuzha	33.8	34.1
Ernakulam	33.6	33.4
Idukki	39.1	39.7
Kottayam	29.1	31.2
Pathanamthitta	-	29.27
Thrissur	33.1	32.0
GKR as District Average	**33.74**	**33.28**

Source : Secondary data collected by KSSP

Table 2.9.13

Female Work Participation Rate in GKR

District	Rank in the State		Work Participation (%)	
	1981	1991	1981	**1991**
Alappuzha	4	3	22.45	21.96
Ernakulam	8	9	14.49	15.38
Idukki	3	1	23.51	23.84
Kottayam	12	12	12.75	12.13
Pathanamthitta	11	11	12.92	12.49
Thrissur	6	6	18.55	17.94

Source : Secondary data collected by KSSP

Table 2.9.14

Average Daily Wage Rates of Skilled Labour in the Construction Sector

Unit : Rs.

District	Carpenter 1st Class						Mason 1st Class					
	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
Rural												
Alappuzha	51	52	54	59	62	70	51	52	54	58	62	70
Ernakulam	49	53	59	59	59	67	49	53	57	59	60	67
Idukki	54	56	60	64	70	73	54	56	60	64	71	74
Kottayam	51	54	56	57	60	70	50	51	56	57	59	71
Pathanamthitta	50	52	56	59	61	75	50	52	56	59	61	68
Thrissur	50	51	51	55	60	66	50	51	53	55	59	66
Urban												
Alappuzha	49	51	54	59	65	72	49	51	55	58	65	72
Ernakulam	52	57	59	59	63	70	52	57	58	59	63	70
Idukki	56	59	60	64	70	71	57	58	60	64	72	72
Kottayam	53	53	56	57	62	74	51	53	56	57	58	74
Pathanamt-hitta	50	52	56	59	63	74	50	51	56	59	63	71
Thrissur	46	48	51	55	60	69	46	48	51	55	61	66

Source : Secondary data collected by KSSP

Table 2.9.15

Average Daily Wages in Different Districts of GKR

Unit : Rs.

District	1958-59	1996-97			
		Rural		Urban	
		Class I	Class II	Class I	Class II
Carpenter					
Alappuzha	2.47	105	105	109	109
Ernakulam	2.32	133	122	147	131
Idukki	-	137	121	138	122
Kottayam	2.52	142	134	147	136
Pathanamthitta	-	134	105	138	106
Thrissur	-	150	125	149	124
GKR as District Average	**2.44**	**134**	**119**	**138**	**121**
Mason					
Alappuzha	3.03	105	105	109	109
Ernakulam	-	133	122	151	131
Idukki	-	138	123	138	121
Kottayam	2.49	144	135	145	131
Pathanamthitta	-	134	105	138	106
Thrissur	2.24	150	125	149	124
GKR as District Average	7.76	**134**	**119**	**138**	**120**

Source : Secondary data collected by KSSP

Table 2.9.16

District wise Employment Details in GKR : 1992

Sector	Alappuzha	Ernakulam	Idukki	Kottayam	Pathanamthitta
Public	35824	100260	14471	33740	22970
Private	20917	66479	59071	28738	12496
Public Central	1440	19062	1309	2472	2777
Public State	18491	26420	8916	15101	10234
Public Local Bodies	1573	3770	927	1461	869
Quasi-Government	14320	51008	3319	14706	9090
Job Seekers (1996)	293850 (89%)	357966 (10.85%)	102215 (3.1%)	240674 (7.3%)	129251 (3.92%)

Source : Secondary data collected by KSSP

Table 2.9.17

Employment in Public/Private/Govt. Sector in the Districts of GKR

District	1981	1985	1988	1989	1990	1991	1992
Public Sector							
Alappuzha	37807	34607	34269	35101	34088	36050	35824
Ernakulam	75877	85900	90525	92566	92855	99134	100260
Idukki	11993	13134	13334	13499	14231	14735	14471
Kottayam	23834	27410	27846	27982	30176	31615	33740
Pathanamthitta	-	12769	15976	20268	20665	21109	22970
Thrissur	37644	42793	42929	43009	44009	43967	44830
GKR	**187155**	**216613**	**224879**	**232425**	**236024**	**246610**	**252095**
Private Sector							
Alappuzha	26709	22086	19836	19156	18936	20043	20917
Ernakulam	51968	52455	54040	54741	55016	54462	66479
Idukki	57110	59171	60861	60884	58030	58743	59071
Kottayam	25795	26734	25575	25472	25304	27368	28738
Pathanamthitta	-	14634	14643	12356	11027	11597	12496
Thrissur	49566	51362	54108	54655	53809	53771	53199
GKR	**211148**	**226442**	**229063**	**227264**	**222122**	**225984**	**240900**
Central Government							
Alappuzha	1771	1187	1483	1419	1409	1417	1440
Ernakulam	13549	15834	15399	18157	18145	18963	19062
Idukki	991	1149	1101	1092	1288	1299	1309
Kottayam	2133	2117	2183	2324	2362	2340	2472
Pathanamthitta	-	2559	2641	2756	2789	3015	2777
Thrissur	4040	4736	4803	4864	5046	4995	5392
GKR	**22484**	**27582**	**27610**	**30612**	**31039**	**32029**	**32452**
State Government							
Alappuzha	20103	18687	18776	19154	18479	19018	18491
Ernakulam	22698	22982	24625	24722	24843	25744	26420
Idukki	7413	7988	8336	8456	8823	9204	8916
Kottayam	13165	13623	13291	13115	13947	14216	15101
Pathanamthitta	-	4933	6781	9412	9632	9361	10234
Thrissur	20462	22534	22899	22957	23720	23820	23898
GKR	83841	90747	94708	97816	99444	101363	103060

Contd...

Table 2.9.17 Contd...

District	1981	1985	1988	1989	1990	1991	1992
Local Bodies							
Alappuzha	1503	1335	1346	1578	1578	1656	1573
Ernakulam	2766	3033	3680	3633	3642	3839	3770
Idukki	720	835	916	897	909	953	927
Kottayam	1248	1391	1390	1144	1198	1494	1461
Pathanamthitta	-	657	740	750	768	814	869
Thrissur	1710	1950	2041	2134	2142	2182	2198
GKR	**7947**	**9201**	**10113**	**10136**	**10237**	**10938**	**10798**
Quasi Government							
Alappuzha	14430	13398	12664	12950	12622	13959	14320
Ernakulam	39864	44051	46821	46047	46225	50588	51008
Idukki	2869	3162	2981	3054	3211	3279	3319
Kottayam	7288	10279	10982	11399	12669	13565	14706
Pathanamthitta	-	4620	5814	7350	7476	7919	9090
Thrissur	11432	13573	13186	13054	13101	12970	13342
GKR	**75883**	**89083**	**92448**	**93854**	95304	102280	105785

Source : Secondary data collected by KSSP

Table 2.9.18

Religion-wise Percent Distribution of Households in GKR

District	As per 1991 Census			As per Actual Survey 1999-2000		
	Hindu	Muslim	Christian	Hindu	Muslim	Christian
Alappuzha	68.98	9.26	21.7	67.29	23.23	9.47
Ernakulam	48.00	14.02	37.83	46.44	37.03	16.53
Idukki	51.01	6.70	42.23	53.44	39.05	7.51
Kottayam	48.76	5.35	45.83	50.49	45.20	4.32
Pathanamthitta	55.58	4.03	40.35	53.24	43.54	2.23
Thrissur	59.49	15.97	24.5	40.28	59.72	0
GKR	55.3	9.22	35.41	53.36	37.17	9.47

Source : Secondary data collected by KSSP

Table 2.9.19

Social Group-wise Distribution of Households in GKR

District	SC	ST	OEC	OBC	Others
Alappuzha	7.45	0.69	7.97	42.94	40.95
Ernakulam	6.32	0.28	4.52	45.43	43.45
Idukki	9.69	9.41	5.07	30.53	45.3
Kottayam	4.7	1.005	2.28	31.24	60.77
Pathanamthitta	9.94	1.31	11.55	24.78	62.42
Thrissur	11.85	0.74	0	18.52	68.87
GKR	**7.14**	**1.91**	**4.42**	**37.22**	**49.31**

Sc: Sheduled Caste; ST: Sheduled Tribe; OEC : Other Economically backward Class; OBC: Other Backward Class

Source : Secondary data collected by KSSP

Table 2.9.20

Agegroup wise Percent Distribution of Population in Districts of GKR

District	Category	Age Group (Years)					
		<3	3 – 5	6 – 15	16 – 35	36 – 60	>60
Alappuzha	Total	3.02	2.97	14.16	39.33	29.02	11.5
	Male	51.10	54.29	54.47	49.31	49.19	48.13
	Female	48.90	45.71	45.53	50.69	50.81	51.87
Ernakulam	Total	4.05	3.52	12.05	42.13	28.06	10.19
	Male	52.48	50.73	50.93	50.90	51.13	45.89
	Female	47.52	49.27	49.07	49.10	48.87	54.11
Idukki	Total	2.41	2.43	12.19	48.19	29.06	5.71
	Male	54.62	48.47	52.74	51.32	50.53	51.38
	Female	45.38	51.53	47.26	48.68	49.47	48.62
Kottayam	Total	3.33	3.68	13.75	39.22	28.75	11.27
	Male	52.14	52.79	50.75	51.04	50.29	46.38
	Female	47.86	47.21	49.25	48.96	49.71	53.62
Pathanam -thitta	Total	3.56	3.87	13.24	36.78	28.69	13.87
	Male	49.42	54.81	50.23	50.04	48.65	48.40
	Female	50.58	45.19	49.77	49.96	51.35	51.60
Thrissur	Total	8.68	2.42	12.09	39.69	23.47	13.66
	Male	50.82	64.71	50.59	55.56	48.48	54.17
	Female	49.18	35.29	49.41	44.44	51.52	45.83
GKR	**Total**	**3.46**	**3.33**	**12.98**	**41.09**	**28.56**	**10.55**
	Male	**51.96**	**52.27**	**51.79**	**50.63**	**50.16**	**47.35**
	Female	**48.04**	**47.73**	**48.21**	**49.37**	**49.84**	**52.65**

Source : Secondary data collected by KSSP

Table 2.9.21

Projected Population Growth Trend for Different Age-groups in Kerala : 1991-2026

Age Group	Year							
	1991	1996	2001	2006	2011	2016	2021	2026
0- 4	2773770	2284932	2446869	2463120	2393159	2246981	2054644	1923392
5- 9	3036045	2743081	2255899	2418065	2434680	2365100	2219216	2027174
10-14	3022820	3018597	2726516	2240088	2402425	2419276	2349884	2204188
60-64	863548	912366	1003460	1157268	1411400	1717978	1956212	2336740
65-69	679445	800421	851446	941069	1089343	1333202	1628514	1860441
70-74	446583	600619	715935	767829	853969	993659	1222205	1500534
75+	559285	667734	871173	1097964	1287133	1485063	1734533	2093052

Source : Secondary data collected by CESS

Table 2.9.22

District wise Percent Distribution of Marital Status in GKR

District	Category	Unmarried	Married	Widow/ Er	Divorced
Alappuzha	Total	42.86	49.85	6.80	0.48
	Male	56.90	49.47	13.54	21.25
	Female	43.10	50.53	86.46	78.75
Ernakulam	Total	43.52	49.77	6.56	0.16
	Male	56.16	49.99	17.64	23.26
	Female	43.84	50.01	82.36	76.74
Idukki	Total	44.54	50.77	4.46	0.23
	Male	55.78	50.02	21.67	32.00
	Female	44.22	49.98	78.33	68.00
Kottayam	Total	43.41	50.15	6.17	0.27
	Male	55.55	50.05	17.54	22.92
	Female	44.45	49.95	82.46	77.08
Pathanam-thitta	Total	40.66	51.99	6.91	0.44
	Male	55.32	49.78	16.32	23.26
	Female	44.68	50.22	83.68	76.74
Thrissur	Total	43.10	50.64	5.97	0 28
	Male	60.07	49.72	28.57	50.00
	Female	39.93	50.28	71.43	50 00
GKR	**Total**	**43.15**	**50.26**	**6.28**	**0.29**
	Male	**56.05**	**49.87**	**17.02**	**23.65**
	Female	**43.95**	**50.13**	**82.98**	**76.35**

Source : Secondary data collected by KSSP

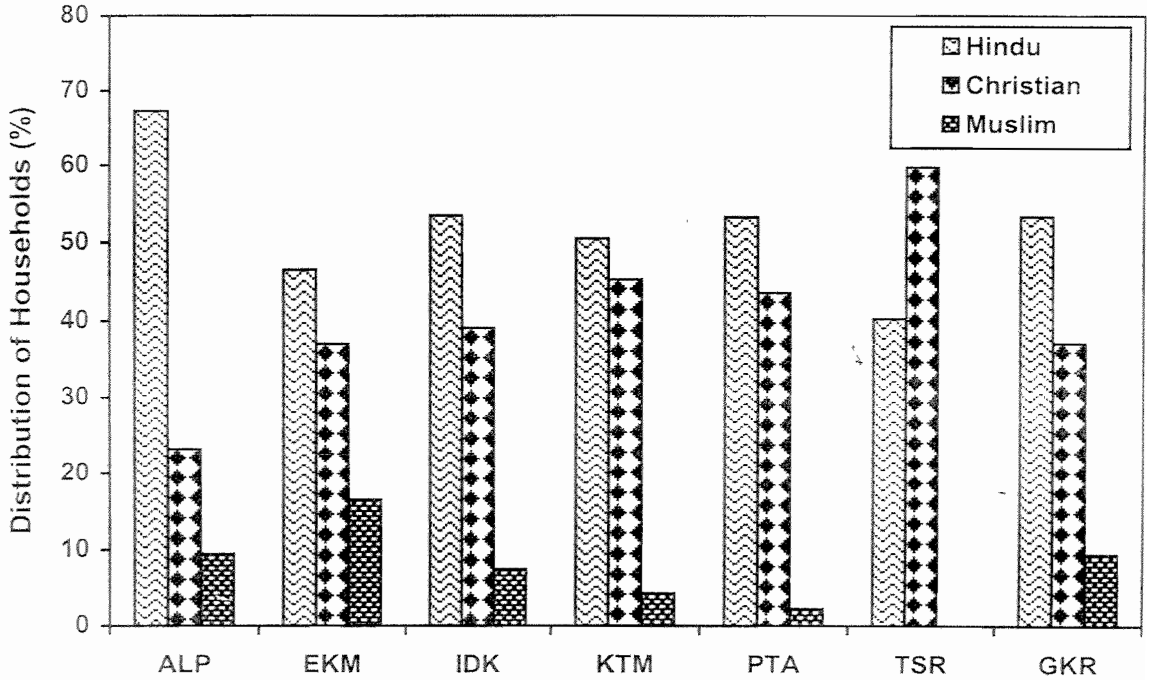

Fig. 2.9.1 : District and Religion-wise Distribution of Households in GKR (1999-2000)

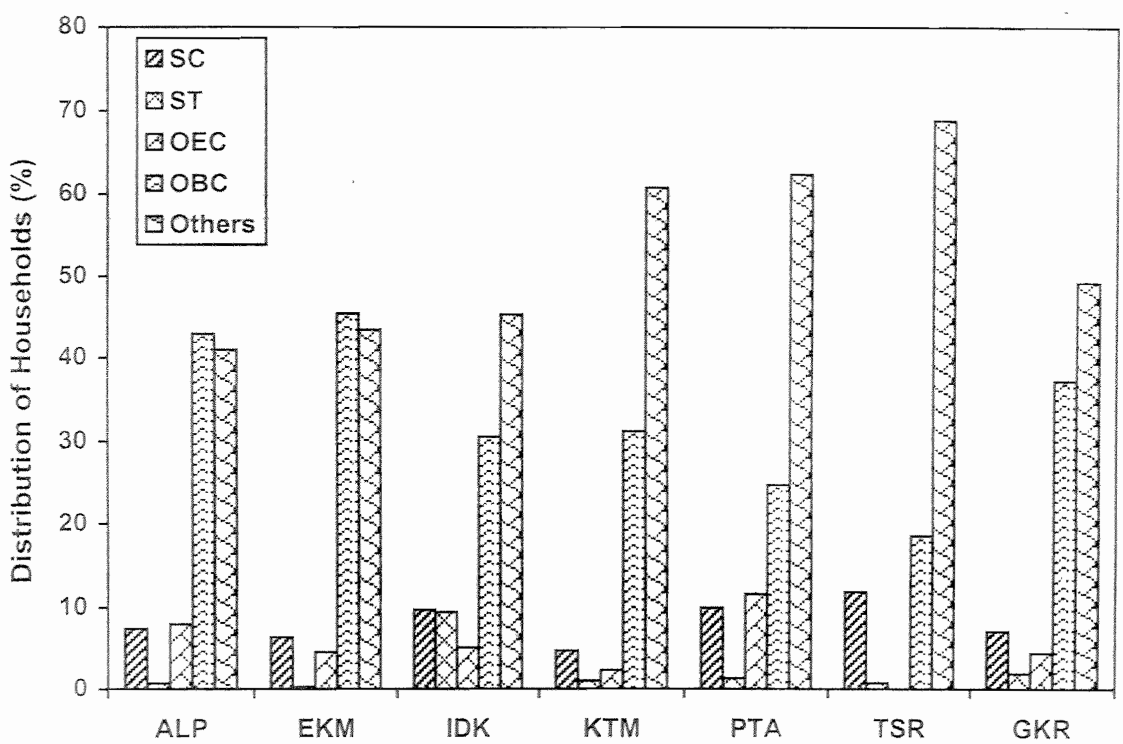

Fig. 2.9.2 : District and Social Group-wise Distribution of Households in GKR

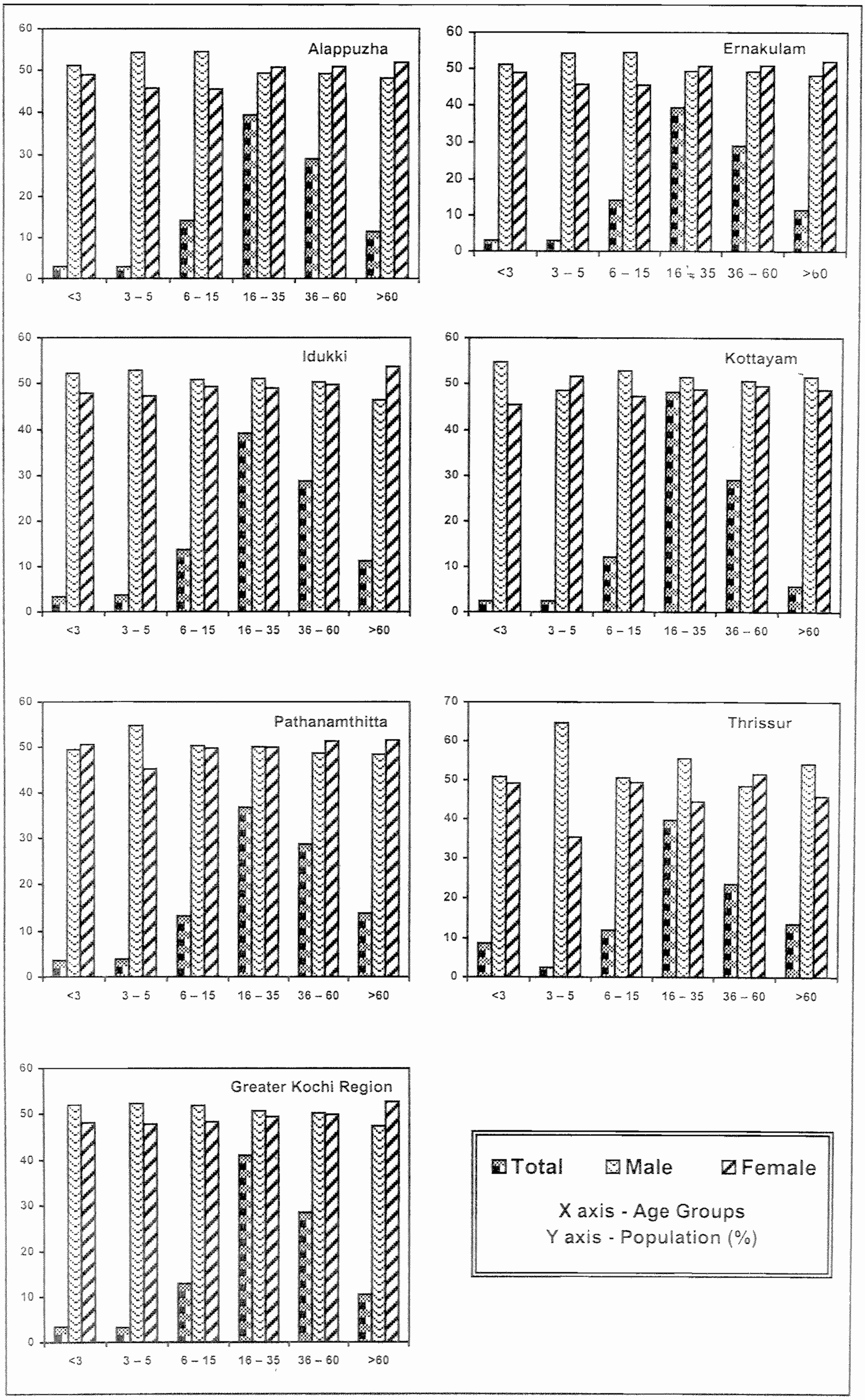

Fig. 2.9.3 : District and % Wise Distribution of Different Age Groups in GKR

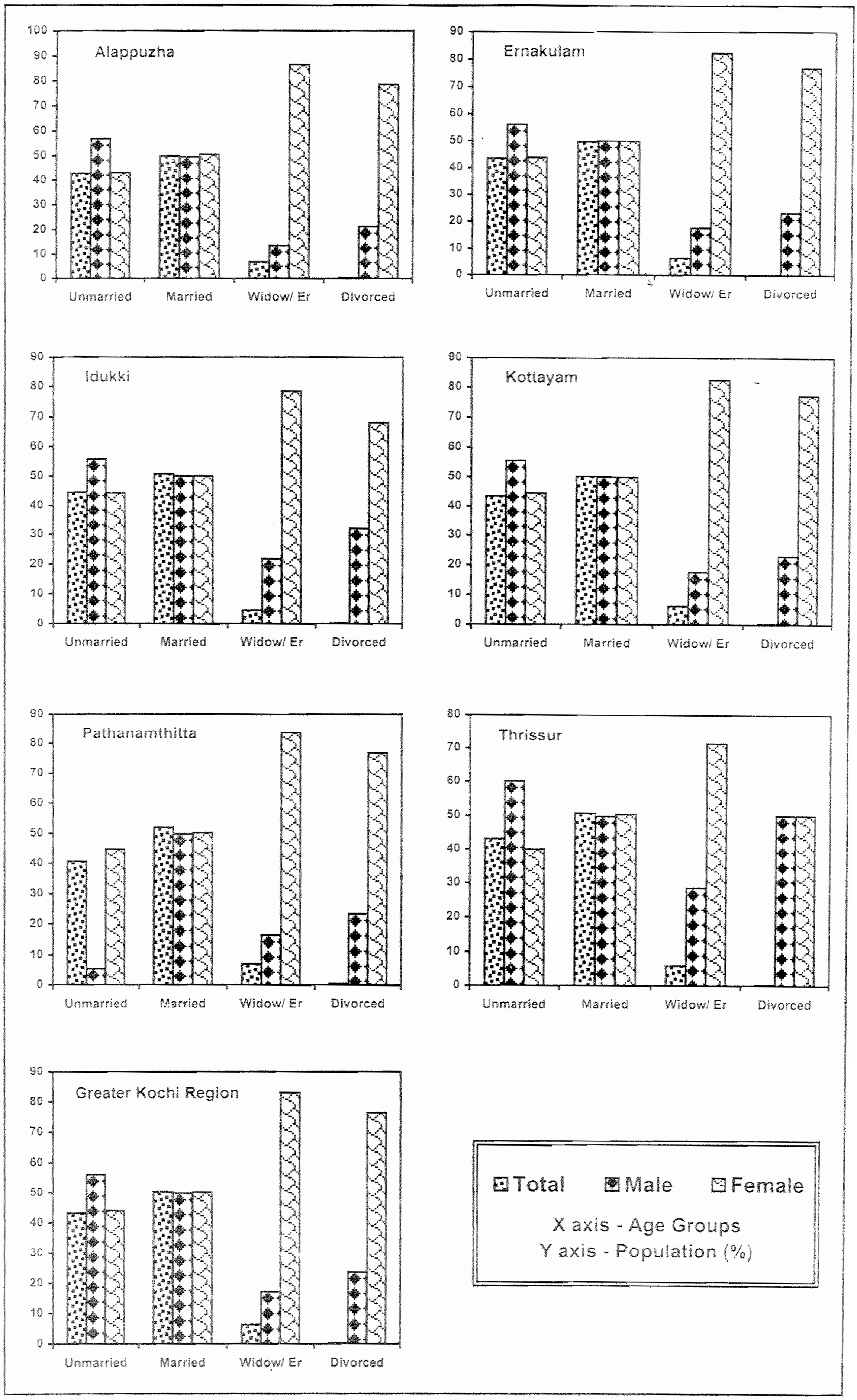

Fig. 2.9.4 : District and % Wise Distribution of Marital Status in GKR

2.10 Amenities and Infrastructure

The supportive capacity of a planning region is the maximum quantity of resources that the region can provide for development without affecting the bio productivity and ecosystem integrity. This study presents, the supportive capacity details with respect to the socio-cultural resources, distributive resources and transformational resources.

The resources, which are directly or indirectly related to the social and cultural status of the population of the planning region, are the socio-cultural resources. The selected socio-cultural resources identified for the purpose of this study are housing, education, health, culture, tourism, social security and welfare, human resources and animal resources. Under each resource type, the available secondary data is presented and analysed to get an idea of the resource base of the region. Time series data whenever possible is given to assess the change in the resource base with time.

2.10.1 Housing Resources

Total number of houses in GKR is 3364434 of which 228155 are vacant. The percentage of vacant houses to total houses is maximum in Idukki district (8.14%) and minimum in Kottayam district (5.72%). **Table 2.10.1** gives the number and percentage of vacant houses in GKR. All the values of GKR districts are below the state average in the proportion of vacant houses to total houses. The state average in this respect is 8.47.

The percentage of residential houses is maximum in Idukki district and minimum in Kottayam District. Idukki, Thrissur, Alappuzha and Ernakulam districts have percentage of residential houses greater than the state average, Pathanamthitta, Kottayam are below state average. The state average value is 65.83. Number of shops cum residence is also maximum in Idukki district and minimum in Ernakulam district. All districts except Ernakulam are above the state average in the percentage of shops cum residences. Alappuzha ranks first in the percentage of workshops and household industries and Idukki ranks last. Pathanamthitta and Idukki fall below state average in this respect, all others are above state average. Hotels, Tourist homes etc. are maximum in Ernakulam district and minimum in Kottayam district. The state average in the percentage of hotels, sarais, dharmasalas etc. is 0.40. Ernakulam and Idukki districts are above this value. In the case of shops including eating-places Kottayam has maximum number and Idukki has minimum (**Table 2.10.2**). The state average is 4.54%. Kottayam, Alappuzha and Pathanamthitta districts are above the state average and other districts.

With respect to the percentage of factories, workshops and worksheds and business houses and offices, Ernakulam ranks first. The state average is 2.84%. Pathanamthitta and Idukki districts are below the state average in this respect. Kottayam district has maximum percentage of places of entertainment and community gathering and other non- residential houses. Thrissur stands first in the percentage of restaurants, meat shops and eating- places and places of worship (**Table 2.10.3**).

Number of houses per 1000 population is another indicator of development in the housing resources sector. Except Thrissur district, all other districts of GKR are above the state average (282) in this regard. Pathanamthitta has maximum number (330) and Thrissur has minimum number (268). Kottayam ranks second (301), followed by Idukki (296) and Alappuzha (295). Maximum number of residential houses per 1000 population is in Pathanamthitta district and minimum in Thrissur district (**Table 2.10.4**).

The rural urban difference in terms of number of households per 1000 census houses and number of households per sq. km. are given in **Table 2.10.5**. This Table shows that the rural-urban difference in the number of households per 1000 census houses varies from 4 in Pathanamthitta to 18 in Ernakulam district. The total number of households per sq. km. is highest (287) in Alappuzha district and lowest (46) in Idukki district. Very significant difference in the number of households per sq. km. is present between rural and urban areas among the districts of GKR. This difference varies from 111 in Idukki district to 345 in Ernakulam.

The distribution of households by the type of house occupied is given in **Table 2.10.6**. The percentage of permanent houses varies from 42.23% in Idukki to 85.94% in Ernakulam district. The percentage of semi permanent houses varies from 4.6% in Ernakulam to 24.23% in Thrissur district. The highest percentage of temporary houses is in Idukki district and its lowest percentage is in Ernakulam district.

The quality of housing can be estimated from the kind of raw materials used for housing. Percentages of houses with bricks as raw materials in rural and urban parts of each district are given in **Table 2.10.7**. Rural part of Alappuzha has maximum percentage of houses with bricks followed by Pathanamthitta rural and Kottayam rural. Ernakulam rural has minimum score in this type of housing. In the urban areas Alappuzha has maximum (62.57%) followed by Kottayam, Thrissur and Pathanamthitta. The difference between rural and urban areas is maximum in Kottayam and Thrissur districts. Houses with unburnt bricks as wall materials are maximum in rural Idukki and rural Alappuzha. In urban areas, Thrissur has maximum percentage of houses of this type and minimum in Ernakulam district.

It can be seen that rural Ernakulam has more percentage of houses with stones as raw materials and Alappuzha has minimum percentage. Alappuzha rural has maximum number of houses with tiles, slate etc. as the raw material and Idukki rural has minimum in this category. In the urban areas, Kottayam has maximum number of this type and Idukki has minimum.

Table shows the distribution of houses with mud as raw material. In the rural areas, all the districts of GKR have percentage of houses of this type below state average. Thrissur has maximum followed by Idukki and Ernakulam with minimum in the urban areas. All districts except Ernakulam and Kottayam are above state average. Idukki district has maximum percentage of houses with grass, cadjan leaves and reeds as thatch materials. It is minimum in Ernakulam and Kottayam. But when houses with grass, leaves and reeds or bamboos as wall material are concerned, all other districts except Alappuzha, have more or less the same percentage of houses of this type. Alappuzha has very high percentage of houses of this type compared to other districts.

Analysis of the quality of houses shows that Ernakulam district and Kottayam district are first in the quality of housing and Idukki last. The difference between rural and urban areas in terms of quality of houses is maximum in Kottayam district. Maximum number of owned houses is in Alappuzha and minimum in Idukki. In Alappuzha, the rented houses are minimum in number and in Idukki it is maximum (**Table 2.10.8**). **Table 2.10.9** shows the percentage distribution of households by rooms.

2.10.2 Educational

The educational resource base of the planning region is of relatively more importance to the quality of life of the community. The experience of Kerala in the field of education has been different from that in other parts of the country, with its achievements in some areas – such as primary education and women's literacy – equating those of even with several developed countries. At the same time lacunae exist in a number of important areas. The need for improving the quality of education and levels of performance is obvious. The problems besetting educational management and financing are however much more acute. There is also the problem of combining academic excellence with equitable distribution of educational opportunities already largely attained.

Kerala is the most literate state in India. It had an overall literacy rate of 89.81% (1991) as against the national literacy rate of 52.21%. A female literacy rate of 88.17% as against 75.65 in 1987 and a male literacy rate of 93.62% in 1991, compared to 87.73 in 1981.

The literacy rate in Kerala among scheduled castes (SC) and scheduled tribes (ST) in 1991 was only 79.65% and 51.09% respectively. **Table 2.10.10** gives a comparison of the literacy rates in the districts of GKR. The literacy rates of GKR as district average; as per 1991 data is 92.32%. It can be seen that from 1961 to 1981 there was a gradual and steady increase in the literacy rate from 52.24% to 75.59% for GKR. But from 1981 to 1991, the increase is very steep from 75.59% to 92.32%. This increase is, a part of the increase in the literacy rate all over Kerala by the Kerala - Total Literacy Programme - 1990. Idukki district is far below all other districts with 86.94% of literacy rate as per 1991 data. On an all Kerala basis, Idukki district is at the 6th place, while Kottayam is in the first place in terms of literacy rate - 1991. In 1981, Idukki district was in the 10th place among the 14 districts of Kerala.

Table 2.10.11 gives district-wise literacy rate (1981 & 1991) for general, scheduled castes and scheduled tribes. For general category of population, in 1991 it is seen that the female literacy rate is 5.54% less than male literacy rate in GKR. This difference between female and male literacy rate varies from 3.26% in Pathanamthitta district to 7.86% in Idukki district. The literacy rates among the scheduled castes in GKR is 83.28 while among the scheduled tribes, it is 71.75%. The scheduled castes literacy rates vary from 72.67% in Idukki district to 90.28% in Kottayam and the scheduled tribe literacy rate varies from 51.4% in Thrissur district to 88.69% in Kottayam district. The difference between male and female literacy rates among the scheduled castes is 10.01%. This difference is double the corresponding increase among the general category. Among the scheduled tribes, the difference between male and female literacy rates (7.77%) is less than that among the scheduled castes. The male-female difference between SC varies from 7.07% in Pathanamthitta district to 16.75% in Idukki district and the same difference among ST varies from 2.54% in Kottayam district to 10.88% in Idukki district.

1981 data on the literacy rate of SC and ST population when compared with the corresponding values of 1991 indicate the following. For SC population, the literacy rate increased from 61.95% to 83.28% between 1981 and 1991. In the case of ST population, it increased from 50.64% to 71.75%.

The structure of educational system in Kerala is reflected in the literacy rates of the population as already explained. The formal education is a three-tier system consisting of primary, secondary and tertiary education. The management of educational institutions is under three categories such as government, private aided and private unaided. The number of educational institutions forms the most important type of educational resource. **Table 2.10.12** gives the category-wise number of schools in the districts of GKR from 1988-89 to 1993-94. The total number of schools decreased from 4828 to 4817 between 1988-89 and 1990-91. In 1991-92, it increased to 4852 and then it decreased to 4791 in 1993-94.

The number of schools under primary and secondary education shows that almost 75% of the actual number of schools is primary schools. Among the primary schools, 43% are managed by private agencies with financial aid from the government and among the high schools (secondary schools) about 60% are private aided schools. Except in 1993-94, there is not much variation in the total number of primary schools in GKR. But the total number of primary schools decreased from 3598 to 2277 between 1992-93 and 1993-94.

But in the case of the number of secondary schools, from 1988-89 to 1992-93, the number did not show much variation and in 1993-94, the total number of high schools increased from 1246 to 2514. This increase was recorded in all the districts in the number of government schools and private aided schools. The total number of schools is highest in Thrissur district followed by Ernakulam district, Kottayam, Alappuzha, Pathanamthitta and Idukki districts. This order is not changed from 1988-89 to 1993-94. The number of schools in Idukki district is almost half the number of schools in other districts.

Table 2.10.13 gives the number of schools in the districts of GKR anc GKR as a whole for 1988-1999. The total number of schools in GKR in 1996-9; was 4826, which increased to 4828 in 1997-98 which then decreased to 4827 ıı 1998-99. There is not much variation in the number of schools in the districts (GKR during the above period.

This comparison shows that Thrissur and Ernakulam districts are in the forefront in terms of the number of schools and Idukki district is far behind. **Table 2.10.14** shows the classification of schools in panchayat areas, municipalities and corporation in the districts of GKR as per 96-97 data. In GKR as a whole 865 of the schools are in the panchayat areas. 11% in the municipalities and only 3% in the Kochi Corporation. In Alappuzha district, 84% of the schools are in the panchayat areas and 16% are in the municipalities.

In Ernakulam district, 72% of the schools are located in the panchayat areas and 14% each are in the municipalities and Kochi Corporation. Idukki district with only one municipality has 4% schools and the remaining 96% of the schools are in the panchayat areas. In Kottayam district, 96% of the schools are located in panchayats and the remaining is in the municipal areas. Pathanamthitta and Thrissur district indicate almost the same picture. The above comparison shows that in comparison to other districts of GKR, Ernakulam district has more concentration of schools in the urban areas.

In Kerala higher secondary or pre-university education was a part of the university education. The delinking of higher secondary education from universities to the schools is not complete even now. **Table 2.10.15** shows the details of the higher secondary schools as per 1998 data. The total number of higher secondary schools in GKR comes to 244. Out of this majority (59%) are in the private aided sector and the remaining is in the government sector. In the case of number of higher secondary schools also, Ernakulam, Kottayam and Thrissur districts are in the forefront in comparison to other districts of GKR.

The physical infrastructural facilities of schools is a major aspect that has to be looked into, when we analyze the educational resources of a region **(Table 2.10.16)**. We have 1998 data on the details of schools having building facilities and drinking water, latrines/urinals. In GKR, 1529 schools have pucca buildings and 130 schools have thatched sheds. The number of schools with pucca building facilities is highest in Ernakulam district and lowest in Idukki. This is almost proportional to the total number of schools in each district, but in Alappuzha district the number of schools with thatched sheds is 51 and in Ernakulam it is 3 only. This shows a nonequitable distribution of physical infrastructure of schools in GKR.

There are 1474 schools with drinking water facilities and 1479 schools with sanitation facilities in GKR. Here also, in proportion to the total number of schools, Idukki district stands far behind other districts and Ernakulam is in the first place.

The schools with out sufficient strength of students in the government and private aided sector are known as uneconomic schools. The total number of uneconomic schools in GKR as per 1998 data is 875. Out of these, 46.5% of the schools are in the government sector and 53.5% are in the private aided sector. Pathanamthitta district with 232 uneconomic schools ranks first in the number of uneconomic schools and Idukki district with 70 uneconomic schools ranks last (**Table 2.10.17**).

Table 2.10.18 gives the number of Industrial Training Institutions (ITIs). The data shows that there are 210 ITIs in GKR as per 1998 records. Out of this, 11 are in the government sector and 199 in the private sector. Another situation is that while all the private ITIs are affiliated to National Council for Vocational Training (NCVT), only 64% of the government ITIs have affiliation with NCVT. Districts like Ernakulam, Alappuzha and Thrissur are in the forefront in the number of ITIs. Idukki district is far behind other districts even in this case.

The Teachers Training Institutes (TTIs) are the training centres for primary school teachers. **Table 2.10.19** gives the number of training schools and trainees from 1987-88 to 1992-93. The number of training schools in GKR from 1987-88 to 1992-93 remained almost constant, i.e. 56 to 57. Ernakulam district ranks first in having 14 TTIs and Idukki ranks last with only 3 TTIs. The total number of teacher trainees varied from 4339 in 1987-88 to 4066 in 1992-93.

The Arts and Science colleges under the Government of Kerala and teaching departments of the Universities are the centres of higher education in the state. Kerala Agricultural University in Thrissur district, Cochin University of Science and Technology and Sree Sankara Sanskrit University, Kalady in Ernakulam district and Mahatma Gandhi University in Kottayam district are the Universities in GKR.

The district-wise number of Arts and Science colleges in GKR for 1968-69 to 1997-98 is given in **Table 2.10.20**. The total number of colleges remained the same i.e. 89 during 1990-91,1991-92 and 1992-93, which increased to 95 in 1996-97 and no further increase in 1997-98.

Table 2.10.21 gives the district-wise number of students in the primary and secondary schools. From 1993-94 to 1994-95, the total number of students in GKR increased from 800550 to 2032017. As per 1993-94 data, 51% of the students are boys and 49% are girls. This ratio is almost the same in 1994-95 also. The increase in the number of students from 1993-94 to 1994-95 is 12,31,467. This increase is about 154%. The total number of ST students in GKR as per 1994-95 data is 16532, which is 0.81% of the total number of students. According to 1996-97 data, the total number of students in GKR is 21,39,773 recording an increase of 107756 only. This increase is only 5.3% of the total number of students in 1994-95.

The total number of SC students in GKR as per 1996-97 data was 238116, which is 11% of the total number of students in GKR. The total number of ST students in GKR for the year 1996-97 is 15744. This data shows that 48% of the ST students in GKR is in Idukki district and only 4% are in Alappuzha district. Similarly, Table shows that maximum percentage (27.8%) of SC students in GKR is in Thrissur district and the lowest of percentage of SC students (11.8%) is in Idukki district.

As per this data, the total number of SC students in GKR has decreased to 229700 from 238116 in 1996-97. This is 3.67% of decrease. Similarly, Table shows that the number of ST students also recorded a decline from 15744 in 1996-97 to 15268 in 1997-98. This is approximately 3.2% of decrease.

The total number of students comes to 1860981 in 1998-99. In 1996-97, it was 2139773, which means that from 1996-97 to 1998-99, there was a decrease of 278792 in the total number of school students. This has been pointed out as related to the decrease in the birth rate in Kerala.

The total number of SC students as per this data comes to 222421 in GKR for 1998-99. Compared to the total number of SC students in GKR in 1997-98, this data has shown a decrease of 7279 (3.2%). The total number of ST students as per this Table is 14699 for 1998-99. This also is less than the corresponding data for 1997-98 for which it was 15268.

All the above Tables show that the total number of school children in GKR is showing a decrease from 1993-94 to 1998-99. This decrease is represented in the number of SC and ST students also.

A comparison of the total number of students in the tertiary education for 1968-69, 1992-93 and 1996-97 is given in **Table 2.10.22**. With the available data on the number of college students in 1968-69 and 1996-97, we can see that this number has increased from 73040 in 1968-69 to 174981 in 1996-97. The 1996-97 data shows that the highest percentage of college students in GKR is in Ernakulam district (24.8%). The lowest percentage of college students in GKR is 3.9%, which is for Idukki district.

The number of teachers in schools (district-wise data) is given in **Table 2.10.23**. Table shows that the total number of school teachers decreased from 78032 in 1987-88 to 61731 in 1992-93. During all these years the number of teachers in schools was highest in Thrissur district followed by Ernakulam and the lowest number of teachers was in Idukki district.

Table 2.10.24 gives the district-wise details of the number of school teachers in 1994-95. The total number of school teachers in GKR as per this data is 70703. Further, this Table shows that 76.2% of the total number of school teachers are females. Among the districts of GKR, the number of school teachers vary from 6190 in Idukki to 17074 in Thrissur district. In 1995-96 the total number of school teachers in GKR was further decreased from 70703 in 1994-95 to 68947 in 1995-96. But the percentage of female teachers increased from 76.2% to 77.4%. 1995-96 recorded another decrease in the number of teachers from 68947 to 68542 in 1996-97. The total number of teachers in GKR was further decreased to 67803 in 1997-98. But the data for 1998-99 shows that this year recorded 9% increase in the total number of school teachers and the percentage of female teachers increased to 79.4%.

The above comparison shows that from 1987-88 to 1997-98, the total number of school teachers in GKR showed a decreasing trend and in 1998-99, it showed 9% increase from the previous year. Also the majority of the school teachers during all these years were females in all the districts. Another important aspect is that Thrissur followed by Ernakulam district dominated the other districts in the total number of teachers in schools. Idukki district has the least number of teachers among all the districts of GKR.

Table 2.10.25 compares the total number of college teachers in GKR for the year 1973-74,1992-93 and 1996-97. In 1973-74, the total number of college teachers in GKR was 3908. By the year 1992-93, the total number of college teachers in GKR increased to 7329. But in 1996-97, this figure has decreased to 6594. Kottayam district comes first in the number of college teachers and Idukki district with 248 teachers comes last.

2.10.3 Medical

In terms of health care and health related infrastructure development, Kerala has attained achievements comparable to the developed nations. High literacy rate, health awareness among women, family based health care methods, high rate of personal hygiene, etc. have a major role in these achievements. Low child mortality and long life expectancy are the major indicators of this development. Apart from this, the success stories in the population control in Kerala also deserve a special mention. High minimum wages, land reforms, high literacy rates and access to universal health care are the factors responsible for the same. With this background we are able to examine the health resources of GKR planning region in Kerala.

The birth rate, death rate and infant death rate for 1958 and 1993 are given in the **Table 2.10.26**. It can be seen that for GKR on an average, the death rate has decreased from 6.67 to 5.71 and the infant death rate has decreased from 41.27 to 10.37. By comparing the 1993 birth rate, death rate and infant death rate in GKR with the corresponding values for Kerala State, it can be seen that all these vital rates are lower than the state average. But Thrissur district has recorded a birth rate and death rate greater than the state average in 1993 and the infant death rate in Thrissur is almost equal to the State average. The lowest birth rate in 1993 was recorded in Alappuzha with 13.16 and Idukki district with death rate 3.86 recorded the lowest death rate. Pathanamthitta district has recorded lowest infant death rate of 7.69. When compared with the state average of 13, this is very remarkable.

Table 2.10.27 gives the child mortality indicators as per 1991 data. The average number of children dying between birth and age 1 in GKR is 33 per 1000 births. This rate increases to 38 and 50.8 between birth and age 2 and between birth and age 5 respectively. This Table shows that these rates are very high in the case of Idukki district. Alappuzha district and Pathanamthitta districts are relatively with a lower rate of this probability of death in the child age.

Table 2.10.28 shows that the highest percentage of married females is in the age group of 15-44. In GKR this percentage comes to 61.7. All the districts of GKR have values more or less equal to this GKR average.

The health service sector in Kerala is operating through a network of government medical institutions like medical colleges, district hospitals, taluk hospitals, community health centres, primary health centres and dispensaries, in addition to the private hospitals. **Table 2.10.29** shows the district-wise number of Allopathy medical institutions in 1997 and 1998. These medical institutions include hospitals, primary health centres, community health centres, dispensaries, T.B. clinics and leprosy control clinics.

The total number of medical institutions in GKR as per 1997 data is 539 and in 1998 it has recorded a slight increase to 541. But during the same period the number of beds increased from 17298 to 17452. As per 1998 data, Thrissur district and Ernakulam district are in the forefront with 122 and 117 medical institutions respectively. Idukki and Pathanamthitta district have 63 and 64 institutions respectively. This variation among the districts is seen in the number of beds also.

Table also gives the number of beds in hospitals per lakh of population in 1998. The number of beds in hospitals per lakh of people in GKR is 149.8. Idukki district and Pathanamthitta district have this value 78 and 81 respectively, which are far below GKR average. In Alappuzha district, it is 201 which is far above GKR average. The Kottayam and Thrissur also have this number above the GKR average. The number of beds in hospitals per lakh of population is a good indicator of the available health resources. In this respect as per 1998 data, Idukki and Pathanamthitta districts are the problem areas.

Table 2.10.30 gives the number of category wise medical institutions and the number of beds in each. Out of the 541 medical institutions in GKR, 75.5% are primary health centres, 14% are hospitals, 6% are community health centres and the remaining is contributed by dispensaries, TB clinics and leprosy control clinics. It can be seen that except in the case of leprosy control clinics, all other categories of medical institutions are relatively more in Thrissur and Ernakulam districts.

The district-wise number of medical and paramedical personnel under the Directorate of Health Services as per 1998 data is given in the **Table 2.10.31**. The total number of medical officers in GKR as per this data is 1449. Comparing this data with the population in each district of GKR, we have calculated the number of medical officers per lakh of population. For GKR as a whole, the number of doctors per lakh of population is 12.44. All the districts have almost the same number of doctors per lakh of population as that of GKR.

The contribution of the private sector to the Health sector of Kerala cannot be neglected. **Table 2.10.32** gives the number of private medical institutions and doctors in 1986 and 1995. The total number of private doctors in 1986 was 6959 which increased to 9768 in 1995, i.e. approximately 40% increase. The total number of private hospitals in 1986 was 5080, which increased to 6026, which is about 18.6% increase. As per 1995 data, the private allopathy doctors per lakh of population are 62.76 in Ernakulam and it is 37.48 in Alappuzha district. For GKR, it is 46.9.

When compared with the number of doctors in government hospitals, per lakh of population, there is not much difference between the districts of GKR, whereas the number of private doctors per lakh of population shows very high variation. This is because, in the distribution of private hospitals, government has no control and they are established with preference to the economically developed areas.

The district-wise distribution of Ayurvedic institutions and Homeopathic Institutions, number of beds and number of patients treated in 1997 and 1998 is given in **Table 2.10.33**. The total number of Ayurvedic hospitals and dispensaries in 1992-93 was 292, which increased to 318 in 1997 and in 1998 it was increased to 322. The total number of Ayurvedic doctors in 1998 was 409.

The total number of Homoeopathic institutions in GKR in 1997 and 1998 was 212. The total number of Homoeopathic hospitals and dispensaries in Ernakulam district is 47 followed by Kottayam district with 41. The lowest number of such institutions is 22 in Pathanamthitta district.

The population control strategy in Kerala is being operated through family welfare centres in addition to the main hospitals. There are 230 rural main centres and 2061 subcentres in GKR. The number of rural main centres is maximum (95) in Thrissur and minimum (53) in Pathanamthitta district. A maximum of 492 subcentres are in Thrissur district and a minimum of 231 are in Idukki district **(Table 2.10.34)**.

The above discussion on the health resources in GKR points to the fact that Thrissur and Ernakulam district are relatively at higher resource status compared to Idukki, Alappuzha and Pathanamthitta districts.

Table 2.10.1

District wise Number of Vacant Houses in GKR : 1991 Census

District	No. of Vacant Census Houses	% of Vacant Houses to Total Houses
Alappuzha	36840	6.29
Ernakulam	53945	6.80
Idukki	26640	8.14
Kottayam	30885	5.72
Pathanamthitta	27795	7.16
Thrissur	52050	7.13
GKR	**228155**	**6.78**

Source : Secondary data collected by KSSP

Table 2.10.2

District wise Percent Residential Houses in GKR

District	A	B	C	D	E	F
Alappuzha	65.33	0.44	1.45	0.14	0.31	4.75
Ernakulam	65.15	0.21	1.20	0.21	0.77	4.49
Idukki	69.58	0.56	0.38	0.26	0.38	3.43
Kottayam	63.28	0.48	1.23	0.13	0.28	4.78
Pathanamthitta	63.47	0.47	0.85	0.24	0.34	4.57
Thrissur	68.20	0.30	1.28	0.14	0.32	4.01
GKR	**65.83**	**0.41**	**1.07**	**0.19**	**0.40**	**4.42**

A - Residential House; B - Shop Cum Residence; C - Work Shop Factory Cum Res. House Hold Industry; D - Residence Combined with Other Uses; E - Hotels, Dharmasala Tourist Homes etc.; F - Shops Incl. Eating Places

Table 2.10.3

District wise Percent Non Residential Houses in GKR

District	A	B	C	D	E	F
Alappuzha	2.87	1.13	0.25	0.90	15.07	1.12
Ernakulam	3.57	1.06	0.27	0.70	13.86	1.68
Idukki	2.03	1.07	0.34	0.78	11.97	1.08
Kottayam	3.06	0.95	0.35	0.82	17.61	1.31
Pathanamthitta	2.45	0.83	0.31	0.98	17 37	0.96
Thrissur	3.07	1.16	0.29	1.09	11.64	1.08
GKR	**2.84**	**1.03**	**0.30**	**0.88**	**14.58**	

A - Factories Work shop & Work sheds; B - Restaurants, Meat Shops & Eating Places; C - Places of Entertainment & Community Gathering (Excl. Place of Worship); D - Place of Worship (Temple, Church Mosque, Gurud-wara); E - Other non-Resid-ential Houses; F - Business Houses & Offices

Table 2.10.4

Districtwise Number of Houses per 1000 Population

District/ State	Total Houses	Residential	Non- Residential	Difference
Alppuzha	295	199	96	103
Ernakulam	289	193	96	97
Idukki	296	210	86	124
Kottyam	301	196	105	91
Pathanamthitta	330	214	116	98
Thrissur	268	187	81	106
GKR	**297**	**200**	**97**	**103**
Kerala	**282**	**187**	**95**	**92**

Source : Secondary data collected by KSSP

Table 2.10.5

District wise Number of Households per 1000 Houses per km^2 Area (1991)

District	No. of Households per 1000 Census Houses			No. of Households per Km^2		
	Total	Rural	Urban	Total	Rural	Urban
Alappuzha	1006	1004	1010	287	253	417
Ernakulam	1012	1003	1021	231	153	498
Idukki	1007	1006	1015	46	45	156
Kottayam	1005	1003	1016	164	147	372
Pathanamthitta	1003	1002	1006	98	89	327
Thrissur	1008	1006	1014	172	142	450

Source : Secondary data collected by KSSP

Table 2.10.6

District wise Distribution of Households by Type of House Occupied in GKR : 1991

District	Total No. of House-holds	Percent Households Occupying Houses of Type				
		Perma-nent	Semi Perma-nent	Temporary		
				Total	Serviceable	Non Serviceable
Alappuzha						
Total	397675	65.66	6.12	28.22	8.24	19.98
Rural	280425	64.50	5.69	29.41	8.55	20.86
Urban	117250	67.47	7.15	25.38	7.50	17.88
Ernakulam						
Total	535310	85.94	4.61	9.45	3.92	5.53
Rural	279685	83.84	5.27	10.89	4.83	6.06
Urban	255625	88.24	3.88	7.88	2.93	4.95
Idukki						
Total	238765	42.23	19.86	37.91	30.50	7.41
Rural	222475	41.17	20.16	38.67	31.18	7.49
Urban	10290	65.15	13.30	21.55	15.82	5.73
Kottayam						
Total	353930	71.17	12.12	16.71	8.54	8.17
Rural	293505	69.40	12.64	17.95	9.06	8.89
Urban	60425	79.74	9.56	10.70	6.04	4.65
Pathanmthitta						
Total	254060	69.53	11.76	18.71	10.25	8.45
Rural	222085	68.51	12.36	19.12	10.34	8.78
Urban	31975	76.61	7.58	15.81	9.61	6.21
Thrissur						
Total	512475	57.89	24.23	17.88	8.79	9.09
Rural	381115	54.59	25.68	19.73	9.71	10.02
Urban	131360	67.45	20.03	12.52	6.12	6.40
GKR						
Total	2286215	67.68	12.8	19.52	9.97	9.55
Rural	1679290	63.77	12.2	24.03	11.52	12.51
Urban	606925	77.88	8.90	13.22	5.38	7.84

Source : Secondary data collected by KSSP

Table 2.10.7

District wise Distribution of Houses according to Building Raw Material Used (1990)

District	Total	Rural	Urban	% of Houses in the Category to total Houses	
				Rural	Urban
Brick as Raw Material					
Alappuzha	324860	212370	112490	52.44	62.57
Ernakulam	256335	62335	194000	14.89	24.55
Idukki	58360	53955	4405	17.43	24.55
Kottayam	190065	142190	47875	32.21	48.46
Pathanamthitta	137830	118110	19720	34.97	38.91
Thrissur	203025	123460	79565	23.30	39.69
GKR	**1170475**	**712420**	**458055**	-	-
Unburnt Bricks as Wall Material					
Alappuzha	9160	7180	1980	1.77	1.10
Ernakulam	15535	12265	3270	2.93	0.87
Idukki	95230	93040	2190	30.06	12.21
Kottayam	25415	23570	1845	5.34	1.87
Pathanamthitta	3468	32320	2360	9.57	4.06
Thrissur	116565	91265	25300	17.22	12.62
GKR	**296585**	**259640**	**36945**	-	-
Stone as Raw Material					
Alappuzha	60960	50955	10005	12.58	5.55
Ernakulam	412355	285595	126760	68.23	33.78
Idukki	91415	84090	7325	27.15	40.83
Kottayam	192675	162695	29980	36.85	30.35
Pathanamthitta	117160	99190	17970	29.37	35.45
Thrissur	269340	202490	66850	38.21	33.34
GKR	**1143905**	**885015**	**258890**	-	-
Mud as Raw Material					
Kerala	660645	588245	72400	9.84	3.45
Alappuzha	7995	7320	675	1.81	0.37
Ernakulam	8655	6460	2195	1.54	0.58
Idukki	24180	23440	740	7.57	4.12
Kottayam	15555	13515	2040	3.06	2.06
Pathanamthitta	11025	9470	1555	7.39	3.70
Thrissur	56110	47405	8705	8.95	4.34
GKR	**123520**	**107610**	**15910**	-	-

Contd...

Table 2.10.7 Contd...

District	Total	Rural	Urban	% of Houses in the Category to Total Houses	
				Rural	Urban
Grass, Cadjan Leaves, Reeds and Thach as Raw Material					
Alappuzha	169085	124585	44500	30.76	24.67
Ernakulam	70335	43530	26805	10.40	7.14
Idukki	103485	100220	3265	32.38	18.20
Kottayam	73655	65730	7925	14.89	8.02
Pathanamthitta	64270	57320	6950	16.97	13.71
Thrissur	133285	106130	27155	20.03	13.54
GKR	**614115**	**497515**	**116600**	-	-
Grass, Leaves, Reeds, Bamboo as Wall Material					
Kerala	647335	497405	149930	8.32	7.15
Alappuzha	121225	83665	37560	20.66	20.83
Ernakulam	44240	24860	19380	5.94	5 16
Idukki	26425	25635	790	8.28	4.40
Kottayam	40705	36350	4355	8.23	4.41
Pathanamthitta	31140	28525	2615	8.45	5.16
Thrissur	66135	51905	14230	9.79	7.10
GKR	**329870**	**250940**	78930	-	-

Source : Secondary data collected by KSSP

Table 2.10.8

Districtwise Percent Distribution of Households by Tenure Status (1990)

District	Total			Rural			Urban		
	Owned	Rented	Others	Owned	Rented	Others	Owned	Rented	Others
Alappuzha	97.32	2.11	0.57	98.68	1.03	0.29	94.05	4.70	1.25
Ernakulam	91.08	7.54	1.38	96.61	2.45	0.94	85.03	13.11	1.86
Idukki	77.71	14.72	7.57	77.36	14.77	7.87	85.23	13.70	1.07
Kottayam	94.72	3.95	1.33	96.14	2.63	1.23	87.80	10.39	1.81
Pathanam-thitta	95.91	2.93	1.16	96.40	2.49	1.11	92.51	6.02	1.47
Thrissur	95.79	3.13	1.08	97.07	1.82	1.11	92.07	6.93	1.00

Source : Secondary data collected by KSSP

Table 2.10.9

Districtwise Percent Distribution of Households by Number of Rooms

District	No. excl. Room	Number of Rooms						Unspecified
		1	2	3	4	5	6	
Alappuzha	N	9.86	32.06	23.23	14.42	8.68	9.50	0.25
Ernakulam	0.01	12.37	25.07	26.07	17.44	9.50	8.85	0.69
Idukki	0.06	16.41	40.63	23.75	9.12	4.96	4.66	0.41
Kottayam	0.02	15.62	29.90	21.89	14.49	8.30	9.37	0.41
Pathanam-thitta	0.02	15.66	32.04	20.50	14.39	8.16	8.70	0.53
Thrissur	0.02	11.34	22.58	24.43	18.90	10.81	11.47	0.45

Source : Secondary data collected by KSSP

Table 2.10.10

District-wise Percent Literacy Rate Trend

District	1961	1971	1981	1991
Alappuzha	56.90	70.44	78.58	93.87
Ernakulam	50.33	65.37	76.82	92.38
Idukki	44.33	56.42	67.44	86.94
Kottayam	61.52	72.88	81.66	95.72
Pathanamthitta	-	-	-	94.86
Thrissur	48.16	61.61	73.59	90.18
GKR	**52.24**	**65.34**	**75.59**	**92.32**

Source : Secondary data collected by KSSP

Table 2.10.11

District-wise & Sex-wise Percent Literacy Rate in GKR

District	General			Scheduled Caste			Scheduled Tribe		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
1981									
Alappuzha	82.18	75.10	78.52	73.72	62.27	67.95	58.67	48.75	53.71
Ernakulam	80.75	72.88	76.82	68.89	57.34	63.10	55.74	59.27	52.60
Idukki	72.15	62.55	67.44	57.76	39.68	48.76	47.23	39.33	43.35
Kottayam	83.96	79.35	81.66	76.29	67.24	71.79	75.51	71.78	73.63
Pathanam-thitta	-	-	-	-	-	-	-	-	-
Thrissur	77.31	70.21	73.59	63.52	53.02	58.16	34.33	25.18	29.90
GKR	**79.27**	**72.02**	**75.61**	**68.04**	**55.91**	**61.95**	**54.29**	**48.86**	**50.64**
1991									
Alappuzha	96.79	91.12	93 87	93.52	84.77	89.07	79.74	69.17	74.48
Ernakulam	95.46	89.27	92.35	87.29	77.55	82.37	81.49	72.11	79.96
Idukki	90.82	82.96	86.94	81.03	64.28	72.67	68.16	57.28	62.78
Kottayam	97.46	94.00	95.72	93.99	86.63	90.28	89.98	87.44	88.69
Pathanam-thitta	96.55	93.29	94.86	90.08	83.01	86.47	75.89	70.53	73.21
Thrissur	93.77	86.94	90.18	84.19	73.80	78.82	55.48	47.54	51 40
GKR	**95.14**	**89.6**	**92.32**	**88.35**	**78.34**	**83.28**	**75.12**	**67.35**	**71.75**

- Data not available

Source : Secondary data collected by KSSP

Table 2.10.12

District-wise Total Number of Different Category Schools from 1988 to 1994

District	1988-89			1989-90			1990-91		
	LPS	UPS	HS	LPS	UPS	HS	LPS	UPS	HS
Alappuzha	415	148	186	414	148	185	411	147	187
Ernakulam	496	204	281	495	203	280	491	204	279
Idukki	217	113	129	217	113	129	218	114	129
Kottyam	480	199	236	480	199	236	478	201	236
Pathanamthitta	429	124	165	428	134	165	427	135	165
Thrissur	534	226	236	533	226	236	529	277	239
GKR	**2571**	**1014**	**1233**	**2567**	**1023**	**1231**	**2554**	**1078**	**1235**
	1991-92			1992-93			1993-94		
	LPS	UPS	HS	LPS	UPS	HS	LPS	UPS	HS
Alappuzha	410	148	188	410	147	188	188	147	404
Ernakulam	496	207	284	495	206	284	284	205	483
Idukki	218	114	129	218	114	129	129	114	217
Kottyam	478	205	238	478	204	238	238	200	469
Pathanamthitta	427	142	167	426	141	167	167	139	419
Thrissur	533	228	240	531	228	240	240	226	522
GKR	**2562**	**1044**	**1246**	**2558**	**1040**	**1246**	**1246**	**1031**	**2514**

LPS – Lower Primary Schools; UPS –Upper Primary Schools; HS – High Schools

Source : Secondary data collected by KSSP

Table 2.10.13

District-wise Trend of Total Number of Schools : 1991-99

District	1991	1992	1993	1994	1997	1998	1999
Alappuzha	745	746	745	739	743	743	743
Ernakulam	974	987	985	972	984	996	993
Idukki	461	461	461	460	466	453	454
Kottayam	915	921	920	907	911	911	912
Pathanamthitta	727	736	734	725	729	733	733
Thrissur	995	1001	999	988	993	992	992
GKR	**4817**	**4852**	**4844**	**4791**	**4826**	**4828**	**4827**

Source : Secondary data collected by KSSP

Table 2.10.14

District wise Number of Schools in Different Panchayats, Municipalities and Corporations (1996-97)

District		HS	UPS	LPS	Total
Alapuzzha	MUN	39	16	61	116
	PAN	151	132	344	627
Sub Total		190	148	405	743
Ernakulam	COP	50	28	62	140
	MUN	50	19	63	132
	PAN	192	158	359	709
Sub Total		292	205	484	981
Idukki	MUN	7	2	9	18
	PAN	127	111	210	448
Sub Total		134	113	219	466
Kottayam	MUN	31	14	39	84
	PAN	210	190	427	827
Sub Total		241	204	466	911
Pathanmthitta	MUN	24	14	41	79
	PAN	143	127	380	650
Sub Total		167	141	421	729
Thrissur	MUN	44	15	54	113
	PAN	201	211	468	880
Sub Total		245	226	522	993
GKR	COR	50	28	62	140
	MUN	195	80	267	542
	PAN	1024	929	2188	4141
Total		**1269**	**1037**	**2517**	**4823**

MUN : Municipality, PAN : Panchayat, COR : Corporation

Table 2.10.15

District and Management wise Details of Higher Secondary Schools : 1998

District	Total No. of Higher Secondary Schools	Total No. of Batches Sanctioned		
		Science	Humanities	Commerce
Alappuzha	39	61	28	24
Ernakulam	55	84	34	42
Idukki	29	46	20	17
Kottayam	48	81	31	29
Pathanamthitta	29	45	19	22
Thrissur	44	64	33	25
GKR	**244**	**381**	**165**	**159**

Most of the institutes are either government or government aided

Table 2.10.16

District-wise Details of Schools Facilities in GKR : 1998

District	Total Number of Schools Having			
	Pucca Building	Thatched Sheds	Drinking Water	Urinal and Latrines
Alappuzha	268	51	297	304
Ernakulam	366	3	360	367
Idukki	135	28	127	121
Kottayam	276	20	242	244
Pathanamthitta	251	8	226	217
Thrissur	233	20	222	226
GKR	**1529**	**130**	**1474**	**1479**

Source : Secondary data collected by KSSP

Table 2.10.17

Districtwise Total Number of Uneconomic Schools in GKR : 1998

District	Govt. Schools	Private Aided	Grand Total
Alappuzha	66	52	118
Ernakulam	89	78	167
Idukki	45	25	70
Kottayam	96	98	194
Pathanamthitta	80	152	232
Thrissur	31	63	94
GKR	**407**	**468**	**875**

Source : Secondary data collected by KSSP

Table 2.10.18

District-wise Number of ITIs and Seat Strength in GKR (as on Dec.1998)

District	Number of Institution			Seat Strength		
	Govt. ITI	Pvt. ITI	Total	Govt. ITI	Pvt. ITI	Total
Alappuzha	2 (1)	46 (46)	48	712	5868	6580
Ernakulam	2 (1)	54(54)	56	928	6990	7918
Idukki	1 (0)	8 (8)	9	224	760	984
Kottayam	2 (2)	30 (30)	32	1152	2864	4016
Pathanamthitta	1 (1)	31 (31)	32	176	2916	3092
Thrissur	3 (2)	30 (30)	33	1116	2884	4000
GKR	**11 (7)**	**199 (199)**	**210**	**4308**	**22282**	**26590**

NCVT : National Council for Vocational Training
Value in ( ) indicates the it is afficiated to NCVT. All Pvt. it is are afficiated to NCVT
Source : Secondary data collected by KSSP

Table 2.10.19

District wise Number of Teachers Training Institutes in GKR : 1987 - 1993

District	No. of Training Schools	No of Trainees in the School					
		1987-88	**1988-89**	**1989-90**	1990-91	1991-92	**1992-93**
Alappuzha	9	771	728	644	631	622	622
Ernakulam	14	1114	1093	919	1029	1021	1021
Idukki	2*	119	157	183	199	217	217
Kottayam	10	814	775	654	749	742	742
Pathanam-thitta	12	831	834	810	903	857	857
Thrissur	9	690	683	557	674	607	607
GKR	**56**	**4339**	**4270**	**3767**	4185	4066	**4066**

Number of training schools are 3 with effect from year 1989
Source : Secondary data collected by KSSP

Table 2.10.20

District-wise Number of Arts and Science Colleges in GKR : 1968 to 1998

District	1968-69	1990-91	1991-92	1992-93	1996-97	1997-98
Alappuzha	13	11	11	11	12	12
Ernakulam	15	24	24	24	25	25
Idukki	-	5	5	5	8	8
Kottayam	19	21	21	21	21	21
Pathanamthitta	-	8	8	8	9	9
Thrissur	13	20	20	20	20	20
GKR	60	89	89	89	95	95

Source : Secondary data collected by KSSP

Table 2.10.21

District-wise Number of Students (1-10)

District	1993-94		1994-95		1996-97		1998-99	
	Total	% Girls	Total	% Girls	Total	% Girls	Total	% Girls
Alappuzha	127499	49.2	337435	49.1	321346	49.0	306463	49.0
Ernakulam	180559	48.8	474703	49.6	449100	49.6	429351	49.6
Idukki	72938	48.2	182505	48.6	172455	48.7	160735	48.5
Kottyam	125237	48.6	316799	49.3	301489	49.3	288635	49.4
Pathanamthitta	78288	49.2	202314	49.1	192649	49.1	185700	49.0
Thrissur	216029	48.8	518261	49.3	502734	49.3	490103	49.4
GKR	**800550**	**48.8**	**2032017**	**49.3**	**2139773**	**49.3**	**1860981**	**49.3**

District	1996-97 (SC)		1997-98(SC)		1998-99 (SC)		1994-95 (ST)		1996-97 (ST)		1997-98 (ST)		1998-1999 (ST)	
	Total	% Girls	Total	% Girls	Total	% Girls	Total	% Girls	Total	% Girls	Total	% Girls	Total	% Girls
Alappuzha	36293	48.1	34772	48.2	33323	48.2	611	44.3	626	46.3	629	44.3	719	46.2
Ernakulam	46144	49.2	44611	49.1	43094	48.9	1493	44.4	1444	45.8	1775	45.2	1937	44.3
Idukki	28123	49.3	26476	48.8	26193	49.1	8160	48.1	7589	47.5	7163	48.4	6818	47.5
Kottyam	28286	48.4	27222	48.6	26106	49.0	3848	49.4	3593	47.9	3387	49.4	3132	49.3
Pathanam-thitta	32969	48.7	31881	48.3	30148	48.4	1329	51.2	1137	50.4	1101	49.4	965	48.5
Thrissur	66301	49.1	64738	49.5	63557	49.1	1091	53.1	1355	50.5	1213	58.5	1128	55.7
GKR	238116	48.8	229700	48.9	222421	48.8	16532	48.5	15744	47.8	15268	49.0	14699	48.1

Table 2.10.22

District-wise Number of Students in Arts and Science Colleges in GKR

District	Year		
	1968-69	1992-93	1996-97
Alappuzha	14376	30707	27122
Ernakulam	19708	46016	43389
Idukki	-	5936	6749
Kottayam	24483	49273	45993
Pathanamthitta	-	21658	18848
Thrissur	14473	34413	32880
GKR	**73040**	**188003**	**174981**

Source : Secondary data collected by KSSP

Table 2.10.23

District-wise and Year-wise Total Number of Teachers in Schools in GKR

District	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
Alappuzha	12767	12669	12711	12401	12200	11971
Ernakulam	18070	17733	17083	17439	17171	5935
Idukki	6667	6720	6491	6583	5963	6427
Kottayam	13332	13081	12700	12487	12053	11872
Pathanamthitta	8801	8544	8318	8233	8107	8079
Thrissur	18395	18269	17996	17642	17533	17447
GKR	**78032**	**77016**	**75299**	**74785**	**73027**	**61731**

Source : Secondary data collected by KSSP

Table 2.10.24

District-wise and Year wise Details on the No. of School Teachers in GKR

District	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
	1994-95			1995-96			1996-97			1997-98			1998-99		
Alappuzha	2702	8761	11463	2266	8753	11019	2590	8498	11088	2534	8682	11216	2301	8046	10347
Ernakulam	3758	12696	16454	3458	12609	16067	3446	12417	15863	3413	12371	15784	3220	12270	15490
Idukki	2236	3954	6190	2134	3902	6036	2065	3945	6010	1918	3827	5745	1828	3906	5734
Kottayam	2953	8643	11596	2715	8526	11241	2634	8535	11169	2575	8564	11139	2488	8303	10791
Pathanam-thitta	1863	6063	7926	1812	6001	7813	1703	5923	7626	1513	5927	7440	2550	12453	15003
Thrissur	3335	13739	17074	3171	13600	16771	3060	13726	16786	2953	13526	16479	2822	13704	16526
GKR	**16847**	**53856**	**70703**	**15556**	**53391**	**68947**	**15498**	**53044**	**68542**	**14906**	**52897**	**67803**	**15209**	**58682**	**73891**

Table 2.10.25

District-wise Total Number of Teachers in Arts and Science Colleges (1973-74 to 1996-97)

District	1973-74	1992-93	1996-97
Alappuzha	845	1045	1005
Ernakulam	1081	1885	1811
Idukki	78	218	248
Kottayam	1141	1991	1919
Pathanamthitta	-	844	825
Thrissur	763	1346	786
GKR	**3908**	**7329**	**6594**

Source : Secondary data collected by KSSP

Table 2.10.26

District-wise Important Rates in GKR during the yeras 1958 and 1993

No. per 1000 Population

District	Birth Rate		Death Rate		Infant Death Rate	
	1958	1993	1958	1993	1958	1993
Alappuzha	22.32	13.16	6.30	5.85	34.35	11.15
Ernakulam	-	16.45	-	5.65	-	12.25
Idukki	-	13.26	-	3.86	-	9.16
Kottayam	27.02	15.93	6.86	6.04	40.43	9.06
Pathanamthitta	-	15.06	-	6.45	-	7.69
Thrissur	21.55	18.28	6.86	6.40	49.03	12.90
GKR	**23.63**	**15.36**	**6.67**	**5.71**	**41.27**	**10.37**

Source : Secondary data collected by KSSP

Table 2.10.27

District wise Child Mortality Rate (1991)

No. per 1000 births

District	Probability of Dying upto the Age		
	1 Year	2 Year	5 Year
Alappuzha	25	33	45
Ernakulam	32	37	48
Idukki	57	67	74
Kottayam	28	30	52
Pathanamthitta	27	22	39
Thrissur	29	39	47
GKR	33	38	50.8

Source : Secondary data collected by KSSP

Table 2.10.28

District wise Proportion of Married Females in Selected Age Groups (1991)

District	% Married Females to Total Females in the Age Group						
	10-14	15-19	20-24	15-44	60-69	70-79	80+
Alappuzha	0.3	3.8	44.9	61.0	47.9	25.2	13.0
Ernakulam	0.7	3.5	40.7	60.0	51.2	31.5	18.6
Idukki	0.5	5.5	51.0	63.5	60.2	47.1	28.0
Kottayam	0.4	2.5	39.2	59.6	60.4	38.7	21.9
Pathanamthitta	0.4	3.6	50.5	64.9	60.0	38.6	19.5
Thrissur	0.6	7.6	50.6	61.2	44.4	24.5	14.4
GKR	**0.5**	**4.4**	**46.2**	**61.7**	**54.0**	**34.3**	**19.2**

Source : Secondary data collected by KSSP

Table 2.10.29

District-wise Spatial Distribution of Medical Institutions and Beds under Allopathy (1997-98)

District	No. of Medical Institutions		No. of Beds		No. of beds/ Lakh of Population
	1997	1998	1997	1998	1998
Alappuzha	90	90	4006	4016	201
Ernakulam	116	117	4038	4137	147
Idukki	64	63	840	840	78
Kottayam	84	85	3354	3378	185
Pathanamthitta	63	64	941	962	81
Thrissur	122	122	4119	4119	150
GKR	**539**	**541**	**17298**	**17452**	**149.8**

Source : Secondary data collected by KSSP

Table 2.10.30

Medical Institutions and Beds in GKR Category-wise 1998

District	Hospitals		PHCs + MCH		CHC		Dispensary		T.B. Clinics		Others
	No.	Beds	No.	Beds	No.	Beds	No.	Beds	No.	Beds	
Alappuzha	12	3442	67	266	6	232	2	-	2	76	-
Ernakulam	22	2991	80	643	8	395	3	68	4	40	-
Idukki	3	328	55	374	3	138	1	-	1	-	-
Kottayam	13	2501	64	451	6	366	-	-	2	60	-
Pathanam-thitta	7	518	52	257	3	175	1	-	1	12	1
Thrissur	19	3405	88	469	7	239	5	6	1	-	2
GKR	76	13185	406	2460	33	1545	12	74	11	188	3

CHC - Community Health Centres; Others - Leprosy Control Clinic/ Units/ Leprosy Sanitorium

Table 2.10.31

District-wise No. of Medical and Paramedical Personnel under DHS (1998)

Personnel	Alppuzha	Ernakulam	Idukki	Kottyam	Pathanam-thitta	Thrissur	GKR
Medical Offices	256	388	122	234	144	305	1449
Dentists	6	9	3	5	4	8	35
Senior Nurses	161	224	26	145	42	220	818
Junior Nurses	553	414	104	460	127	511	2169
Lady Health Inspectors	71	74	58	46	44	99	392
Pharmacists	134	154	64	108	79	160	699
Junior Health Inspectors	213	268	222	211	184	328	1426
Health Inspectors	53	65	54	51	43	79	345

DHS : Directorate of Health Services
Source : Secondary data collected by KSSP

Table 2.10.32

District wise Number of Private Medical Institutions and Doctors in GKR (1986 & 1995)

District	System of Medicine									
	Allopathy		Ayurveda		Homeopathy		Others		Total	
	Institutions	Doctors	Institutions	Doctors	Institutions	Doctors	Institutions	Doctors	Institutions	Doctors
1986										
Alappuzha	392	533	301	322	224	229	3	3	920	1087
Ernakulam	436	1110	365	387	371	389	3	3	1175	1889
Idukki	194	291	98	93	72	71	4	4	368	459
Kottyam	376	643	398	429	327	344	5	6	1106	1422
Pathanamthitta	231	459	178	185	104	109	1	1	514	754
Thrissur	256	598	592	600	137	138	12	12	997	1348
GKR	**1885**	**3634**	**1932**	**2016**	**1235**	**1280**	**28**	**29**	**5080**	**6959**
1995										
Alappuzha	367	650	346	384	328	355	9	11	1050	1400
Ernakulam	542	1768	406	450	444	496	25	31	1417	2745
Idukki	239	380	180	200	123	127	13	13	555	720
Kottyam	474	1041	501	554	440	486	17	18	1432	2099
Pathanamthitta	257	642	187	212	167	186	17	20	628	1060
Thrissur	288	984	455	541	171	183	30	36	944	1744
GKR	2167	**5465**	**2075**	**2341**	1673	**1833**	**111**	**129**	**6026**	**9768**

Table 2.10.33

District-wise Distribution of Institutions Beds and Patients Treated
Under Ayurvedic/Homeopathic System of Medicine in GKR (1997 & 1998)

District	No. of Hospitals		No. of Beds		No. of Dispensaries		Total No. of Institutions		Total No. of Patients Treated In 1998		Total No. of Doctors
	1997	1998	1997	1998	1997	1998	1997	1998	Inpatients	Outpatients	
Ayurvedic System of Medicine											
Alappuzha	10	10	180	180	45	46	55	56	1296	596238	69
Ernakulam	13	13	230	230	51	51	64	64	3460	883322	80
Idukki	3	3	110	110	28	29	31	32	1286	825049	48
Kottyam	8	8	150	150	36	36	44	44	1151	1223258	58
Pathanamthitta	4	4	80	80	35	36	39	40	354	1046786	50
Thrissur	14	14	243	243	71	72	85	86	3217	1101202	104
GKR	52	52	993	993	266	270	318	322	10764	5675855	409
Homeopathic System of Medicine											
Alappuzha	3	3	75	75	35	35	38	38	811	1012433	41
Ernakulam	3	3	75	85	44	44	47	47	865	1083509	50
Idukki	2	2	50	50	28	28	30	30	2410	101508	32
Kottyam	3	3	175	175	38	38	41	41	2612	1332923	48
Pathanamthitta	1	1	25	25	21	21	22	22	-	388325	22
Thrissur	1	1	25	25	33	33	34	34	361	594479	35
GKR	**13**	**13**	**425**	**435**	**199**	**199**	**212**	**212**	**7059**	**4513177**	**228**

Table 2.10.34

District-wise Number of Family Welfare Centres (1998)

District	Rural Main Centres (PHC, CHC)	Sub Centres
Alappuzha	69	368
Ernakulam	86	351
Idukki	58	231
Kottayam	69	359
Pathanamthitta	53	260
Thrissur	95	492
GKR	**430**	**2061**

Source : Secondary data collected by KSSP

2.11 Distributive Resources

2.11.1 Water Supply

2.11.1.1 Domestic and Livestock Water Requirements

The domestic water requirements were calculated for each individual river basin considering the present population and the projected population of 2025 AD. **Table 2.11.1** gives the water requirement for domestic purposes at a per capita requirement rate of 20 lpcd.

Based on the estimates of Kerala Water Authority, only 40% of the rural population in the area is at present provided with protected water supply. A survey carried out by CWRDM indicates that almost 60% of the population in the urban areas is also provided with protected water supply. The National Water Policy of 1987 and the State Water Policy of 1992 clearly states that all the existing and future reservoirs - both irrigation and hydel - should have drinking water supply component.

So far as Kerala is concerned, in addition to the Aruvikkara and Peppara reservoirs, which were built for water supply alone, only Malampuzha and Peechi have drinking water component, i.e., only 4 out of the more than 30 reservoirs. None of the reservoirs in GKR study area has this component. Perhaps, the cheapest, best and the only long-term solution to meeting most of the domestic and industrial water needs in the future is to draw water from all existing and future reservoirs. Details of water supply schemes in the study area basin wise are given in **Table 2.11.2** alongwith the present and future (2025 AD) water requirements for the livestock population in the river basins; the figures recommended by Kerala Agricultural University (1997) have been adopted for computation of water demand.

2.11.1.2 Irrigation Water Requirement

From the statistics on the area irrigated, the present utilization of water for irrigation purposes was estimated. Most of the minor irrigation projects in the midland and lowland region while only 50% of the projects in the highland cater to rice cultivation. Details of minor irrigation schemes in the districts of Trissur, Ernakulam, Kottayam, Alappuzha and Pathanamthitta are given in **Table 2.11.3**. It is assumed that 25% of the irrigation water already being utilized is available as return flow. The monthly Et0 values for different river basins with the existing cropping pattern are furnished in **Table 2.11.4**

The crop coefficients for common crops grown in this area are given in **Table 2.11.5.** Experiences in the humid tropical region indicate that even a cropping system scientifically designed for this area will require much more water than what is estimated for the present cropping system. In a State like Kerala, the plantation/spice crops form the backbone of farming activity and therefore, not only rice crop but also these crops require irrigation facilities. Statistics on the year wise area under crops in Kerala show that, in particular, rice cultivation is systematically decreasing while rubber cultivation is increasing.

The trend is shown in **Fig 2.11.1**. The present and future water requirements for irrigation are presented in **Table 2.11.6** The maps showing the landuse, prepared using the satellite data, for the river basins of Muvattupuzha, Meenachil, Manimala, Pamba and Achencoil are given in **Figs. 2.11.2-2.11.6. Table 2.11.7** gives the climatic water balance for the river basins in different physiographic regions.

2.11.1.3 Industrial Water Requirement

Industrial water requirements of different river basins are furnished in **Table 2.11.8**. A basinwise water demand for industries was arrived at from the available information and through discussion with certain industries. Even though the projection of industrial growth in this area could not be done based on an incremental increase method, it is assumed that the manufacturing sector may increase in size and output by around 300% in 25 years. In the present case, 300% increase rate is taken for the period ending in 2025 AD. This may be possible in the area, considering the infrastructural facilities like the major sea port at Kochi, intermediate port at Alappuzha and international airport at Nedumbassery as well as the development of coastal railway, doubling of the railway lines, electrifying activities of the Indian Railways, development of National Highways, introduction of National Waterway No.3, etc.

Further the Government of Kerala has requested the assistance of the World Bank for the improvement of Inland Water Transport on three selected feeder canals in the Vembanad Estuary viz., Alappuzha – Kottayam, Alappuzha – Changanassery and Kottayam – Vaikom. The Thermal Power Plant at Kayamkulam also will be a boon for the industrial growth in this area. The present economic policies of the Govt. of India and the initiatives of the NRI is of the State are expected to drastically change the industrial climate in the coming years and also the water requirement. .

2.11.1.4 Water for Energy

The Kerala State Electricity Board has proposed few hydroelectric projects in the study region for the Ninth Plan period, the details of which are given in **Table 2.11.9**. These projects are in addition to the already existing major projects. Though hydel power generation is a non-consumptive use, the implementation of these small projects will bring about changes in the spatial and temporal distribution of water. In formulating, executing and operating these projects, the downstream requirements within the basin and in the wetland system may have to be given due weightage.

2.11.2 Transportation

2.11.2.1 Road Transport

The transportation resources are estimated on the basis of the road length and number of motor vehicles. The growth trends in the above two aspects are also included.

The district-wise length of PWD roads such as State Highways, major district roads, other district roads and village roads is given in **Table 2.11.10** From 1980-81 to 86-87, the total length of PWD roads increased from 7540 km to 9320 km and from 1986-87 to 1992-93, it further increased to 9541km. Between 1980-81 and 1986-87, the total road length in GKR marked an increase of 1780 km. But between 1986-87 and 1992-93, the increase was only 221 km. From 1992-93 to 1997-98, the total road length increased from 9541 km to 10143 km with an increase of 602 km.

Out of the total road length (10143 km), state highways contribute to - 22.16% major district roads - 46.57%, other district roads - 24.09% and village roads contribute remaining 7.18%.

Table 2.11.11 shows the type of material of construction wise length of roads under PWD in the years 1992 and 1993. The types of roads include cement concrete, black topped, water bound mecadam and others. In 1992, the total length of all the above types was 9504 km, which increased marginally (by 27 km) to 9531 in 1993. In all the districts, the local administrative bodies such as Panchayats maintain some roads. The types of roads maintained by panchayats include black topped and metalled, graveled and earthen. The total length of these types in GKR comes to around 43421 km. (**Table 2.11.12**).

Number of registered vehicles in different categories in each district of GKR is given in **Table 2.11.13** for different years. Further increase in number of vehicles and road lengths in each district during the period 1987-88 to 1991-92 and 1991-92 to 1997-98 is summarized in **Table 2.11.14**. From 87-88 to 91-92, the total number of vehicles increased by 1,21,555, whereas during the same period, the increase in the road length of main roads (maintained by PWD) is only 77 km.

In Idukki district there appears to be reduction of 100 km in the total road length maintained by PWD, excluding this district, for the other districts, the total increase in road length is 177 km for an increase of 119038 vehicles. Thus for the GKR as a whole, the average increase in the number of vehicles per km is 673. Increase in total number of vehicles is maximum in Ernakulam (40825) and minimum in Alappuzha district (12690). In Ernakulam district, for 1 km increase, the increase in the number of vehicles is 1237, whereas in Alappuzha district, the same is 343 vehicles per km. This means that to maintain at least the GKR average in this respect, the total road length in Ernakulam district should have been doubled.

From 1991-92 to 1997-98, the total number of vehicles increased from 336876 to 763122 in GKR, with a net increase of 426246 for an increase of 638 km road lengths.

During the period from 1991-92 to 1997-98 also, the increase in the total number of vehicles is maximum in Ernakulam district, but along with that the road length also recorded the highest increase of 262.84 km. During the same period Thrissur district recorded a maximum increase of 4181 vehicles per km and Idukki recorded a minimum increase of 68 vehicles per km.

The above comparison shows that the ratio between the increase in number of vehicles and road length for a given period of time varies in a random manner. This random variation can be seen in the rate of growth of vehicles in different districts for 1996-97 and 1997-98. In 1996-97, Alappuzha recorded a growth rate of 12.22%, which in 1997-98 was 21.24%. Similarly in Idukki district, the rate of growth of vehicles was 15.53% in 1996-97, but during 1997-98 it was reduced to 8.8% (**Table 2.11.15**).

2.11.2.2 Water Transportation

Inland Water Transport

Transport system is one of the most important infrastructure facilities required for the economic development of a country. The major modes of transport are Roadways, Railways, Airways and Inland Waterways of which Inland Waterways require minimum investment. It is estimated that the initial investment required for provision of 1 km of track is twice in the case of roads than that of water and nearly 4 -5 times higher in the case of rail transport.

So far as Kerala is concerned, the allocation for inland water transport in the State's five-year plans were negligible. It is about 2-4 percent of the outlay for Transport and Communications in almost all the plans. The inland water system in Kerala carried as much as 6.3 lakh MT of freight traffic in the year 1995-96. As the passenger traffic is concerned, it is estimated that in the year 1995 mechanised vessels alone of both private and public sectors carried more than 20 millions passengers, which decreased to about 3.0 millions in the year.

Traffic projections for the waterways based on the available records for the coming 15 years will be as follow assuming that the canals will be developed:

Particular	Years			
	1995	2000	2005	2010
Passengers (in lakhs)	202.7	300.0	310.0	325.0
Cargo (in lakh MT)	6.3	7.5	9.0	12.0

Source: NATPAC. Dept. of Irrigation and Inland Water Authority of India

Inland Water System of Kerala

In Kerala, the canal system can be broadly classified into:

- The interior coastal system consisting of the West Coast Canal from Trivandrum to Cochin and extended upto Badagara by means of Cochin-Ala-Ponnani-Badagara canal system. Beyond the missing link between Badagara and Kattampalli in the north, another canal system partly along the coast exists from Kattampalli to Hosdurg

- The inland canal system consisting of a number of link canals mostly in South Kerala connecting the towns of the midland and the coastal regions

41 west flowing rivers together with the backwaters and artificial canals form an integral part of the inland navigation system in Kerala. The total length of West Coast Canal is about 560 km including the length of nearly 48km between Azheekkal and Badagara where there is no existing canal. 83km long Vembanad Lake constitutes the centre of these inland waterways. The West Coast canal and the navigable rivers provide arterial waterways routes north to south and east to west similar to National and State Highways.

West Coast Canal

The continuous canal from Trivandrum to Badagara and from Kattampalli to Hosdurg is known as West Coast Canal. The division of canal is given in **Table 2.11.16**.

Government of India has been giving importance to the development of waterways in recent years. The Inland Water Authority was constituted in 1986 to take up the development of inland waterways in the country. The Kollam-Kottappuram section of the West Coast Canal has already been declared as National Waterway III (**Fig. 2.11.1**) and the Inland Water Authority is responsible for development of this stretch. The proposals under consideration of the IWAI are as follows:

Keeping in view, the physical constraints and the size of vessel that can ply in the waterway, the channel has been designed with dimensions of 32 m widths between two lines, 2 m depth below chart datum and side slopes of 1:2.5 in closed reaches. In wider reaches, the channel width of 38 m between two lines with depth of 2.15 m below chart datum and side slopes of 1:5 has been recommended keeping in view the higher rate of siltation. A minimum radius of 250 m is suggested at all bends with necessary additional widths for free manouverability of the vessel.

A total dredging material quantity of about 3.73 million m^3 is estimated for development of the design channel and the material can be removed using cutter suction dredgers and manual dredging. Bank protection works such as pitching in wider reaches and vertical piling supporting concrete slabs are recommended in narrow canal reaches. Suitable aids to navigation to demarcate the channel are also provided.

The traffic forecasts and channel constraints dictate the vessel design. The following two types of vessels are considered as design vessels for the channel. However, the actual vessels plying can have one or more different features within the overall limits.

Vessel Type	Length (m)	Beam (m)	Depth (m)	Draft (m)	Capacity (MT)
Self Propelled	50	8.5	2.1	1.5	350
Flotilla (push tug + 4 dumb barges)					
Push tug	15	4.25	2.0	1.4	4x100
Dumb barge (each)	26.5	4.20	2.0	1.5	100

Sixteen IWT terminals with necessary infrastructure were proposed, with basic criteria of reaching 1.2lakh tónnes traffic by 2009-10 at each terminal.

The proposed terminals are located at Kottapuram, Cochi Port area (1 General Cargo + 1 Container Cargo) Ernakulam, Aluva, C.E.P.Z., Ambalamugal, Vaikom, Chertala, Alappuzha (1 General Cargo + 1 POL) Thrikunnapuzha, Kayamkulam, Chavara, Kollam (1 General Cargo + 1 POL). The total traffic / load to be carried through these terminals are given in **Table 2.11.17**.

The capital cost has to be incurred in four phases. The details of capital costs to be incurred phase-wise for the waterway, terminal and fleet for two different recommended combinations of fleet are given in **Table 2.11.18**.

In the proposed National Waterway, it is envisaged that while the Government (IWAI) would shoulder the responsibility of developing the waterway and construction of terminals, the operation of cargo-fleet would be carried out by private agencies/state or co-operative bodies. The investment in waterway development and terminals is estimated to be Rs. 65.34 crores as detailed in **Table 2.11.19**.

2.11.2.2.1 Improvement of Feeder Canals

The Government of Kerala has requested the assistance of the World Bank for the improvement of inland water transport of three feeder canals in Kerala all of which fall in GKR study region, as a pilot project. The main developments envisaged in this project are improvements in the feeder canals in the Alappuzha - Kottayam districts connecting with the National Waterway system. The feeder canals selected for improvement by dredging, provision of navigational aids, bank protection works, safety measures and encouragement of public and private sectors to use the waterways for navigation are:

Sr. No.	Waterways	Feeder Canal	Length (km)
1.	Alappuzha - Kottayam	AK canal	32
2.	Alappuzha - Changanassery	AC canal	32
3	Kottayam - Vaikom	KV canal	40

The alignment of these canals is shown in **Fig. 2.11.2**. M/S Louis Berger International Inc are undertaking the design of this project with the major objectives of this pilot project:

- To promote greater use of the natural resources of inland waterways in Kerala, as an integral part of the State's transport network with private sector and community participation and
- To use the experience gained through the pilot project for preparing a master plan for the revival of the inland water transport sector in the State.

The proposal improvement works may include:

- Widening to ensure the minimum required width,
- Dredging and removing obstructions,
- Easing of any sharp curves,
- Improvement of side protection on both the banks,
- Rebuilding of bridges that have inadequate vertical clearances for vessels to pass and removal of old bridges/remnants of other structures, and
- Rehabilitation of old jetties, if required and construction of new jetties

The earlier studies on inland waterways in Kerala focussed on the development and traffic projections of National Waterway III without recognizing the development and traffic needs on the feeder canals. Based on the existing information, the passenger traffic projection upto 2025 for the three feeder canals has been projected and summarized in **Table 2.11.20** alongwith the commodity flow.

A preliminary assessment of the benefits accruing of from the scheme is based on the assumption that full utilization of the waterway will be made for cargo movements from commercial hinterlands Alappuzha, Changanassery, Kottayam, Idukki and Kochi. Other than direct benefits, the additional generation of jobs potential to agricultural labourers, boat builders, carpenters, mazdoors, etc are the indirect benefits. It has tremendous tourist potential also.

2.11.3 Communication Resources

The secondary data relating to the details on the post offices and telephone connections form the data on the communication resources for the years 1958-59, 1993 and 1996-97 are summarized in **Table 2.11.21** for all the districts under GKR. In 1958-59, the total number of all the categories of post offices in GKR was only 799, which increased to 2298 by the years 1996-97, registering an average growth of 5% per year in GKR during the last 40 years registering.

Details on the area and population served by one post office in all the districts is given in **Table 2.11.22** in GKR. The average area served by one post office is 7.65 km^2 and population served by one post office is 5705.5. In

Alappuzha district, 4.88 km^2 area is served by one post office and in Idukki this comes to 16.67 km^2. The maximum number of population served by one post office is 7969 in Ernakulam district and the minimum value in this respect is 3876 in Idukki district.

Regarding the telecommunication sector, the total number of telephone connections in GKR as per 1994 data was 219188, which included Alappuzha district - 23512, Ernakulam district - 86439, Idukki District - 11969, Kottayam district - 39953, Pathanamthitta district - 18494 and Thrissur district - 38821. This has increased to 490396 in 1998 with an increase of 123.7% within a period of four years. The average increase in the number of connections per year is 31%. As per 1997-98 data, the maximum number of working connections are in Ernakulam district whereas lowest are in Idukki district.

The total number of telephone exchanges in GKR is 357. This number varies from 39 in Alappuzha to 87 in Ernakulam. The equipped capacity is maximum in Ernakulam district (215412) and the same is lowest in Pathanamthitta district (76826). The number of telephone connections per sq. km. is 29 in GKR. It varies from 5 in Idukki to 54 in Ernakulam. The number of telephones per thousand populations varies from 25 in Idukki to 77 in Pathanamthitta. District wise details of tele-communication sector are furnished in **Table 2.11.23**.

2.11.4 Energy Supply

Present status of power transmission is given in **Table 2.11.24**. There is only one 400 KV substation with no lines whereas 2200 numbers of 11 KV system with 2000 lines CKM. There is no substation with LT system. In year 1961, the only 20% of the villages were electrified. The total electrification of the villages occurred in 1980-81. The number of distribution transformers increased from 14015 in 1986-87 to 25940 in 1996-97. The length of HT lines and LT lines increased tremendously from 1067 km to 23455 km for HT lines and 992 km to 119935 km for LT lines. Due to increase in infrastructure and other facilities the per capita consumption increased from 13 KWH in 1951 to 211 KWH in 1994. Annual revenue rose from 0.58 crore in 1957 to 548 crores in 1994, indicating continuous consumption of power.

Details of power transmission and distribution network with respect to T&D lines, step up & step down transformers, number of villages electrified and pump sets used are summarized in **Table 2.11.25** for Kerala since 1980-81. A continuous growth has been observed in all the parameters. T&D lines, number of step up, step down and distribution transformers, number of pump sets energized have increased by about 2.3, 1.7, 2.8, 3.0 and 3.6 times respectively over a period of 17 years (1980 to 1997). All the villages in Kerala are electrified.

Length of distribution lines continually increased from 1961 to 1997 for all categories except for 33 KV, 22 KV and 3.3 KV lines. Increase in EHT & HT CKM ranged from 300% to 500%, whereas there was a sharp increase of around 1500% in LT lines. The details of the transmission and distribution lines are summarized in **Table 2.11.26** for different capacity substations in Kerala.

Table 2.11.1

Basin wise Present and Projected Annual Water Demand

Basin	Domestic (Mm^3)		Live stock (Mm^3)	
	Present	Projected	Present	Projected
Chalakkudy	51.31	72.38	3.36	5.10
Periyar	247.33	349.40	11.90	21.8
Muvattupuzha	142.88	183.07	6.53	7.48
Meenachil	93.78	117.17	4.69	6.06
Manimala	61.83	87.35	2.73	4.05
Pamba	90.01	107.94	4.86	6.70
Achencoil	101.74	128.10	4.99	7.74
Total	**788.88**	**1045.41**	**39.06**	**58.93**

Source : Secondary data collected by CWRDM

Table 2.11.2

River Basin wise Water Supply Schemes

River Basin	Status of Schemes	Number of Schemes	No. of Villages/ Towns Benefited
Chalakkudy	Existing	7	24
	Ongoing	2	2
	Proposed	7	16
	Total	**16**	**42**
Periyar	Existing	27	54
	Ongoing	6	6
	Proposed	15	29
	Total	**48**	**89**
Muvattupuzha	Existing	16	33
	Ongoing	7	10
	Proposed	18	38
	Total	**41**	**81**
Meenachil	Existing	23	54
	Ongoing	9	22
	Proposed	10	22
	Total	**42**	**98**
Manimala	Existing	12	40
	Ongoing	2	4
	Proposed	5	11
	Total	**19**	**55**
Pamba	Existing	12	13
	Ongoing	13	18
	Proposed	10	14
	Total	**35**	**45**
Achencoil	Existing	13	14
	Ongoing	3	9
	Proposed	8	23
	Total	24	46

Table 2.11.3

District wise Details of Minor Irrigation Schemes

District	Type of Scheme	No. of Schemes	Area Irrigated (ha)	
			Net	Gross
Alappuzha	Class I	59	7708	11563
	Class II	806	19036	19036
	Lift Irrigation	12	698	1047
	Integrated Paddy Development	153	5491	5491
	Total	**1030**	**32933**	**37137**
Eranakulam	Class I	24	2399	3276
	Class II	755	7083	7083
	Lift Irrigation	148	13861	20792
	Integrated Paddy Development	79	234	234
	Community Irrigation	7	196	196
	Total	**616**	**23773**	**31581**
Kottayam	Class I	29	3426	5110
	Class II	538	7241	7241
	Lift Irrigation	11	408	612
	Integrated Paddy Development	31	980	980
	Community Irrigation	7	196	196
	Total	**616**	**12251**	**14139**
Pathanamthitta	Class I	20	1015	1523
	Class II	578	6806	6809
	Lift Irrigation	37	2064	3096
	Integrated Paddy Development	55	693	693
	Community Irrigation	2	32	32
	Total	**692**	**10610**	**12150**
Thrissur	Class I	14	1547	2321
	Class II	272	3732	3732
	Lift Irrigation	67	5523	8284
	Integrated Paddy Development	61	825	825
	Community Irrigation	29	982	982
	Total	443	12609	16144

Source : Secondary data collected by CWRDM

Table 2.11.4

Monthly Et_0 Values for Different River Basins

Month → Basin ↓	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Chalakkudy	170	179	219	215	177	125	118	133	133	149	153	171
Periyar	177	181	245	218	178	119	124	137	133	152	149	172
Muvattu-puzha	159	128	162	160	162	148	149	153	150	148	143	152
Meenachil	201	211	245	224	194	132	135	148	156	168	152	168
Manimala	241	117	222	212	213	210	206	238	236	232	179	235
Pamba	203	195	195	166	162	121	136	148	135	191	183	212
Achencoil	256	196	230	217	187	169	167	182	179	189	179	204

Table 2.11.5

Crop Coefficient (Kc) of Important Crops of the Region

Crop	Paddy	Coco-nut	Banana	Tapioca	Vege-tables	Sugar-cane	Tea	Coffee	Pulses	Cocoa	Carda-mom
Kc	0.95-1.15	0.75	0.40-0.85	0.40	1.00	0.55-1.05	1.00	0.90	1.00	1.00	1.00

Table 2.11.6

Basin-wise Annual Irrigation Water Requirement

River Basin	Present utilisation (Mm^3)	Demand in 2025 AD (Mm^3)
Chalakkudy	318	854
Periyar	1700	3525
Muvattupuzha	647	1196
Meenachil	436	875
Manimala	419	980
Pamba	945	1185
Achencoil	430	1175

Source : Secondary data collected by CWRDM

Table 2.11.7

Basinwise Climatological Water Balance

River Basin	Status	Zone		
		Low Land	Mid Land	High Land
Chalakkudy	Surplus	Jun-Dec	May-Nov	May-Nov
	Deficit	Jan-May, Nov-Dec	Jan-May, Nov-Dec	Jan-May. Nov-Dec
Periyar	Surplus	May-Nov	May-Nov	May-Dec
	Deficit	Jan-May, Nov-Dec	Jan-May, Nov-Dec	Jan-May, Nov-Dec
Muvattupuzha	Surplus	May-Oct	May-Dec	Apr-Nov
	Deficit	Jan-May, Oct-Dec	Jan-May, Nov-Dec	Jan-Apr, Nov-Dec
Meenachil	Surplus	Apr-Nov	Apr-Nov	Apr-Nov
	Deficit	Jan-Apr, Nov-Dec	Jan-Apr, Nov-Dec	Jan-Apr, Nov-Dec
Manimala	Surplus	May-Sep	May- Sep	Apr-Nov
	Deficit	Jan-May, Oct-Dec	Jan-May, Nov-Dec	Jan-Apr, Nov-Dec
Pamba	Surplus	Apr-Nov	May- Nov	May-Nov
	Deficit	Jan-Apr, Nov-Dec	Jan-Apr, Nov-Dec	Jan-May. Nov-Dec
Achencoil	Surplus	May-Nov	Apr-Nov	Apr-Nov
	Deficit	Jan-Apr. Nov-Dec	Jan-Apr, Nov-Dec	Jan-May, Nov-Dec

Source : Secondary data collected by CWRDM

Table 2.11.8

Annual Industrial Water Requirement of River Basins

River Basin	Present demand (Mm^3)	Demand in 2025 (Mm^3)
Chalakkudy	15	45
Periyar	250	750
Muvattupuzha	80	240
Meenachil	9	27
Manimala	5	15
Pamba	5	15
Achencoil	51	153
Total	415	1245

Source : Secondary data collected by CWRDM

Table 2.11.9

Details of Proposed Hydroelectric Schemes

Sr. No.	River basin	Scheme	Capacity
1	Chalakkudy	Poringalkuthu RB Extension	66 MW
2	Chalakkudy	Athirapally	163 MW
3	Chalakkudy	Anakayam	10 MW
4	Chalakkudy	Karappara -Kuriarkutty multipurpose project	84 MW
5	Periyar	Maduppetty small HEP	2 MW
6	Periyar	Azhutha diversion	57 MU
7	Periyar	Vadakkepuzha diversion	12 MU
8	Periyar	Lower Meenmutti	3.5 MW
9	Periyar	Sengulam augmentation	85 MU
10	Periyar	Sengulam tailrace	5 MW
11	Periyar	Pooyamkutty HE Project	240 MW
12	Periyar	Bhoothathankettu small HEP	16 MW
13	Periyar	Pallivasal rehabilitation scheme	60 MW
14	Periyar	Neriamangalam spillway utilization	30 MW
15	Periyar	Western Kallar small HE Scheme	5 MW
16	Muvattupuzha	Malankara small HE Project	10.5 MW
17	Muvattupuzha	Kuttiar diversion	37 MU
18	Meenachil	Vazhikkadavu diversion	24 MU
19	Pamba	Maniyar tailrace	5 MW
20	Pamba	Perunthenaruvi small HE Project	10 MW
21	Pamba	Sabarigiri augmentation scheme	24 MW
22	Pamba	Swami saranam scheme	2.76 MW
23	Pamba	Urumbani hydel scheme	21 MW
24	Pamba	Ullunkal small HE Project	7 MW
25	Achencoil	Achencoil hydel scheme	60 MW

Source : Secondary data collected by NEERI

Table 2.11.10

District-wise Length of P.W.D Roads

Year	Road Length (km)						
	Alappuzha	Ernakulam	Idukki	Kottayam	Pathanam -thitta	Thrissur	GKR
State Highways							
1980-81	102	186	371	288	-	186	1133
1987-88	112	179	328	257	173	202	1251
1991-92	113	146	238	257	176	212	1142
1997-98	136	302	899	410	188	314	2249
Major District Roads							
1980-81	243	801	507	651	-	490	2692
1987-88	123	795	540	677	458	502	3095
1991-92	123	862	512	683	449	470	3099
1997-98	461	962	194	1460	579	1068	4725
Other District Roads							
1980-81	832	724	434	856	-	671	3517
1987-88	573	927	373	918	665	721	4177
1991-92	652	922	393	909	727	754	4357
1997-98	469	875	268	153	535	143	2443
Village Roads							
1980-81	-	76	-	-	-	72	148
1987-88	142	36	378	122	154	73	905
1991-92	99	38	378	152	137	104	908
1997-98	102	94	342	85	67	38	728
Total							
1980-81	1257	1787	1312	1765	-	1419	7540
1987-88	950	1937	1619	1974	1450	1498	9428
1991-92	987	1970	1519	2001	1488	1540	9505
1997-98	1169	1036	2107	1702	2233	1563	10143

Source : Secondary Data Collected by KSSP

Table 2.11.11

District-wise Length of Roads Maintained by P.W.D

District	Road Length (Km)				
	Cement Concrete	Black Topped	Water Bound Mecadam	Others	Total
As on 1.4.1992					
Alappuzha	-	872.73	9.05	105.24	987
Ernakulam	0.57	1815.39	42.35	119.72	1970
Idukki	-	1008.09	54.82	456.08	1519
Kottayam	16.00	1861.86	26.10	96.74	2001
Pathanamthitta	0.80	1308.86	30.54	147.33	1488
Thrissur	3.39	1385.58	21.34	129.90	1540
GKR	**3.96**	**8252.51**	**184.2**	**1055.01**	**9504**
As on 1.4.1993					
Alappuzha	-	905.74	2.82	122.54	1031
Ernakulam	0.57	1874.50	16.95	67.01	1959
Idukki	-	1015.35	54.82	454.10	1524
Kottayam	16.00	1901.64	7036	49.11	1974
Pathanamthitta	0.80	1382.02	10.20	94.50	1488
Thrissur	3.39	1530.54	2.91	18.34	1555
GKR	**3.96**	**8609.79**	**7123.7**	**805.6**	**9531**

Source : Secondary Data Collected by KSSP

Table 2.11.12

Type of Roads Maintained by Different Panchayats is each District (as on 1.4.1992)

District	Road Length (km)			
	Black Topped and Metalled	Gravelled	Earthen	Total
Alappuzha	586	2938	2440	5964
Ernakulam	1086	2437	3840	7363
Idukki	215	245	5325	5785
Kottayam	361	1324	4191	5876
Pathanamthitta	212	2206	4730	7148
Thrissur	1521	3743	6021	11285
GKR	**3981**	**12893**	**26547**	**43421**

Source : Secondary Data Collected by KSSP

Table 2.11.13

District-wise Number of Different Category Registered Vehicles in GKR

Year	2-Wheelers	3-Wheelers	4-Wheelers	Buses	LCV	Total
Alappuzha						
1982-83	7075	723	8631	514	2006	19049
1987-88	14058	2074	10249	906	3311	30598
1991-92	21795	4414	11645	1014	4420	43288
1997-98	54828	9736	18714	1943	7640	92861
Ernakulam						
1982-83	17074	2738	14481	1172	6433	41898
1987-88	34627	4618	21010	1822	2703	74780
1991-92	61208	7538	27609	2447	16803	115605
1997-98	160892	19086	45882	5183	30332	261375
Idukki						
1982-83	1033	39	2849	245	1690	5856
1987-88	1802	241	5100	346	2473	9962
1991-92	3201	836	6464	554	2765	13819
1997-98	9267	2804	10146	1238	2759	26214
Kottayam						
1982-83	4299	1011	6437	734	3605	16086
1987-88	10260	3338	9016	1105	5151	28870
1991-92	20190	4900	11895	1528	6182	44695
1997-98	68449	17881	35823	4143	11884	138230
Pathanamthitta						
1982-83	277	1	1286	91	568	2223
1987-88	6474	1359	8074	469	4275	20651
1991-92	16339	3599	13820	594	5696	40048
1997-98	30527	6787	20419	1088	8306	67127
Thrissur						
1982-83	9614	1315	8519	1299	3963	24710
1987-88	21682	5739	13347	2182	7510	50460
1991-92	39187	11802	16789	2719	8924	79421
1997-98	103101	21384	28832	8530	15418	177265
GKR						
1982-83	39372	5827	42203	4055	18365	109822
1987-88	8903	17369	66796	6830	35423	215321
1991-92	161920	33089	88222	8856	44789	336876
1997-98	427114	77678	159816	22125	76339	763122

Goods Vehicles : Four Wheelers & Above and Three Wheelers Including Tempos
Buses . Stage Carriages, Contract Carriages/ Omni Buses
Cars & Station Wagons : Cars, Taxis and Jeeps; Three Wheelers : Autorikshaws
Two Wheelers : Motorised Cycles, Scooter and Motor Cycles
Tractors : Tractors, Tillers, Trailors, Tractors, Trailor Articlerated and others

Table 2.11.14

District-wise Increase in Number of Vehicles and Road length : 1987-1998

District	Increase from 1987-88 to 1991-92		Increase from 1991-92 to 1997-98	
	Vehicles (Nos.)	Road Length (km)	Vehicles (Nos.)	Road Length (km)
Alappuzha	12690	37	49573	182
Ernakulam	40825	33	145770	263
Idukki	2517	100	12395	183
Kottayam	15825	27	93585	33
Pathanamthitta	19397	38	27029	119
Thrissur	28961	42	97844	23

Source : Secondary data collected by KSSP

Table 2.11.15

District wise Growth Rate of Motor Vehicles

District	Rate of Growth (%S)	
	1996-97	1997-98
Alappuzha	12.22	21.24
Ernakulam	17.24	13.42
Idukki	15.53	8.80
Kottayam	18.10	17.02
Pathanamthitta	9.50	9.87
Thrissur	16.40	12.70

Table 2.11.16

Distribution of Canal Length in Different Areas

Sr. No.	Canal Section	Canal Length (Km)
1.	Hosdurg to Azheekkal	54.5
2	Azheekkal to Badagara (Includin uncut portion)	47.5
3.	Badagara to Kadalundy	72 4
4.	Kadalundy to Ponnani	61.3
5.	Ponnani to Ala	79.7
6.	Ala to Cochin	35.4
7.	Cochin to Alleppey	70.8
8.	Alleppey to Quilon	74.8
9.	Quilon to Trivandrum	62.0
10.	Total	558.4

Table 2.11.17

Growth Trend of Different Commodities and Future Projections

Sr. No.	Commodity	Commodity Flow (1000 MT)			
		1994-95	1999-00	2004-05	2009-10
1.	Food grains	63	35	113	151
2.	Mineral and Rare Earth	249	259	273	290
3.	Construction Materials	367	491	657	879
4.	Heavy goods	12	17	22	30
5.	Parcel and piece goods	532	711	952	1274
6.	Chemicals and Fertilizers	622	740	898	1109
7.	P O L	134	246	329	440
	Total	**1979**	**2549**	**3244**	**4173**

Source : Secondary data collected by CWRDM

Table 2.11.18

Phase wise Capital cost for Development of Water Ways

Sr. No.	Item	Phase I	Phase II	Phase III	Phase IV	Total
		1994-95	1999-00	2004-05	2909-10	
1.	Waterway	29.31	4.49	-	-	33.80
2.	Terminal	13.55	5.59	6.92	5.48	31.54
3.	Fleet (i)	28.58	8.24	10.90	13.68	61.40
4.	Fleet (ii)	32.88	9.40	12.41	15.68	70.37
	Total (i)	**71.44**	**18.32**	**17.82**	**19.16**	**126.74**
	Total (ii)	**75.74**	**19.48**	**19.33**	**21.16**	**135.71**

Source : Secondary data collected by CWRDM

Table 2.11.19

Activity wise Expenditure on Develoment of Waterways

Stage	Activity	Development Cost (Rs. Crores)
Waterways	Land acquisition	5.07
	Dredging	18.65
	Bank Protection	6.03
	Extension of locks	1.07
	Aids to Navigation	1.06
	Miscellaneous Works	1.92
	Total	**33.8**
Terminals	Civil Works	21.59
	Mechanical Handling	7.45
	Electrical Works	1.32
	Others	1.18
	Total	**31.54**
	Grand Total	**65.34**

Table 2.11.20

Annual Projection for Passenger Traffic and Commodity Flow through Waterways

Canal/Year	**2000**	2005	2010	**2025**
Passenger Traffic (1000 passenger)				
VK canal	0	2000	2260	3280
AK canal	4100	4100	4650	6700
AC canal	4300	4300	4860	7050
Total	**8400**	**10400**	**11770**	**17030**
Commodity Flow (1000 MT)				
VK canal	0	30	114	280
AK canal	40	50	60	150
AC canal	20	30	32	80
Total	**60**	**110**	**206**	**510**

Table 2.11.21

District-wise and Category-wise Post-offices in GKR

District	1958-59					1993					1996-97				
	Head Offices	Depart ment	Sub offices Extra Dept.	Branch Offices	Total	Head Offices	Depart ment	Sub offices Extra Dept.	Branch Offices	Total	Head Offices	Depar tment	Sub offices Extra Dept.	Branch Offices	Total
Alappuzha	-	-	-	-	-	4	96	54	92	246	4	99	53	91	247
Ernakulam	-	-	-	-	-	5	137	39	199	380	5	141	37	198	382
Idukki	-	-	-	-	-	2	52	13	230	297	2	52	13	230	297
Kottayam	1	-	69	255	325	5	127	56	233	421	5	127	56	234	22
Pathanam -thitta	-	-	-	-	-	5	130	85	233	453	5	142	78	237	462
Thrissur	2	-	103	369	474	3	104	32	157	296	5	167	54	263	409
GKR	3	-	172	624	799	24	646	279	1144	2093	26	728	291	1253	1819

Table 2.11.22

District-wise Details on Area and Population Served by One Post Office (1998)

District	No. of Post Offices	Area (Km^2)	Area Served by One Post Office (Km^2)	Total Population	Population Served by One Post Office
Alappuzha	290	1414	4.88	2105453	7260
Ernakulam	382	2407	6.30	3043983	7969
Idukki	301	5019	16.67	1166657	3876
Kottayam	409	2203	5.39	1929236	4717
Pathanamthitta	313	2642	8.44	1235704	3948
Thrissur	489	3032	6.20	2979810	6094
GKR	**2184**	**16717**	**7.65**	**12460843**	**5706**

Source : Secondary data collected by KSSP

Table 2.11.23

District-wise Details of Telephone Network (1997-1998)

District	No. of Exch-anges	Equipped Capacity	Working Connect-ions	Awaiting List		No. of Telephone	
				OYT	Non-OYT	per Km^2	per 1000 persons
Alappuzha	39	83416	65735	604	38361	46	33
Ernakulam	87	215412	129210	737	67056	54	46
Idukki	66	31368	26672	380	26216	5	25
Kottayam	64	112619	91670	1762	46090	42	50
Pathanam-thitta	41	76826	55583	768	32955	21	77
Thrissur	60	136266	121526	977	67502	40	45
GKR	357	655907	490396	5228	278180	29	46

Source : Secondary data collected by KSSP

Table 2.11.24

Status of PowerTransmission System

Sr. No.	System	Sub-Stations (Nos.)	Lines (CKM)
1	400 KV	1	Nil
2	220 KV	5	1067
3	110 KV	44	2390
4	66 KV	103	2562
5	11 KV	2200	25000
6	LT Lines	-	125000

Source : Secondary data collected by NEERI

Table 2.11.25

Details of Power Transmission and Distribution in Kerala

Year	T & D lines (CKM)	Transformers (KVA)			No. of Villages Electrified (Nos.)	Pump set Energised (Nos.)
		Step-up	Step-down	Distribution		
1980-81	75781	1197975	2968500	1112248	1268	91389
1985-86	98644	1626975	3975800	1366209	1268	145526
1990-91	129092	1700475	4887500	2020522	1219	222387
1995-96	156536	1699475	7255700	3079408	1219	304904
1997-98	173433	2024480	8324400	3380706	1384	329355

Source : Energy, Centre for Monitoring Indian Economy (April 2001)

Table 2.11.26
Transmission & Distribution Lines in Kerala

Sr. No.	Year	Transmission & Distribution Lines as at the end of the Year (in Circuit KM)								
		220 KV	110 KV	66 KV	33 KV	22 KV	11 KV	6.6 KV	3.3 KV	L.T
1	1960-61	-	527	1373	36.2	169	5209	-	35	8899
2	1965-66	-	617	1718	36.2	172	6327	-	35	14189
3	1968-98	317	1068	1602	-	160	7046	-	35	16952
4	1973-74	317	1350	1711	-	160	9447	3	35	25968
5	1977-78	854	1404	1841	-	160	11953	3	35	37817
6	1978-79	854	1545	1879	-	160	12645	3	35	42507
7	1979-80	854	1545	2005	-	160	13348	3	35	47605
8	1980-81	887	1545	2046	-	160	14189	3	35	55963
9	1981-82	887	1559	2168	-	160	15103	3	35	62810
10	1982-83	887	1650	2274	-	160	15580	3	35	66865
11	1983-84	887	1887	2385	-	160	15846	3	35	68265
12	1984-85	887	1896	2349	-	160	16317	3	35	71259
13	1985-86	887	1897	2373	-	160	16917	3	35	76141
14	1986-87	887	2199	2411	-	160	17507	3	35	80809
15	1987-88	887	2256	2482	-	160	17956	-	-	85570
16	1988-89	981	2277	2482	-	160	18411	-	-	89442
17	1989-90	981	2297	2482	-	160	19127	-	-	95938
18	1990-91	1064	2329	2492	-	160	20221	-	-	101834
19	1991-92	1064	2329	2531	-	160	21551	-	-	108420
20	1992-93	1067	2347	2549	-	119	22556	-	-	114689
21	1993-94	1067	2390	2562	-	119	23455	-	-	119935
22	1994-95	1067	2378	2664	-	119	24509	-	-	125390
23	1995-96	1176	2425	2669	-	121	25807	-	-	129893
24	1996-97	1176	2429	2669	-	121	26444	-	-	132864

Source : Secondary data collected by NEERI

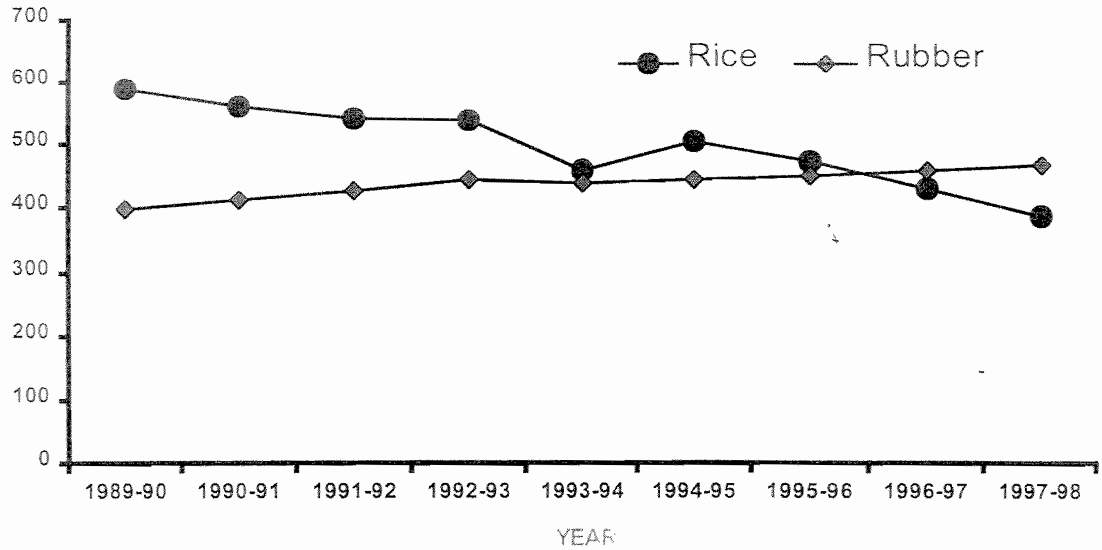

Fig. 2.11.1 : Year wise Area under Rice and Rubber - A Trend Indicator

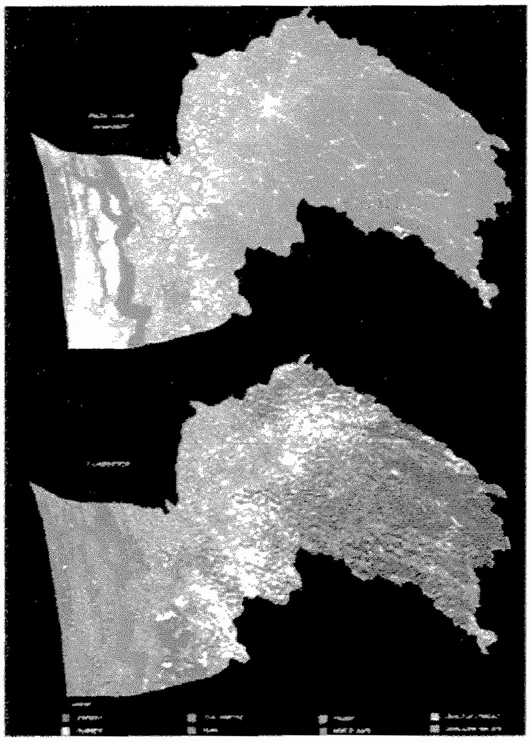

Fig. 2.11.2 : Landuse Map of Muvattupuzha River Basin

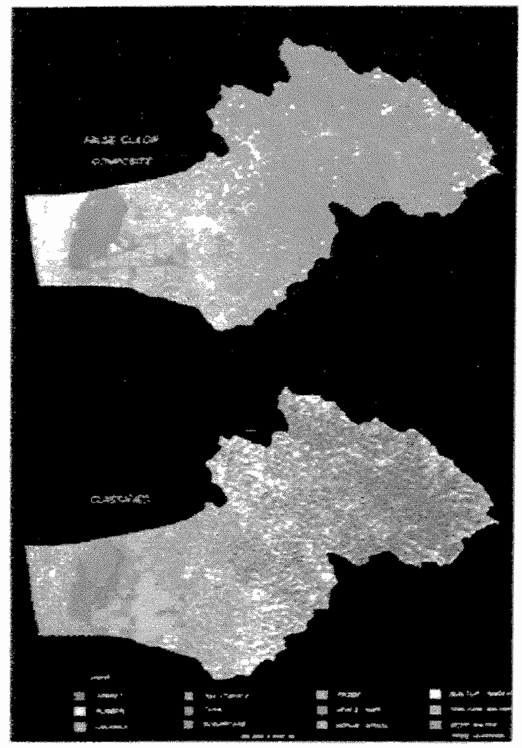

Fig. 2.11. 3 : Landuse Map of Meenachil River Basin

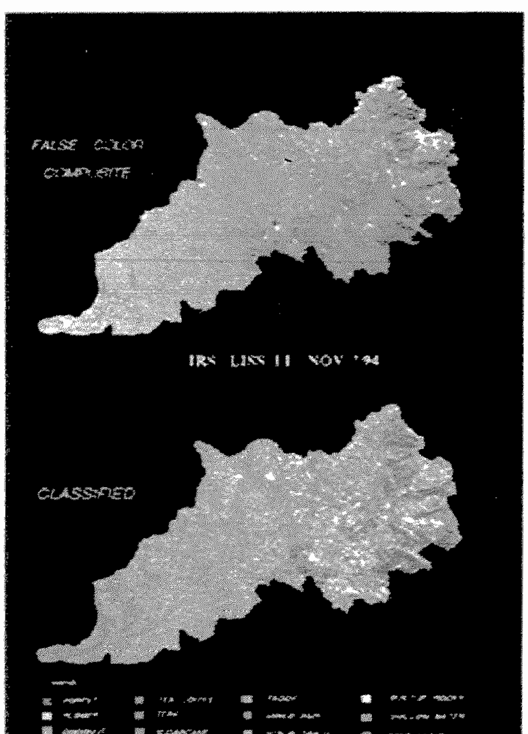

Fig. 2.11.4 : Landuse Map of Manimala River Basin

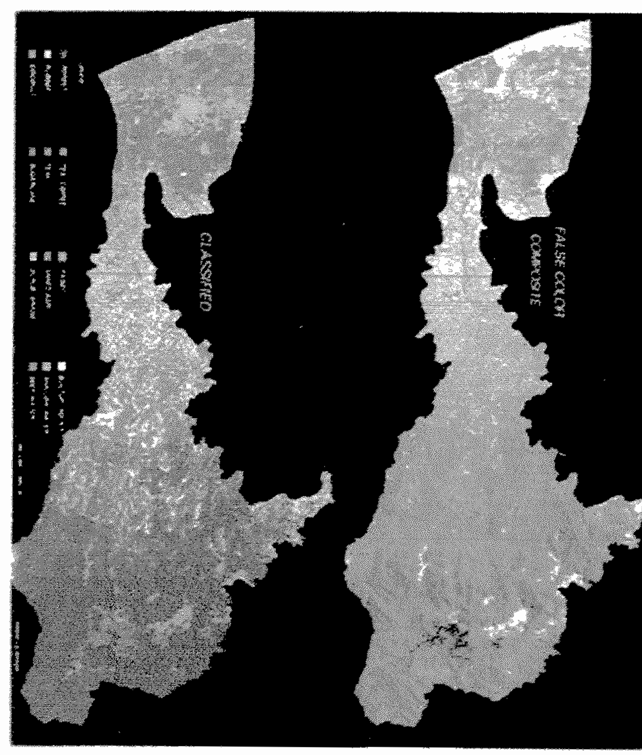

Fig. 2.11.5 : Landuse Map of Pamba River Basin

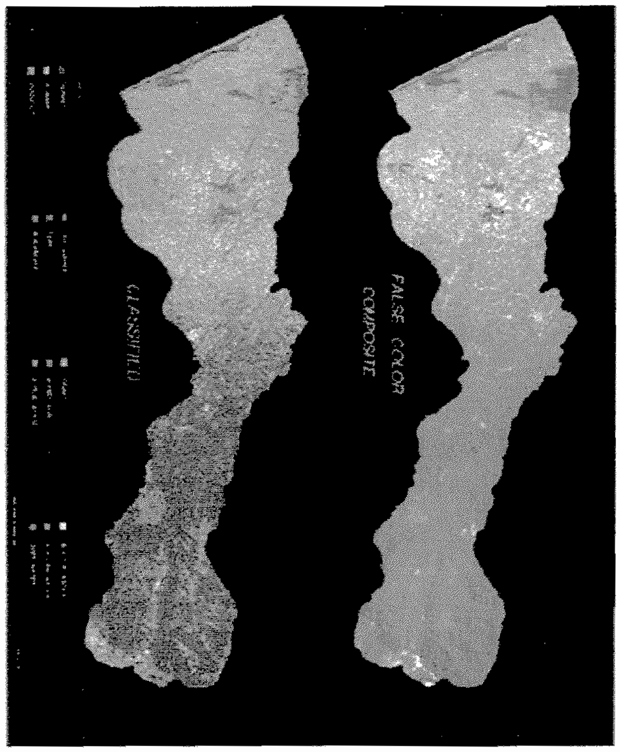

Fig. 2.11.6 : Landuse Map of Achencoil River Basin

2.12 Socio-Cultural Resources

2.12.1 Cultural Resources

The main cultural centres in the districts of GKR are the village libraries registered with the Kerala State Library Council. These village libraries are working as the main cultural and literacy centres, not only in the villages but also in the municipalities and corporations as well. The taluk/district-wise number of village libraries in GKR was collected from the Kerala State Library Council and presented in **Table 2.12.1**.

As per this data, there are 1576 village libraries in GKR. The district-wise comparison of the number of village libraries in GKR shows that Kottayam district has maximum percentage of village libraries in GKR (21.5%). This is followed by 20.62% in Thrissur district, 19.48% in Ernakulam district, 15.1% in Alappuzha, 11.7% in Pathanamthitta and 11.6% in Idukki district.

Since these cultural centres form one of the means for public education (nonformal) also, it can be assume that the backwardness of Idukki and Pathanamthitta district in terms of education is reflected in the number of village cultural centres also.

2.12.2 Tourist Resources

Tourism sector has attracted the attention in Kerala as one of the most highly prioritised industries. So the assessment of the tourism resources is meaningful. But the data readily available on the foreign and domestic tourist arrivals in important tourist centres of GKR is presented in **Table 2.12.2**. From 1988 to 1996, the total number of foreign tourists arrivals in GKR increased from 41232 to 90278 i.e. 118.95% increase. By comparing 1995 data with 1996 data, it can be seen that in 1996, 24.3% increase was recorded in the total number of foreign tourists arrivals. Comparison of the tourists arrival in the districts of GKR indicates that majority (68.22%) of the foreign tourists arrival is in Ernakulam district. Thrissur district has contributed only 2.48% to the total foreign tourists arrivals in GKR. Alappuzha district comes in the second place with 14.19% foreign tourists arrivals in GKR.

From 1988-96, the number of domestic tourists arrivals in GKR increased from 1407648 to 2629466. This increase comes to about 86.8%. During the period of one year from 1995 to 1996, the percentage increase in the total number of domestic tourists arrivals is 12.83%. This means that the increase in the number of domestic tourists arrivals is half the increase in the number of foreign tourists. In the case of domestic tourists arrivals Thrissur district occupies the first place with 66.3% domestic tourists in 1996 followed by Ernakulam with 22.36%, Idukki with 4.72%, Kottayam with 4.2% and Alappuzha district with 2.39% of the total number of domestic tourists arrivals in GKR.

The above analysis shows that in GKR, during the year from 1995 to 1996, it recorded 24.3% increase in the number of foreign tourists arrivals and during the same period, the increase in the number of domestic tourists arrivals was only 12.88%. Another result of the analysis is that Ernakulam ranks first in the total number of foreign tourists arrivals and Thrissur ranks first in the domestic tourist arrival. This also points to the fact that districts like Kottayam, Pathanamthitta and Alappuzha have untapped tourist potential.

2.12.3 Social Security and Social Welfare Resources

The social security and social welfare of a community are two mutually contributing factors, which directly influence the quality of life of people. It is difficult to separate one from the other. The resources, which are aimed at increasing the social security and social welfare, are given in the following part with a background picture of the population who really are in the backyard of the overall development of the society.

Table 2.12.3 gives the number of rural households below poverty line. Comparison of the number of households identified in 1992 (as below poverty line) with the total number of households in each district, the relative percentages of households under poverty line in each district of GKR can be determined. This calculation shows that almost 29.3% of the households in GKR come under the poverty line in 1992. The percentage of households coming under the poverty line varies from 21.72% in Ernakulam district to 33.72% in Thrissur district. In Pathanamthitta district, this percentage is 26.7 and in Kottayam, it is 29.65%. Idukki and Alappuzha districts have 32.71% and 33.19% households under the poverty line. The percapita income at current prices 1992-93 is highest for Ernakulam district (Rs. 8857). This shows the relatively better economic condition of Ernakulam. The percapita income of Alappuzha district is the lowest (Rs. 5255) and the percentage of households under poverty line is nearer to maximum also. So we can assume that Alappuzha district is relatively at a lower economic position.

With the addition of 1,27,501 households in 1995, the total number of households under poverty line in GKR has increased to 811537. This comes to about 18.64% increase. It is interesting to note that Idukki district has recorded a maximum of 46.89% increase in the number of households under poverty line within a period of 1992-to-1995 and Alappuzha district has recorded only 8.24% of the increase.

The fishermen population is one of the economically and socially backward groups in Kerala. **Table 2.12.4** is the district-wise distribution of fishermen population in GKR as per 1997-98 data. Alappuzha, Ernakulam and Thrissur districts have the marine fishermen and all the districts have inland fishermen population. The total marine fishermen population in GKR is 2,46,771. Ernakulam and Thrissur districts have almost equal percentage of marine fishermen, 28.6% and 27.5% respectively whereas Alappuzha district has a higher percentage (43.9%) of marine fishermen population. The total number of inland fishermen in GKR is about 168565, which is 40.6% of the total number of fishermen in GKR. The percentage of inland fishermen in GKR varies from 0.03% in Idukki district to 37.2 in Ernakulam district. The percentage of total number of marine and inland fishermen in Ernakulam is 40.7 followed by

Alappuzha with 32% and Thrissur with 21%. The percentage of total number of marine and inland fishermen in other districts of GKR is negligible.

The scheduled castes and scheduled tribes population is another socially and economically backward class. **Table 2.12.5** is the percentage of SC and ST population based on total population for the year 1981 and 1991. The average percentage of SC population in GKR as per 1981 census was 10.59, which has increased to 10.93% in 1991. This percentage varies from 7.03% in Kottayam district to 13.69% in Idukki district as per 1981 data and 7.43% to 14.56% as per 1991 data. The percentage of ST population in GKR has increased from 0.96% in 1981 to 1.12% in 1991. Percentage of ST population varies from 0.13% in Thrissur district to 3.99% in Idukki district. As per 1991 data, the lowest percentage of ST population is in Alappuzha district (0.14%) and the highest percentage is in Idukki district (4.66%). This means that Idukki district is the focal point with respect to the SC and ST population, which is followed by Pathanamthitta district with 13.3% SC population (1991) and 0.58% ST population (1991).

The rural/urban distribution of scheduled castes population and Scheduled Tribes population is given in **Table 2.12.6**. In Idukki district with highest percentage of SC population 98.05% are in rural areas and only 1.95% is in urban areas. In Pathanamthitta district, 88.31% of SC population is in rural areas and 11.69% is in the urban areas. The average percentage of rural SC population in GKR is 82.92 and that of urban SC population is 17.08%. Percentage of rural SC population is maximum in Idukki district and minimum in Ernakulam district. But in the case of urban SC population, its percentage is highest in Ernakulam district and lowest in Idukki district.

The average percentage of rural urban ST population is also similar to that of rural urban SC population. The rural urban distribution of ST population is also almost similar to that of SC population. It is clear that although Idukki and Pathanamthitta are to be noted for total and rural SC/ST population, Ernakulam district also is to be noted for urban SC/ST population.

The protection of the old age population becomes a crucial problem in Kerala with the disappearance of joint family. Further if these aged people are widowed or divorced / separated the intensity of the problem increases. **Table 2.12.7** gives the proportion of married, widowed, and divorced/separated among the aged (1991). It can be seen that in GKR on an average only 19.2% of population above 80 years old are not widowed or divorced/separated. About 74.4% of this age group is widowed and 0.5% are divorced or separated. In Alappuzha district 81.95% of female population above 80 years are widowed and this percentage is lowest in Idukki where it is 70%. Among the male population above 80 years Pathanamthitta district has a maximum of 27.9% widowed population and Thrissur has a minimum of 22.2% of this group. Thus Alappuzha and Pathanamthitta are relatively at a lower status and Idukki and Thrissur are at a higher social status in this respect.

Table 2.12.8 gives the district-wise details of institutions under scheduled castes and Scheduled Tribe development department as on 31/12/1998. There are nursery schools, hostels for boys and girls and industrial training centres (ITC) under SC development department. There are 51 nursery schools, 13 boys' hostels, 22 girls' hostels and 17 ITCs in GKR under the SC development department. The distribution of institutions other than nursery schools is in a uniform manner among the districts of GKR. Ernakulam district with 22 nursery schools ranks first and Alappuzha with 2 nursery schools ranks last.

Similarly under the scheduled tribe development department also, there are 15 balawadies, 15 boys' hostels, 12 girls' hostels and 17 other institutions in GKR. Idukki district ranks first in the number of such institutions.

The distribution of surplus land to socially and economically backward groups forms another measure to increase the social welfare of the community. **Table 2.12.9** is the district-wise details on the distribution of surplus land upto December 1998. The total number of beneficiaries under this scheme in GKR is 45988, of which 44.66% are scheduled castes, 1.29% ST families and the remaining other groups. The highest percentage of such beneficiaries is in Thrissur district (43.5%) and the lowest percentage is in Pathanamthitta district (1.575).

The total area of land distribution in such a manner in GKR comes to around 16578 acres of which 46.48% of the area was distributed to scheduled castes, 2.64% to scheduled tribes and the remaining to others. But the highest percentage of the area of the surplus land distributed is in Alappuzha, even though the number of beneficiaries is in Thrissur. In Pathanamthitta 0.83% of land was distributed under this scheme

The public distribution system in Kerala is very famous. The main operating centres of this system are the ration shops. **Table 2.12.10** gives a picture of the number of ration cards according to monthly income of households as per 1996 data. The total number of ration cards holders in GKR as per this data is 25,53,860. As per 1991 data the total number of households in GKR is 23,37,363. This means that considering the increase in the number of households during 1991 to 1996 also, almost all the households have ration cards to purchase food grains at subsidised rates.

Also it is seen that 51.2% of the ration cardholders in GKR are the lower income groups (monthly income below Rs. 300). The number of households coming in this group is about 56% of the total number of households in GKR. This shows that this lower income group includes 27% number of households in addition to the 29.3% of households below poverty line. But recent policy changes of the government indicate that the benefit of subsidised ration will be available to those below the poverty line in the future. The implication of this change in the socio-economic situation of the region cannot be predicted now.

During 1991 to 1997 period Kerala State has spent Rs.977 Crores for water supply and sanitation. **Table 2.12.11** gives the district-wise population covered by rural water supply schemes. In 1992 the total population covered under this scheme in GKR was 3919000. which is about 33.64% of the total population as per 1991 census. By 1998, even though this percentage has increased to 45.5, when the increase in population is considered, this is negligible It is seen that from 1992 to 1993, there was 4.8% increase in the total population coming under rural water supply schemes. From 1993 to 1994, it recorded 10.54% increase, between 1994-1995 7.2% increase, between 1995-1996 7.77% increase, 1996-1997 3.92% increase and from 1997-1998, it recorded 1.42% increase. A district-wise comparison of the above data (1998) shows that 26.5% of the total population covered under this scheme in GKR is in Thrissur district. The lowest percentage is for Pathanamthitta district with 8.85%.

Table 2.12.12 gives the achievement under self-employment programme during 1997-98. Out of 6830 applications sanctioned for self-employment scheme for Rs. 9034.92 lakhs, 5124 were disbursed for Rs.2848.87 lakhs. The total amount disbursed in different districts varies from Rs. 172.56 lakhs in Idukki to 737.81 lakhs in Ernakulam.

The social security and welfare is directly dependent on the number of banking institutions in the region and their financial activities. **Table 2.12.13** gives a picture of the growth in the number of scheduled commercial bank offices in Kerala from 1980 to 1993. From 1980 to 1985, the total number of scheduled commercial banks in GKR increased from 1155 to 1348. From 1985 to 1993, it increased from 1348 to 1416 (5% increase). As per 1993 data, the highest number of scheduled commercial banks is in Ernakulam district and lowest is in Idukki district.

Table 2.12.14 shows that the total number of commercial banks in GKR as per 1997 data is 1572. Out of the above, a maximum of 466 are in Ernakulam district and a minimum of 101 are in Idukki district. The total deposits in the commercial banks in GKR amounts to Rs. 3904176 lakhs. It is interesting to note that 71% of the total deposits are in banks in Pathanamthitta district, eventhough the number of bank branches in Pathanamthitta district is only 13.4% of the total number in GKR. This is in agreement with our primary data on the source of income of the households.

In Pathanamthitta district, remittance from abroad is maximum. So it can be safely assured that major portion of the deposits in Pathanamthitta district is from non-resident Indians. The total advances, as on September 1997 in GKR is Rs. 574405 lakhs, out of this only 0.67% is in Pathanamthitta district and 54% is in Ernakulam district.

The loans sanctioned and disbursed by a premier state owned financial institution like Kerala Financial Corporation (KFC) is given in the **Table 2.12.15** to get a relative picture of the financial aids provided by the government to ensure social security and welfare. The total number of such loans disbursed in GKR in 1988 was 3799 for Rs. 8837.61 lakhs. This has increased to 4360 for Rs. 11153.85 lakhs in 1989. In 1990, the number of loans has further increased to 5106 for Rs. 14111.45 lakhs.

From 1988 to 1990 the number of loans has recorded 34.4% increase and the disbursed amount has recorded 59.67% increase in GKR. Ernakulam district has been in the first place with respect to the number and the amount of loans disbursed by KFC. As in 1990, 39.36% of the loans disbursed in GKR by KFC is in Ernakulam district and only 5.6% of the loans were disbursed in Pathanamthitta which is the least amount disbursed in the districts of GKR.

The loans provided by banks to help the people in assuring their welfare vary with time and space. The suitable measure to determine the extent of help rendered by such banks is to credit deposit ratio. It is seen that in GKR, the credit deposit ratio decreased from 58.87% to 26.84% from 1988 to 1989. In 1990, it has increased to 58.06% and in 1991 decreased to 54.79 % followed by another decrease to 44.19% in 1993 (**Table 2.12.16**).

This means that on an average, there was only decrease in the credit deposit ratio in GKR. Idukki district, which stood first with 123.63% credit deposit ratio in 1988, could keep it above 100% upto 1991 only. In 1992 it has gone down to 84.92 and in 1993 to 66.22%. Pathanamthitta, which recorded the least credit deposit ratio of 17.04% in 1988, could not increase it above 15.14% as in 1993. But Ernakulam district could increase the ratio from 92.31% in 1988 to 115.5% in 1993, eventhough the increase was not steady. For Kottayam, Thrissur and Pathanamthitta districts, the credit deposit ratio recorded a decrease on an average from 1988 to 1993.

Table 2.12.1

Taluk/District-wise Number of Village Libraries in GKR

District	Taluk	Number of Libraries
Alappuzha	Ambalapuzha	36
	Cherthala	44
	Chengannur	25
	Kuttanadu	45
	Karthikappilly	48
	Mavelikkara	40
	Total	238
Ernakulam	Aluva	58
	Kochi	23
	Kothamangalam	40
	Kunnathunadu	61
	Kanayannur	42
	Muvattupuzha	41
	North Paravoor	42
	Total	307
Idukki	Devikulam	21
	Thodupuzha	18
	Peerumedu	58
	Udumbanchola	86
	Total	183
Kottayam	Changanassery	63
	Kanjirapally	50
	Kottayam	88
	Meenachil	86
	Vaikom	52
	Total	339
Pathanmthitta	Adoor	52
	Kozhenchery	54
	Mallapally	16
	Ranni	37
	Thiruvalla	25
	Total	184
Thrissur	Chavakkadu	48
	Kodungallur	30
	Mukundapuram	99
	Thrissur	89
	Thalappally	59
	Total	325
	GKR	1576

Source : Secondary data collected by KSSP

Table 2.12.2

District wise Annual Tourists Arrival in GKR : 1990-1996

District	1990	1991	1992	1993	1994	1995	1996
Foreign Tourists Arrivals							
Alappuzha	11693	10054	11731	12470	5022	6375	12811
Ernakulam	51996	54474	59645	60761	78125	56590	61588
Idukki	15677	15904	18160	16640	7881	6429	11023
Kottayam	2180	2808	3434	3706	1966	2137	2621
Pathanamthitta	-	-	-	-	-	-	-
Thrissur	1311	1922	2267	2510	1233	1119	2235
GKR	**82857**	**85162**	**95237**	**96087**	**94227**	**72650**	**90278**
Domestic Tourists Arrivals							
Alappuzha	60714	64216	70521	75065	17947	20070	62955
Ernakulam	628152	614390	634424	655280	622762	568641	588196
Idukki	117217	124273	125656	133994	72581	64912	124200
Kottayam	107265	117060	120103	128546	111960	106168	110826
Pathanamthitta	-	-	-	-	-	-	-
Thrissur	3078482	1286233	1390899	402994	1547146	1570658	1743289
GKR	**3991830**	**2206172**	**2341603**	**1395879**	**2372396**	**2330449**	**2629466**

Source : Secondary data collected by KSSP

Table 2.12.3

District wise Number of Rural Households below Poverty Line (1996)

District	Total Households				Households	
	Identified in1992	Added in 1994	Added in July 1995	Total	Assited by 1992-96	To be Assited since April 1996
Alappuzha	134522	420	10661	145603	14359	131244
Ernakulam	120690	365	12237	133292	19447	113845
Idukki	76205	1098	34642	111945	8789	103156
Kottayam	107276	602	23007	132885	12471	120414
Pathanam-thitta	69327	1072	13357	83756	11443	72313
Thrissur	176016	105	27935	204056	20267	183789
GKR	684036	3662	121839	811537	86776	724662

Source : Secondary data collected by KSSP

Table 2.12.4

District wise Distribution of Fishermen Population in GKR (1997-98)

District	Marine	Inland	Total
Alappuzha	108360	60687	169047
Ernakulam	70539	62724	133263
Idukki	-	42	42
Kottayam	-	24301	24301
Pathanamthitta	-	1408	1408
Thrissur	67872	19403	87275
GKR	**246771**	**168565**	**415336**

Source : Secondary data collected by KSSP

Table 2.12.5

District wise Percent SC/ ST Population (1981 &1991 Census)

District	Scheduled Castes (%)		Scheduled Tribes (%)	
	1981	1991	1981	1991
Alappuzha	9.32	9.51	0.14	0.14
Ernakulam	8.54	8.58	0.14	0.18
Idukki	13.69	14.56	3.99	4.66
Kottayam	7.03	7.43	0.90	0.98
Pathanamthitta	12.57	13.30	0.44	0.58
Thrissur	12.38	12.22	0.13	0.15
GKR	**10.59**	**10.93**	**0.96**	**1.12**

Source : Secondary data collected by KSSP

Table 2.12.6

District wise Percent SC & ST Population in Rural-Urban Area (1991)

District	Scheduled Castes (%)		Scheduled Tribes (%)	
	Rural	Urban	Rural	Urban
Alappuzha	81.26	18.74	61.84	38 16
Ernakulam	62.37	37.63	44.57	55.43
Idukki	98.05	1.95	98.53	1.47
Kottayam	80.62	13.38	97.70	2 30
Pathanamthitta	88.31	11.69	95.20	4.80
Thrissur	80.92	19.08	96.05	3.95
GKR	81.92	17.08	82.32	17.69

Table 2.12.7

District wise Proportion of Married, Widowed and Divorced/Separated among the Aged by Sex (1991)

Sex	Married (%)			Widowed (%)			Divorced/ Separated (%)		
	60-69	70-79	80+	60-69	70-79	80+	60-69	70-79	80+
Alappuzha									
Male	90.4	84.5	64.5	5.3	12.3	25.2	0.6	0.4	0.5
Female	47.9	25.2	13.0	47.2	71.0	81.9	1.4	0.7	0.5
Ernakulam									
Male	90.9	84.4	63.5	5.6	12.3	25.1	0.5	0.4	0.1
Female	51.2	31.5	18.6	43.3	62.9	71.9	1.0	0.5	0.4
Idukki									
Male	92.7	86.2	70.5	5.7	11.5	26.3	0.5	1.0	1.2
Female	60.2	47.1	28.0	36.8	50.6	70.0	1.5	0.6	0.5
Kottayam									
Male	91.3	83.6	66.7	5.4	12.8	23.5	0.5	0.7	0.5
Female	60.4	38.7	21.9	34.4	47.3	70.4	1.2	0.4	0.6
Pathanmthitta									
Male	91.6	86.2	67.0	5.6	11.1	27.9	0.5	0.2	0.7
Female	60.6	38.6	19.5	36.7	59.0	76.4	1.5	0.5	0.6
Thrissur									
Male	92.0	84.6	64.2	4.9	12.4	22.2	0.5	0.5	0.5
Female	44.4	24.5	14.4	48.6	69.2	76.0	1.5	1 1	0.4
GKR									
Male	**91.5**	**84.9**	**66.1**	**5.4**	**12.1**	**25.0**	**0.5**	**0.5**	**0.5**
Female	**54.1**	**34.3**	**19.2**	**41.2**	**60**	**74.4**	**1.4**	**0.6**	**0.5**

Source : Secondary data collected by KSSP

Table 2.12.8

District-wise Details of Institutions under SC/ST Development Department (1997-98)

District	Nursery Schools		Boys Hostel		Girls Hostel		Other Institutions	
	SC	ST	SC	ST	SC	ST	SC	ST
Alappuzha	2	-	-	1	4	-	2	4
Ernakulam	22	-	3	-	4	-	1	-
Idukki	5	13	2	7	3	-	-	9
Kottayam	5	1	2	2	4	-	4	4
Pathanam-thitta	7	-	2	1	4	-	2	-
Thrissur	10	2	4	1	3	-	8	-
GKR	**51**	**15**	**13**	**12**	**22**	**-**	**17**	**17**

Source : Secondary data collected by KSSP

Table 2.12.9

District-wise Distribution of Surplus Land up to Dec. 1998

District	Number of Beneficiaries				Land Distributed (Acres)			
	SC	ST	Others	Total	SC	ST	Others	Total
Alappuzha	3999	48	4357	8404	2179	7	2352	4538
Ernakulam	3984	40	2510	6534	742	5	423	1170
Idukki	2218	360	2411	4989	2042	315	2138	4495
Kottayam	2417	76	2841	5334	1245	60	1232	2537
Pathanamthitta	330	0	394	724	86	0	68	154
Thrissur	7590	67	12346	20003	1411	50	2223	3684
GKR	20538	591	24859	45988	7705	437	8436	16578

Source : Secondary data collected by KSSP

Table 2.12.10

District-wise No. of Ration Cards According to Monthly Income (1996)

District	Monthly Income						
	Upto Rs. 300	Rs. 301-500	Rs. 501-1000	Rs.1001-1500	Rs.1501-2000	Rs. 2001 & Above	Total
Alappuzha	248091	69576	30991	23956	16640	42181	431435
Ernakulam	279256	121527	88766	36072	24739	40536	590896
Idukki	102242	67933	51040	11111	82555	9604	324485
Kottayam	195590	78440	43574	20593	18857	22127	379181
Pathanam-thitta	150038	47065	26018	14166	10476	11644	259407
Thrissur	331778	93148	56116	30452	21347	35615	568456
GKR	**1306995**	**477689**	**296505**	**136350**	**174614**	**161707**	**2553860**

Source : Secondary data collected by KSSP

Table 2.12.11

District-wise Population Covered by Rural Water Supply Schemes: 1992-96

Population in Lakhs

District	1992	1993	1994	1995	1996	1997	1998
Alappuzha	8.03	8.53	8.82	9.17	9.45	9.79	9.82
Ernakulam	7.17	7.47	9.34	10.36	10.91	11.46	11.69
Idukki	3.21	3.31	3.36	3.80	4.31	4.62	4.76
Kottayam	6.74	7.05	7.09	7.44	7.90	7.96	7.98
Pathanamthitta	2.95	3.25	3.28	4.19	4.55	4.66	4.69
Thrissur	11.09	11.47	11.63	11.71	13.18	13.77	14.06
GKR	**39.19**	**41.08**	**43.52**	**46.67**	**50.29**	**52.26**	**53.00**

Source : Secondary data collected by KSSP

Table 2.12.12

Achievement Under Self Employment Programme (1997-98)

District	Applications Sanctioned and Amount Disbursed			
	Number	Sanctioned (Rs. in Lakhs)	Number	Disbursement (Rs. in Lakhs)
Alappuzha	1108	595.72	847	417 86
Ernakulam	1765	1033.89	1267	737.81
Idukki	437	233.66	348	172.56
Kottayam	1412	757.62	931	502.12
Pathanamthitta	424	428.46	493	291 50
Thrissur	1684	985.57	1238	727.02
GKR	6830	4034.92	5124	2848.87

Table 2.12.13

District-wise Distribution of Scheduled Commercial Banks in Kerala (as on 31st December) : 1980-1993

District	1980	1985	1988	1989	1990	1991	1992	1993
Alappuzha	242	189	194	196	199	197	200	200
Ernakulam	364	394	400	405	402	410	413	418
Idukki	71	81	91	94	97	96	96	96
Kottayam	201	224	226	226	226	227	228	228
Pathanamthitta	0	162	164	164	165	164	164	165
Thrissur	277	298	301	304	302	303	308	309
GKR	**1155**	**1348**	**1376**	**1389**	**1391**	**1397**	**1409**	**1416**

Source : Secondary data collected by KSSP

Table 2.12.14

District-wise Distribution of Commercial Bank Offices in GKR and Details of Deposits and Advances (Rs. in Lakhs)

District	No. of Branches			Deposits as on			Advances as on		
	Dec. 1970	June 1973	Sep. 1997	Dec. 1970	June 1973	Sep. 1997	Dec. 1970	June 1973	Sep. 1997
Alappuzha	48	81	216	1521	2641	185957	850	1295	67052
Ernakulam	142	167	466	4651	7245	440375	5243	6959	310150
Idukki	-	29	101	-	322	24635	-	128	21065
Kottayam	55	88	243	1468	2232	189665	802	1162	78001
Pathanam-thitta	-	-	210	-	-	2759053	-	-	3827
Thrissur	106	135	336	1901	3329	304491	927	1514	94310
GKR	**351**	**500**	**1572**	**9541**	**15769**	**3904176**	**7822**	**11058**	**574405**

Source : Secondary data collected by KSSP

Table 2.12.15

Details of Loans Sanctioned and Disbursed by Kerala Financial Corporation (Rs. in Lakhs) : (1988-1990)

District	As on 31.03.1988				As on 31.03.1989				As on 31.03.1990			
	Sanctioned		Disbursed		Sanctioned		Disbursed		Sanctioned		Disbursed	
	No.	Amount	No.	Amount	No.	Amount	No.	Amount	No.	Amount	No.	Amount
Alappuzha	534	1577.26	512	1312.49	636	1866.80	586	1520.75	750	2292.39	717	1793.47
Ernakulam	1587	4302.53	1484	3106.17	1866	6305.86	1736	4218.07	2133	7792.88	1966	5554.87
Idukki	216	1046.92	182	698.34	280	1276.76	231	927.37	375	1511.07	318	1223.81
Kottayam	801	1702.04	784	1460.78	895	2287.28	843	1695.44	1001	2633.92	940	2105.39
Pathanam-thitta	127	504.42	133	373.93	195	708.56	175	559.45	271	952.28	270	797.57
Thrissur	770	2526.88	704	1885.90	869	3131.18	789	2232.77	993	3677.29	895	2636.34
GKR	4035	11660.05	3799	8837.61	4741	15576.44	4360	11153.85	5523	18859.83	5106	14111.45

Table 2.12.16

Deposits and Advances of Scheduled Commercial Banks Including Regional Rural Banks in Kerala (1988-93)

District	1988			1989		
	Deposit	Credit	Credit/ Deposit Ratio (%)	Deposit	Credit	Credit/ Deposit Ratio (%)
Alappuzha	34550	18788	54.38	413112	21954	53.14
Ernakulam	82933	76560	92.31	98399	90197	91.66
Idukki	5079	6279	123.63	6056	7347	121.32
Kottayam	36021	21922	60.86	42670	25864	60.61
Pathanamthitta	50491	8602	17.04	58902	10115	17.17
Thrissur	60197	26370	43.81	70452	29620	42.04
GKR	**269271**	**158521**	**58.87**	**689591**	**185097**	**26.84**
	1990			**1991**		
Alappuzha	47950	24781	51.68	56430	26771	47.44
Ernakulam	114004	108329	95.02	133388	123902	92.89
Idukki	7492	8731	116.54	8902	9126	102.52
Kottayam	49237	27902	56.67	58089	29465	50.72
Pathanamthitta	67644	10465	15.47	79060	11411	14.43
Thrissur	79596	32237	40.50	95430	35627	37.33
GKR	**365923**	**212445**	**58.06**	**431299**	**236302**	**54.79**
	1992			**1993**		
Alappuzha	144636	57612	39.84	26898	7305	25.45
Ernakulam	332937	278078	83.53	29458	34024	115.50
Idukki	20355	17284	84.92	3967	2627	66.22
Kottayam	147812	59326	40.14	34692	12207	35.18
Pathanamthitta	206150	24504	11.89	41353	6262	15.14
Thrissur	223786	68280	30.52	21344	7268	34.05
GKR	**1075676**	**505084**	**46.96**	**157712**	**69693**	**44.19**

Source : Secondary data collected by KSSP

2.13 Economic Resources

Before going into the details of socio-economic/quality of life situation in the planning region, it becomes necessary to discuss some of the general economic indicators, which the planning agencies and economists usually refer.

The net domestic product at current prices for 1980-81 and 1996-97 are given for different districts and GKR. It can be seen that the contribution of tertiary sector to the net domestic product has shown a slight increase from 38.08% in 1980-81 to 38.64% in 1996-97. In GKR, with regard to the proportion of contribution to net domestic product, primary sector comes second. Its contribution of 35.48% in 1980-81 was increased to 36.09% in 1996-97. Consequently, there was a decrease in the contribution of secondary sector from 26.43% in 1980-81 to 25.26% in 1996-97. In the case of the districts of GKR, the dominating sector with respect to its percentage contribution to the net domestic product varies from 1980-81 to 1996-97. Alappuzha district keeps the tertiary sector as the dominating sector in both these years with a slight increase in the percentage contribution from 42.2% in 1980-81 to 44.2% in 1996-97. In Ernakulam district, the dominating sector shifts from tertiary (38.8%) in 1980-81 to secondary (37.8%) in 1996-97. Idukki district keeps its major contribution from primary sector in both these years and is able to increase the percentage contribution of primary sector from 54.5% to 66.1% in 1980-81, for Kottayam district, the primary sector contributed 43.75% of net domestic product, but in 1996-97 the dominating sector has changed to tertiary with 45.47% contribution. As per 1996-97 data, in Pathanamthitta district, the primary sector comes first with 45.2%, but in 1980-81, tertiary sector with 39.7% contribution was dominating. For the Thrissur district, the tertiary sector exists as the dominating sector both in 1980-81 and 1996-97. But the contribution of this sector has increased from 39.9% in 1980-81 to 42.7% in 1996-97 (**Table 2.13.1**).

The growth of sectoral income during 1997-98 based on 1980-81 prices is given below in the **Table 2.13.2**. The average rate of growth in all the sectors in GKR is 6.56 during 1997-98. Tertiary sector has recorded a maximum growth rate of 8.3 followed by secondary with 7 and primary with only 4.02. The total growth rate is highest for Ernakulam (7.4) followed by Thrissur (7) and the minimum growth rate of 5.87 was recorded by Idukki district. The rate of growth in the primary sector is almost equal (4) for all the districts. But in the secondary and tertiary sectors, different districts have different values of growth rates. It is interesting to note that Idukki, with a growth rate of 9.2 recorded the highest value in the secondary sector and Kottayam district with 5.5 recorded the lowest value. In the tertiary sector Ernakulam district with 9.1 comes first in the growth rate and Alappuzha with 7.6 comes last.

Conventional planners have accepted the percapita income as an indicator of the quality of life of people in a planning region. **Table 2.13.3** gives the districtwise percapita income at current prices. The percapita income at current prices for different years is given and the district average is estimated as for GKR. For GKR, the average percapita income in 1970-71 was 620 which increased to 1647 in 1980-81 (165.6% increase) and which further increased to 4708 in 1990-91 (185.85% increase). From 1990-91 to 1997-98 the percentage increase in percapita income had shown a fluctuating trend. From 1990-91 to 1991-92, it recorded 21% increase in the percapita income from 4708 to 5704. Between 1991-92 and 1992-93 the increase was only 10% followed by 15% increase between 1992-93 and 1993-94, 19% increase between 1993-94 and 1994-95, 10% increase between 1994-95 and 1995-96 and 9% increase between 1995-96 and 1996-97. As per 1996-97 records, the highest percapita income was 13637 in Ernakulam district followed by Idukki (12059), Pathanamthitta (9595), Kottayam (9105), Thrissur (9019) and Alappuzha (8081).

The districtwise percapita income at 1980-81 prices for 1996-97 and 1997-98 along with the ranks of districts among the 14 districts of Kerala is given in the **Table 2.13.4**. The average growth in GKR in between 1996-97 and 1997-98 is 5.2% with respect to the percapita income. Ernakulam district, which recorded 6% growth, stands first and Idukki, which recorded 4.44% stands last. The ranking of districts according to the percapita income at 1980-81 prices gives the same picture in both the years. It has to be noted that these ranks are almost similar to the ranks in percapita income at current prices already discussed. Ernakulam district ranks first among all the 14 districts of Kerala and Alappuzha ranks 13th in this list.

The consumer price index or cost of living index numbers for agricultural and industrial workers in GKR is given below in the **Table 2.13.5**. From January 1998 to October 1998, the index has shown an average variation of 4.34% in GKR. Idukki district has the lowest index and lowest percentage variation in index. Ernakulam with the highest percapita income has the price index greater than Idukki but its percentage variation in index is the highest of 4.78%. Alappuzha district and Thrissur having lowest percapita income are with highest consumer price index.

The comparison of the above economic indicators such as net domestic product, sectoral growth rate percapita income and consumer price index reveals the following facts about the districts of GKR.

- Tertiary sector has contributed more to the net domestic product in Alappuzha, Kottayam and Thrissur where as primary sector contributes more in Idukki and Pathanamthitta. In Ernakulam secondary sector is dominating as per 1996-97 data.
- Growth rate is more in tertiary sector than that of primary and secondary.
- Ernakulam district ranks first and Alappuzha ranks in the percapita income

Table 2.13.1

District-wise Distribution of Net Domestic Product (at Current Prices) : 1980-81 and 1996-97

District	1980-1981				1996-1997			
	P	S	T	Total	P	S	T	Total
Alappuzha	10149	7675	12985	30809	56571	40838	77229	174638
	(32 9)	(24 9)	(42.2)	(100)	(32.4)	(23.4)	(44.2)	(100)
Ernakulam	12830	18385	19782	50997	102426	156757	155507	414690
	(25.2)	(36.0)	(38.8)	(100)	(24.7)	(37.8)	(37.5)	(100)
Idukki	10506	5469	3295	19270	92858	22440	25194	140492
	(54.5)	(28.4)	(17.1)	(100)	(66.1)	(16.0)	(17.9)	(100)
Kottayam	10777	3616	10240	24633	81617	40838	77229	174638
	(43.75)	(14.68)	(41.57)	(100)	(45.43)	(19.10)	(45.47)	(100)
Pathana-mthitta	20500	13157	22180	55837	55563	189968	48451	123010
	(36.7)	(23.6)	(39.7)	(100)	(45.2)	(15.4)	(39.4)	(100)
Thrissur	12263	9083	14193	35544	79875	72772	113951	266598
	(34.5)	(25.6)	(39.9)	(100)	(30.0)	(27.3)	(42.7)	(100)
GKR	**77025**	**57385**	**82675**	**217085**	**468910**	**328152**	**502013**	**1299075**
	(35.48)	**(26.43)**	**(38.08)**	**(100)**	**(36.09)**	**(25.26)**	**(38.64)**	**(100)**

Figure in brackets indicate the percentage distribution
P - Primary; S - Secondary; T - Tertiary
Source : Secondary data collected by KSSP

Table 2.13.2

District-wise Rate of Growth of Sectoral Income : 1997-98 (at 1980-81 Prices)

District	Primary	Secondary	Tertiary	Total
Alappuzha	4.0	6.2	7.6	6.38
Ernakulam	4.0	7.3	9.1	7.4
Idukki	4.0	9.2	8.0	5.87
Kottayam	4.1	5.5	8.1	6.20
Pathanamthitta	4.0	6.5	8.6	6.50
Thrissur	4.0	7.3	8.3	7.0
GKR	**4.02**	**7**	**8.3**	**6.56**

Source : Secondary data collected by KSSP

Table 2.13.3

District-wise Per Capita Income at Current Prices : 1970-71 to 1996-97

District	1970-71	1980-81	1990-91	1991-92	1994-95	1995-96	1996-97
Alappuzha	598	1311	4268	4865	6852	7461	8081
Ernakulam	646	2017	6502	8010	11545	12572	13637
Idukki	658	1995	4612	6073	9805	10930	12059
Kottayam	652	1452	4038	4945	7548	8322	9105
Pathanamthitta	-	-	4408	5056	7948	8762	9595
Thrissur	545	1462	4422	5277	7599	8297	9019
GKR	**620**	**1647**	**4708**	**5704**	**8550**	**9391**	**10249**

Source : Secondary data collected by KSSP

Table 2.13.4

District-wise Per Capita Income at 1980-81 Prices

District	Per Capita Income (Rs.)				
	1996-97	**Rank**	**1997-98**	**Rank**	**Growth (%)**
Alappuzha	2015	13	2114	13	5.00
Ernakulam	3681	1	3902	1	6.00
Idukki	2836	2	2962	2	4.44
Kottayam	2478	4	2596	4	4.76
Pathanamthitta	2468	5	2594	5	5.10
Thrissur	2337	7	2458	7	5.63
GKR	**2636**		**2771**		**5.2**

Rank in the State

Source : Secondary data collected by KSSP

Table 2.13.5

Consumer Price Index (Cost of Living Index) for Agricultural and Industrial Workers in GKR :1998
(Base 1970=100 units)

District	1998										Variation Jan to Oct	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Index	Percent
Alappuzha	950	954	958	963	968	973	978	982	987	992	42	4.42
Ernakulam	920	925	929	934	939	945	952	955	960	964	44	4.78
Idukki	911	915	917	921	925	930	936	938	941	947	36	3.96
Kottayam	939	944	948	953	956	962	968	971	975	979	40	4.26
Thrissur	950	954	956	958	963	968	974	979	984	991	41	4.26
GKR	**934**	**938**	**942**	**946**	**950**	**956**	**962**	**965**	**969**	**975**	**41**	**4.34**