CONSULTATION ON NATURAL RESOURCES OF KERALA

September 7 (Tuesday), 2004

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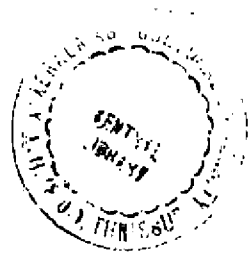

CONTENTS

NATURAL RESOURCE BASED PLANNING FOR SUSTAINABLE AGRICULTURAL DEVELOPMENT IN KERALAM

AGRO-ECOLOGICAL ZONATION OF KERALA; AN ILLUSTRATION

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1. PROLOGUE

Development programmes must be evolved as per the needs of local community in consonance with the resource endowments. Dairying without the means to grow fodder, poultry without access to cheap feed, choice of land for crops disregarding topolocation, gravity irrigation on undulating topography etc. are some of the glaring examples (though less appreciated) of development efforts which perennially depend upon external props (state revenue through subsidies) for survival.

Sustainable development for the rural communities therefore would demand planning for the scientific exploitation and optimum utilisation of the production potentials of the material and human resources to which they have access, and call for investments for building infrastructure, which would foster the utilisation of the resource potentials.

The decentralised planning in Keralam primarily focus on a development process based on the local resources and the People's Campaign for Planning gives the opportunity to develop the resource base in a given area and to optimise it in a sustainable manner. Today, between 35-40% of the total developmental expenditure is being implemented by Panchayath Raj institutions. The government of Keralam was very firm in its conviction that without involving people in the process of planning, no genuine democratic decentralisation can be brought about.

People's Participation must be seen in its fullest sense (After all, people's participation means different things to different people. It varies according to individual perceptions). The definition of People's Participation in planning meant that all decisions related to development planning would be taken by the people including defining the scope of development, choosing the development path, formulating plans, determining the priorities, deciding location, identifying beneficiaries, implementation, resource mobilisation, monitoring and supervision. Enabling the Panchayath Raj institutions means developing concurrently, the skills in plan formulation and implementation on the one hand and on the other accessing them the controls of managing public resources viz. human (government staff) and financial (plan and non plan investments).

Panchayath is the basic unit for planning because it is not only the resources entity but is also an institutional entity as the supporting institutions are organised and infrastructure is developed. At Panchayath level both physical resources and the supporting structures and institutions converge.

The new initiative with the assistance of SDC in empowering the people and capacity building in planning and execution of projects for natural resources management at panchayat level in the northern districts of Kerala should therefore result in replicable models of resource integration for sustainable development of the state.

2. THE SCENARIO

Productivity of Keralam's agriculture was one of the highest in the country, both with respect to the individual crops and gross income per net cropped area, before the era of five year planning began. It was so, even after Keralam came into being as a separate political entity till the end of the fifties and early sixties.

After decades of development planning and in spite of substantial investment in related development initiatives, Keralam's performance in the agriculture front at present is often described as 'stagnant', 'moribund' etc. The progress on this front is not commendable, except in specific sub-sectors such as rubber, milk and marine products.

Productivity of the agriculture sector is rising but at a lower pace than the national average. The state has been relegated to lower status in the productivity of major crops in which the state is to compete with others such as paddy, coconut etc. In crops, which the state had near monopoly (coconut and pepper with the exception of rubber), the productivity is not rising. Keralam has also been overtaken by other states in the ranking of gross income per unit of cultivated land, bringing the state down to third or fourth position

2.1 The Weaknesses

Keralam's agriculture has stepped into the Twenty-first century in the context of the following weaknesses

- K Declining share of the agriculture sector both as a proportion to the state's GDP and as per capita income of those dependent on this sector for employment and livelihood.
- K Slow growth in the production and low productivity for most of the major crops (paddy, coconut, pepper, etc) in spite of increasing gross income per unit of land.
- K Erosion on the dependency of agriculture as a source of livelihood as a consequence of the dwindling land: person ratio and inadequate growth of the off-farm opportunities.
- K The incessant drift towards less labour absorbing systems of land use (seasonal and annual to perennial crops and of late to trees) as a consequence of the dichotomy of land ownership and lesser participation of family labour for sociological, physiological and economic reasons.
- K The change in the societal value of land as an asset rather than as a source of income and livelihood security.

2.2 The Opportunities

Contrary to the above, Keralam is blessed with all the factors that are considered in the development literature as very conducive to a vibrant, dynamic and sustainable agriculture. They are:

- The natural advantages in well endowed biophysical resource endowments for biomass production.
- The inheritance of basically sustainable land use, cropping systems, and integrated farming.

- A good headstart (in mid 1950's the state had the highest land and crop productivity in the country) with a blend of high value cash crops.
- The apparently favourable institutional changes.
- Land reforms (acclaimed to be the most progressive in the country with the abolition of all forms of tenancy, nearly eliminating landlessness).
- Relatively easy access to institutional credits.
- Easy physical accessibility to market through extensive rural road network.
- The high level of literacy and better accesses to information.

2.3 The Challenge

Lack of appreciation of some of the biophysical and socioeconomic features unique to Keralam, and their implications in the formulation of policies and interventions in technology development, economic support and political initiatives that foster agriculture, has been primarily responsible for the situation to which the state's agriculture has come to pass. The state relied on national mainstream policies, strategies and programmes, most of which turned out to be irrelevant in Keralam's context and hence ineffective, and at times even counter-productive to sustain its agriculture. Can we change that mind-set so that the hopes and expectations of agriculture to be the engine of growth and source of employment in Keralam? THAT IS THE BIGGEST CHALLENGE KERALAM'S AGRICULTURE DEVELOPMENT FACES TODAY.

Given the sociopolitical context, the task of changing the current trend is daunting. Still we can venture out because we have seen, many times, forces capable of transforming the entire scenario appear suddenly from no where, defying all rational explanations, in this great land of ours which has undergone many a trials and tribulations only to emerge as resilient if not invigorated.

3. RETROSPECT:
The Commodity-based development paradigm

Agricultural development planning pursued hitherto in our country and copied in our state, has been focused on enhancing the production and availability of marketable commodities (for food or industrial raw materials or for export) such as rice, rubber, black pepper, tea, coffee, etc. Evolving policies, designing projects, building infrastructure, research, delivery systems, and investment are all attuned to promote the production of these identified commodities. Such a paradigm of agricultural development did enable the state as well as our country in achieving appreciable production advances in selected commodities and attaining overall agricultural growth. However, there are quite a few facts, which are inherent but not fully appreciated in the development paradigm centered on commodities.

When development is focussed on selected commodities only those areas endowed with resources congenial to the production are benefited while poorly endowed are left out naturally (say, the northern districts of Keralam). Thus the rainfed areas, the hilly areas and such other poorly endowed areas are out of the mainstream of development. Evidences are now emerging increasingly that the development approach pursued at national level has resulted in exclusion of substantial and significant proportion of regions and populations from the main stream of agricultural development.

By default the people who inhabit poorly endowed areas e.g. marginal farmers, tribal communities, fisherfolk who subsist on artisanal fishing in the coastal regions, etc could remain only as onlookers and not participants in the development process. Incidentally, these groups are the poorest and constitute the bulk of the poverty-stricken in the state.

Moreover, the focus on marketable products resulted in the loss of diversity in production and in land use, in turn in the break down of the farming systems in Keralam and the holistic approach to resource use and management. Natural resource management thus became one of the major casualties.

4. PROSPECT:
Resource focused development

Ecological and economic sustainability are enhanced when available land, water, energy and human resources are used in a mutually reinforcing manner. A systems approach involving integrated attention to crop and livestock farming and to agroforestry and aquaculture will be helpful in generating more jobs and maximising income through value addition, and in protecting the resource-health. Resource-based planning would lead to the optimised use of specific resource endowments in sustainable manner and help to improve the livelihood security of the people who subsist on them. Full utilisation of the production potentials, through intensification and diversification of the land and water resources themselves offer tremendous opportunities for income enhancement and generation of employment in the agriculture sector of the state.

The aim of the small farm/family households who constitute the bulk of the rural resource-poor in Keralam is not maximising returns from specific activity or product. The farmers' objective is maximising income and employment in a sustainable manner from the total resources, both biophysical and human, at the command of the households or to which they have access, through product conversion and thereby by value addition. Rural families put together a living, through multifarious activities. The urban concept of employment will have little meaning under such conditions. Every effort has to be made to optimise this strength of diversity of sources of occupation and income in daily life, through the integrated use and management of resources. Technology and support services should facilitate the realisation of this objective and thereby improve the livelihood security of the rural households.

4.1 Natural Resources Integration Models (NRIM)

Kerala State, although very small in geographical extent, comprises several types of land resource configurations and land use patterns. A tiny strip of land on the western side of the Western Ghats, the state is quite different in physiography, climate, soil and crops, when compared to other states of India. Consequently the living standards, cultural identity and other socio-economic features of Keralites are unique. The fragile and extremely sensitive ecosystems that prevail in the state are prone to degradation, unless managed judiciously. Therefore, any intention to intervene in the land use systems prevalent in Kerala should be on a scientific footing in the light of information on the land resource configurations and resource use patterns in each agro-ecological unit of the state.

Development planning, including investment in techno-infrastructure, research, delivery systems, and investment policies has to be restructured with the focus on the sustainable development of the total resource potentials of a given spatial entity, in contrast to the current commodity focus. This can be achieved by delineating the state into major homogeneous resource endowment areas (ecosystems), and by identifying potential opportunities to optimise the use of resources, biophysical as well as human, for sustainable generation of income and employment, on the basis of currently available technology, marketing opportunities, and skill attainments of the people of specific locations.

5. NATURAL RESOURCES OF KERALA

5.1 land resources

Keralam is relatively rich in biophysical resources, which are needed for agricultural production. The relatively high gross income (nearly double the national average) per unit of land is partial reflection of the better natural resource endowment of Keralam. Being located in the high rainfall tropical region (between 4 and 12 degree North latitude), the state falls in one of the regions in the world with high incidence of solar radiation during 365days (despite cloudy days during the rainy months), warm temperature and high rainfall with average annual precipitation of 300 cm; all congenial for high biological activity which is manifested by the rich biodiversity. Within a short span of 120 km breadth of the state, the land mass rises from 5 metres below sea level to soaring heights of 2500m, transforming the climate from high rainfall tropics preferred by paddy-cum-fish, banana, arecanut, coconut, pepper, cashew and rubber, to the cool temperate, conducive to the production of cardamom, coffee and tea.

5.2 Terrain features

Except for the coastal belt (about one tenth of the land surface), the landscape of Kerala is dissected and undulating with hills and valleys alternating each other. The degree of undulation of the landscape varies which is reflected in the three generally recognised broad physiographic formations viz. the highlands, the midland and the coastal plains. Within each of the physiographic formations, the land form is comprised of more than one facet laid out in a topo-sequence commencing from the ridge crests, moving downwards through slopes of varying degrees, and dropping into valleys of differing size which in turn terminate in drains of small or big dimensions. Typically four types of facets viz. the hill top, the upper slope, the lower slope and the valley could be distinguished on a slope continuum. The type of facets that could be identified and the proportion of land occupied by them vary between the major physiographic formations. For instance it may not be possible to distinguish hill tops from the upper slopes on the highlands as the land formation is highly dissected and in turn the slopes are steeper and valleys are narrower. On the midlands the hill tops are distinguishable into flat plateau or gently sloping humps, the slopes are gentle and the valleys are broad.

5.3 The Microenvironments

The undulating topography (valleys, slopes and hills), arising from geological formations, together with a variety of soil types, multiply into microenvironments which foster crops requiring contrasting agronomic conditions. Valleys with near water-logged conditions for most part of the year where two crops of rice are grown are seen juxtaposed

with dry hill tops decked with dense canopied rubber and cashew which withstand 6-7 months of dry period, all in a farm holding of less than one hectare. These natural endowments enable Keralam to produce a variety of crops grown in the high rainfall humid tropics to cool subtropics. The implications of these variegated climatic and physiographic endowments (heterogeneity of resource base) are very significant in planning for the sustainable development of Keralam's agriculture.

5.4 Water Resources

Like the diversity and richness in land resources, Keralam is better endowed in water resources also. The state accounts for one twentieth of the water resources against one eightieth of the land surface of India. There are 41 west flowing rivers and 3 east flowing rivers in Keralam. All rivers are very small, their length and size being controlled by the peculiar topography of the state. There are 4 relatively major rivers in the state viz. Chaliyar, Bharathapuzha, Periyar and Pamba. These rivers are more than 160 km in length and together drain about 35% of total surface water. The rivers and topography of the land offer no scope for locating any medium sized storage reservoir in the coastal and undulated mid land regions. Hence large storages are possible only in the High ranges and Malayoram. In these reaches, the rivers flow through rocky beds with high hills on the sides, thus offering good sites for storage reservoirs.

The rivers have not been gauged systematically for sufficiently long period to assess total surface water resources of the state correctly. But from the gauging so far done, it can be estimated that about 50% of the annual rainfall will be received as run off while the balance is lost by evaporation and by percolation into the earth. The total run off is roughly estimated as 74200 mcum. (2620 IMC).

It is assumed that the entire quantity of run off from the catchment above 75m. contour and a portion of the run off from the area between 15 m. and 75 m. contours can be considered as utilisable. It is estimated that the utilisable water resource in the state is 46600 mcum. (1645 TMC).

6. RESOURCE UNITS IN KERALAM

The significance of NRIM is that it takes care of and is consistent with the issues, problems and needs of particular locations. The domains of the exercise could be as small as an individual facet of the slope continuum, farmsteads, watersheds, agro-climatic zones or districts in the state – depending on the extend of variations in the agroclimatic and socio- economic situations over space. The wider the variations in the parameters over space, the smaller the unit of planning. The hierarchical setup for NRIM is provided in Fig.1.

One of the pre-requisites of NRIM is that there are least variations in the conditions obtained in the chosen unit of planning so that the plan wholly confirms to the development issues and problems of the unit of planning and holds good nearly uniformly throughout. This should be the rationale of NRIM. Specificity to objective situations being the essence of NRIM, it is supposed to become localised in its scope and character. Localisation of planning demands that all local issues and problems perfectly fit into the model.

6.1 Geographic and Administrative Units

Kerala is one of the smallest states in the Indian union with an area of only 38864 km^2. The state is a long narrow coastal strip of land between the Arabian Sea in the West and the mighty Western Ghats in the East, forming almost the southern half of the West Coast of India. It lies between 8° 18' and 12° 48' North Latitude and 74° 52' and 77° 22' East Longitude. The state has a seacoast of nearly 590 km. The state is broader in the central area, but not more than 120 km and narrows down to 30 km at the northern and southern extremities.

Kerala has a three-tier Panchayath Raj System (PRS) consisting of Grama Panchayaths, Block Panchayaths and District Panchayaths, all elected directly. Panchayaths in Keralam are almost 10 times bigger in population (averaging about 25000) compared to the rest of the country. The wards in panchayaths could be considered as equivalent to the villages in the rest of India.

Kerala state is divided into different types of administrative units, comprising 14 districts, 63 taluks, 152 community development blocks, 998 panchayats, 1452 revenue villages, 61 municipalities, and 3 corporations. There could be over 14000 elected representatives (focal points of power) in the entire LSGs put together in contrast to 141 MLAs and 20 MPs of Lok Sabha and 9 MPs of Rajya Sabha.

6.2 Agroclimatic Zones

Regionalisation of territories on the basis of agro-climatic parameters would help in delineation of homogenous areas and identification of key constraints that inhibit the process of development. Delineation of agroclimatic regions must be the result of several factors including physiography, climate, soil and topography. In addition, population density, land use pattern, irrigation and livestock population characteristics are also suggested for consideration.

Generalised guidelines are available in plenty on delineation of agro-ecological zones, sub-zones or units. However, the geographical setting and unique physiographical features, bimodal rainfall patterns and diversity of soils of Kerala make it difficult to apply any general system of zonal delineation. Kerala State thus presents a great challenge in this aspect because of such multiplicity of natural resource endowments, unlike the extensive (and monotonous) agroclimatic situations prevalent in other states of India. Nevertheless, several attempts have been made to classify the state into homogenous zones. One such zonation, done in 1974 but still in vogue in Keralam, is explained.

The "Committee on Agroclimatic Zonation and Cropping Patterns in Kerala" constituted by the Government of Kerala deliberated mainly on the discussion papers "An Alternative Approach to Delineation of Agroclimatic Regions and Identification of Cropping Patterns in Kerala (a First Approximation)" and "An approach towards designing the optimum cropping patterns for Kerala" - presented by Dr. K.N. Shyamasundaran Nair. The committee, then delineated agroclimatic zones in Kerala and identified cropping patterns in each agro-climatic zone, for each season, for each topographic feature namely valley, slope and hill top.

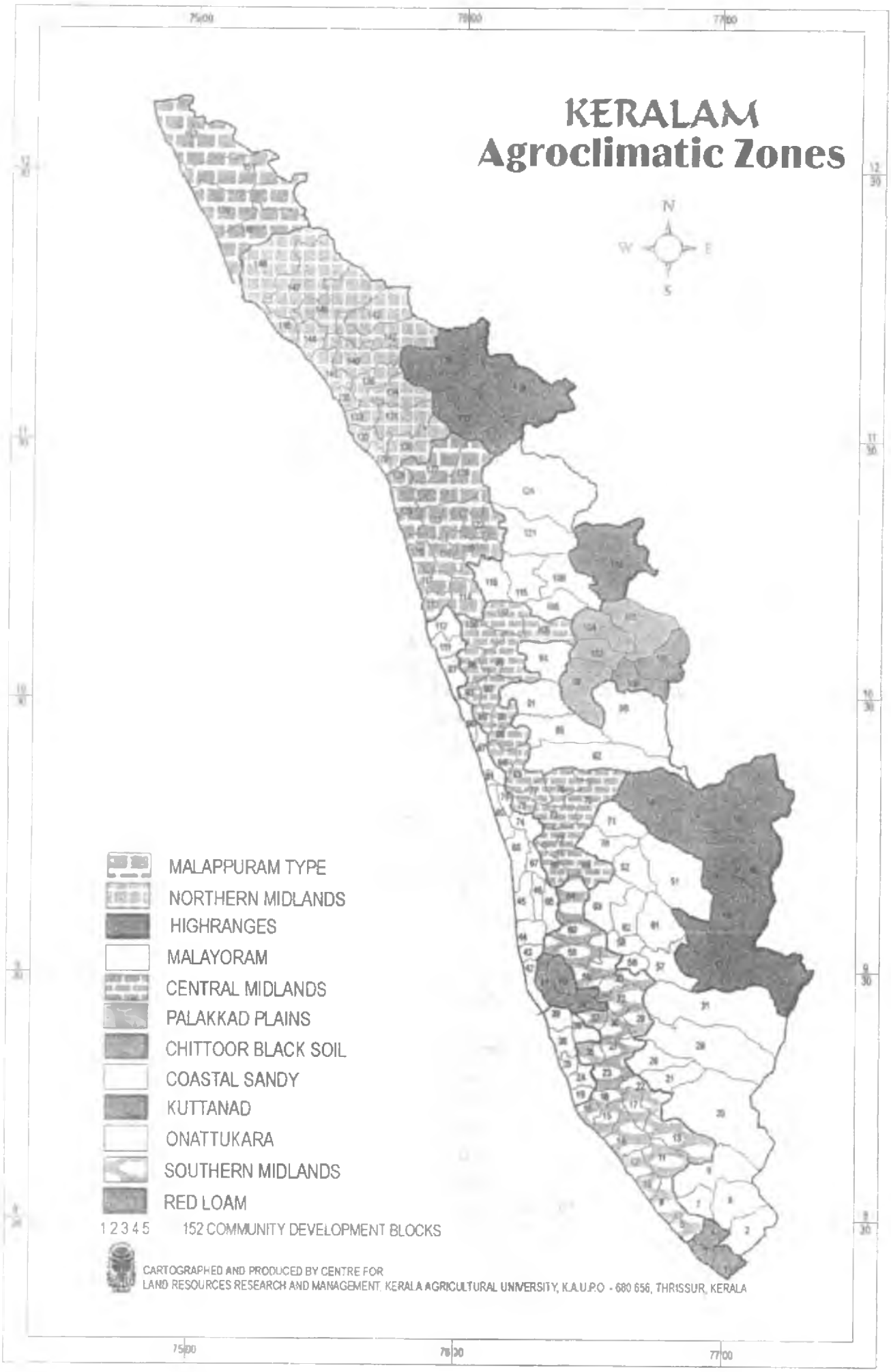
KERALAM
Agroclimatic Zones
N
W
E
S
MALAPPURAM TYPE
NORTHERN MIDLANDS
HIGHRANGES
MALAYORAM
CENTRAL MIDLANDS
PALAKKAD PLAINS
CHITTOOR BLACK SOIL
COASTAL SANDY
KUTTANAD
ONATTUKARA
SOUTHERN MIDLANDS
RED LOAM
1 2 3 4 5 152 COMMUNITY DEVELOPMENT BLOCKS
CARTOGRAPHED AND PRODUCED BY CENTRE FOR
LAND RESOURCES RESEARCH AND MANAGEMENT, KERALA AGRICULTURAL UNIVERSITY, K.A.U.P.O - 680 656, THRISSUR, KERALA

Table 1. Parameters for Identifying Agro-Climatic Zones

Parameter	*Level*	*Description*		
I. Altitude[1]*	Type I	Up to 500 m above MSL (Low altitude zone- hot humid tropics, spread over the entire state)		
	Type II	> 1000 m above MSL (High altitude zone-cool humid temperate, mainly the high ranges of Idukki and Wynad districts)		
II. Rainfall	Pattern I	Both the South West and North East monsoons are active and moderately distributed. South West monsoon with June maximum (South of 11^0 N Latitude).		
	Pattern II	Poorly distributed rainfall. South West monsoon with July maximum and concentrated in 3-4months. North East monsoon relatively weak (North of 11^0 N Latitude).		
III. Soil types	1	Alluvial soil (Spread over river banks)		
	2	Sandy soil (Coastal areas)		
	3	Sandy loam soil (Coastal areas)		
	4	Laterite soil with well defined B horizon (Natural midlands)		
	5	Laterite soil without B horizon (Natural highlands).		
	6	Red soil (Southern-most Kerala)		
	7	Black soil (Chittoor taluk of Palakkad district)		
	8	Peat (Kari) soil (Kuttanad)		
	9	Acid-saline soil (Pokkali and Kaipad areas)		
IV. Topography		*Valleys*	*Hill tops*	*Slopes*
	Model-I	Extensive valleys with level but raised garden lands		
	Model-II a.	Valleys less extensive	Hills with moderate gradients	Slopes having mild gradients
	Model-II b.	Valleys less extensive	Hills with moderate gradients and with egg shaped hump	Steep slopes
	Model-II c.	Valleys less extensive	Hills with table tops	Steep slopes
	Model-III	Narrow valleys	Hills with steep gradients	Steep slopes

6.2.1 *Approach and Methodology*

The committee developed a unique system for delineating the state into agroclimatic zones. Four parameters, which together evolve distinct agronomic environments, were identified. The parameters and their levels used for delineating agro-climatic zones are summarised in table 1. The levels of each parameter are broadly determined to avoid

* *Areas falling between 500 m and 1000 m are not included in this analysis since evergreen forests mostly occupy these areas.*

complexity in the process of land evaluation. In reality, there can be several more levels for each parameter (E.g. there are 38 soil associations identified in Kerala, at 1:250,000 scale).

Statistical combination of the two levels each of altitude and climate, 9 levels of soil types and 5 types of topography would result in 180 different resource configurations. Characterisation of such a large number of zones doesn't fall under the purview of this effort and is not necessary for this scale of zonation.

6.2.2 *Results and discussion*

Combination of the four parameters namely altitude, rainfall pattern, soil type and topography influence the configuration of typical agronomic environments wherein distinct cropping patterns flourish.

The first factor of variability considered for delineation was the variations in altitude. Altitudinal variations influence the temperature regime. High altitude generates temperate climatic conditions in a tropical area. In the present system, all the area above 1000 m from MSL are treated as high altitude and those upto 500 m above MSL as low altitude. The region between 500 and 1000 metre above MSL are left out as the areas were covered by evergreen tropical forests and were not of direct significance to crop production; except that the forest growth helps to regulate the climate.

In the state only two areas fall under high altitude namely, the high ranges of Idukki and Wynad districts. In fact all along the Western Ghats high altitude areas are found. But only in the districts mentioned above, sizeable areas could be located. The low altitude region, endowed with humid tropical climate is spread over the entire length of the state.

The second parameter identified was the rainfall characteristics. The state was divided into two halves namely the areas South and North of 11^0N latitude (approximately South and North of Thrissur) with rainfall pattern I and II respectively. The southern region is having relatively well distributed rainfall and June maxima while the northern region has relatively ill-distributed rainfall and July maxima.

Soil type is the third factor for distinguishing specific zones. The major group under the soil type classification is laterite and its variations. In the traditional midland region the dominant soil type is typical laterite with the B horizon present. The areas skirting the Western Ghat and the High Ranges which together form the traditional Highland region has lateritic soil where the B horizon is absent. Red loam is found in the southern most tip of the state. All these variables constitute distinct homogeneous Agroclimatic zones, though the rainfall pattern is the same. Distinct zones have been identified based on special soil types such as river bank alluvium, peaty soil (Kari) as in Kuttanad and sandy soils, though the rainfall pattern and topographic models are the same. In the coastal area, the texture of the soil especially of the garden lands is considered as a distinguishing feature in identifying two separate zones one with sandy loam and the other with sandy soil. The soil characteristics of the paddy lands such as peaty (Kari) and saline soils (Pokkali) have also been associated in delineating the zones.

Areas having similar rainfall pattern and soil type are further delineated into zones based on topographical features. For instances, the Midland region north of 11^0N has a common rainfall pattern and the soil is of typical laterite with B horizon. It is further delineated into two zones based on the differences in topography with one zone having topographic Model II-b and the other Model II-c. Similarly the Midland region south of 11^0N has been delineated into two zones based on the differences in topographic features as models II-a and II-b.

Following the above approach and using a matrix built upon the altitude, rainfall, soil and topography the state has been delineated into thirteen agro-climatic zones (Fig 2). For developmental purpose State is divided into Community Development Blocks and Municipalities. Development block has been taken as the unit for purposes of delineation. All the blocks and municipalities have been grouped into the appropriate Agroclimatic zone. Whenever a block or municipality was found to fall in more than one agro-climatic zone it was assigned to that zone which has the largest area. Though 13 agro-climatic zones have been identified no block was assigned to one zone viz. the River Bank Alluvium as it is found scattered in several blocks. This zone is found generally all along the banks of the major rivers. It is found relatively extensively in the lower basins of the Periyar and Pumba river systems. Further, such alluvium deposits are generally found in the paddy fields, which form the valley portions of the undulating landscape, which is interspersed with mildly sloping hills even in these areas. Therefore a homogenous agronomic zone is not seen. The principal characteristics and distinguishing cropping patterns for each of the zones are summarised in table 2.

Table 2. Agro-climatic Zones of Kerala

No.	*Zones*	*Altitude Type*	*Rainfall pattern*	*Topography Model*	*Soil type*	*Principal crops*
I	Onattukara	I	I	I	Sandy loam	Rice, Coconut, Tapioca, Arecanut
II	Coastal sandy	I	I	I	Sandy loam	Rice, Coconut
III	Southern Midland	I	I	III	Laterite without B	Coconut, Rice, Tapioca, Arecanut
IV	Central Midland	I	I &II	IIa	Laterite	Rice, Coconut, Tapioca, Arecanut, Banana
V	Northern Midland	I	II	IIb	Laterite	Coconut, Rice, Arecanut
VI	Malappuram	I	II	IIc	Laterite	Rice, Coconut, Cashewnut, Arecanut
VII	Malayoram	I	I	III	Laterite without B	Rubber, Coconut, Pepper, Rice
VIII	Palakkad	I	II	II	Red loam	Rice, Cotton, Groundnut, Millets
IX	Red loam	I	I	III	Red loam	Coconut, Tapioca, Rice
X	Chittoor Block	I	II	IIa	Black soil	Rice, Sugarcane, Cotton, Groundnut, Millets
XI	Kuttanad	I	I	I	Peat (Kari)	Rice, Coconut
XII	High Ranges	II	I & II	III	Red loam	Tea, Coffee, Cardamom; Rice
XIII	River Bank Alluvium	I	I	I	Alluvium	Rice, Coconut, Sugarcane, Arecanut

Each of the zones identified is assigned a popular name. Many of them are currently in vogue and are associated with areas having singular agro-climatic features and cropping patterns

6.3 Watersheds

The hilly terrain of Kerala, except for the coastal areas (about 10 percent of total area), renders a panchayath itself more than one resource entities, the watersheds. A Watershed refers to the total area above a given point on a stream that contributes water to the flow at that point. It is a natural and complete hydrological unit. Hence the proper watershed management through NRIM can accomplish the development of that area.

The size of watersheds in Kerala is highly variable from small to very large ones. These are delineated into different groups according to their size. The watersheds identified in Keralam are categorised as per table 3.

Table 3. Categorisation of watersheds in Keralam

Sl. No.	Category	Area (ha)	Total number in Keralam
1	Macro watershed (River basin)	> 50,000	44
2	Sub – watershed	10,000-50,000	151
3	Milli watershed	1,000-10,000	960
4	Micro watershed	100-1,000	Not estimated
5	Mini watershed	1-100	Not estimated

Watershed characterisation is pre-requisite to development intervention as per NRIM. The approach of watershed characterisation relates land to the flow of water from its origin, through the basin, to the plains and its effect on soil. For the scientific characterisation and management of a watershed as per NRIM the basic data on climate, topography, hydrology, soil resources, natural vegetation, extend of soil degradation, farming systems and rural population have to be collected.

6.4 Land Facets in the toposequence

The topographic models identified during the agroclimatic zonation comprise the features of all the facets (hilltops, slopes and valleys) in a slope contiuum. For example, in High Ranges (Model III) the holltops are with steep gradients, slopes are steep and valleys are narrow while Model I in Onattukara comprises extensive valleys with level but raised garden lands. These models will vary according to agro-climatic zones. However, individual facets of the toposequence can be distinguished even at lower resource units including watersheds and farmsteads.

The micro-environments obtaining on each of the land facets vary, sometimes very considerably, as the soil type, the fertility status, the moisture availability and the drainage capability differ. Despite that each of the facets in a toposequence is endowed with distinctive micro-environments, they are mutually dependent, complementary and supplementary, and not competitive being an integral part of the slope continuum. Together with water, the land base constitutes a resource system. Therefore in developing the land resources, the entire slope continuum has to be seen as an integrated system.

Consequent to the undulating topography, the moisture availability on different facets at any given point of time varies even within small farmsteads which in turn creates different micro environments enabling to grow a variety of crops. It is common to find farmers in Keralam raising 7-8 crops (rice from the valleys; coconut, arecanut, banana etc. from the uplands of the lower slopes; and black pepper, rubber, cashewnut, etc. from the upper slopes) on their farms though small in size of 0.5-1.0 hectares. In addition, farmers rear different types of animals (cattle to meet the needs for draught power and manure, goats for meat and cash etc.). They choose production activities that are mutually supportive, and foster synergy in resource use.

6.5 Heirarchial Setup

In the hierarchy of resource based planning we have to move up from the lowest level. The lowest level, farms, in the context of Kerala, is an average household dealing with not less than ten crops integrated with livestock, fish and trees. So a farm means a heterogeneous resource base with multiple opportunities for development. So the idea of holistic view of the farm is inherent.

A group of farms constitute a watershed that is controlled by the biophysical resources that are manipulated at that level. Several watersheds constitute a panchayath where institutional, infrastructural, organisational support is provided.

7. RESOURCE USE SYSTEM IN KERALAM

7.1 The Farming Systems

Except for the plantation sub-sector (rubber, cardamom, coffee and tea) which is largely confined to highlands and high ranges, agriculture in Keralam practiced in three quarters of the land comprising the coastal lands and midlands can better be characterised as farming systems rather than just crop production. Farming in the average context of Keralam result in a basket of products which include food grains, vegetables, fruits, cash crops ranging from coconut and arecanut to rubber and cocoa, livestock, fish and trees, all in small farmsteads. This variegated production basket is basically attributable to the heterogeneity (in terms of agronomic conditions especially moisture status) of the land resource base as a result of the high rainfall and undulating topography even in spatial entities of one or two hectares. Hence **farming in Keralam results in a *resource use system* rather than a few specific *resource use activities***.

The existing cropping patterns and farming systems in many parts of Keralam are the results of cumulative effort of several generations of farmers who, through trial and error have evolved a system based on the natural resource endowments. Optimum blending of crop growth requirements and land qualities is distinguishable in the cropping patterns, resulting in the maintenance of productivity and better exploitation of the land capability over the years. That is why, the cropping patterns evolved over the generations for most of the agro-climatic zones in Keralam are found to be fairly in order with sound agronomic principles.

It is indeed one of the most valuable heritage handed down by our forefathers. In fact this heritage that enables the choice of crops consistent with the drainage capability

during the rainy months, drought tolerance during summer season and the slope characteristics of the land is the key to sustainability of resource base. Sustainable agri-horti-silvi-pisi-pastural farming systems have been evolved in Keralam through judicious integration of the resource base with crops, tree, livestock and fish.

Attempts to disturb the balance in traditional cropping patterns and farming systems have resulted in low productivity and disastrous soil erosion. Due to high population density and the demands consequent to modernisation of social life, Keralam is also facing pressure on land. Therefore, marginal soils are put to intensive agriculture, resulting in soil degradation. Hence it is essential that the land qualities be scientifically correlated while suggesting farming alternatives.

Thus, the discussion on agriculture as an economic activity in the context of Keralam's resource endowments is not to be confined to crop production alone as is generally understood by all who have something to do with development (of course, not farmers!). It should embrace all forms of biomass production, based on land and water, which have economic value in terms of human consumption, industrial raw materials and exports, be they crops, livestock, fish or trees.

7.2 Rigidity of crop patterns

The endowment of high rainfall and undulating topography engenders sharply contrasting agronomic environments (valleys, uplands, slopes and hill tops) which bring in rigidity and impose restrictions on crop and land use choices. The land use and crop combinations vary largely on account of the variability in moisture availability on each of the land facet at any given point of time. In general, on the valleys (often recognised as paddy lands) where moisture is retained over a longer period of the year and often the drainage status is poor (especially during the rainy months on account of the water accumulation through infiltration and seepage from the adjoining upper facets, over and above the in-situ precipitation) crops such as rice whose water requirements and tolerance towards poorly drained conditions are relatively high, are grown. On the lower slopes (characterised as uplands) where the availability of moisture extends to a shorter period than the valleys (but longer than the upper slopes) and the land is well drained, crops like coconut and arecanut which require moisture during the dry summer months are grown. On the upper slopes and hill tops where moisture availability is least during the long summer period, crops like rubber and cashewnut which tolerate relatively longer periods of moisture stress are grown. On the highlands the valleys are narrow and hence water accumulation is greater and drainage is poor. Rice is grown on the valleys. On the slopes where the land is well-drained, depending upon the altitude coffee, cardamom and tea are grown.

7.3 Predominance of perennial crops

The biophysical conditions namely, longer growing period of over 210 days due to high rainfall regime, and differential moisture regimes from waterlogged to dry as a result of undulating topography, fosters the inclusion of perennial crops in the cropping pattern. Four fifth of the cultivated land in Keralam is under such crops. Predominance of perennial crops renders land use sustainable and less vulnerable to degradation especially soil erosion as the tillage requirements are minimal unlike the seasonal and annual crops.

8. NATURAL RESOURCE MANAGEMENT FOR SUSTAINABLE LIVELIHOOD SECURITY

The evolution of a self-replicating model for natural resource management and rural development should be anchored on the production possibilities of the resources base opened up through technological innovations, and the means for their application against the given socio-cultural context of the community. Emanating from the above proposition rural development should

- be attempted at the optimum utilisation of the local resources - physical, plant, animal and human;
- be capable of achieving self-reliance;
- help in increasing the income of the poorer sections of the rural people such as marginal farmers and landless labour; and
- generate more opportunities for employment through recycling of resources and products.

Designing action programmes for achieving the above objectives through resource based development would involve

- inventorying resources and their appraisal;
- identification of the technological possibilities opened up through past work in the research organisations; and
- finally evolving action programmes by matching resources with technological possibilities.

8.1 Inventorying the resource base

The first step towards identifying the production possibilities in the various agroclimatic conditions is to evaluate the resource base, land, water and human power. Resource based planning and development is likely only when the development parameters are properly identified and interpreted. The basic parameters necessary for planning for agriculture development in any situation are Detailed soil survey information, Physiography, Climate, Water resources including drainage and water balance, Natural vegetation and biodiversity, Physical infrastructure like transport, communication, warehouses, markets etc, Economic and social characteristics of inhabitants, Land cover/ land use, Hydrogeomorphology, etc

Every panchayat in Keralam has, now with them, a development document *(Vikasana Regha)* which contains almost all the above information. NRIM exercise should refine the database using state of the art technologies like Remote Sensing and GIS.

8.2 Resource Analysis for NRIM

Given the value of above parameters what is needed for building a mutually consistent and cohesive plan for development is an analysis of the cause effect relationship between parameters that are needed for multi-disciplinary exercises. The resource endowment of an agro-climatic zone, a watershed or an individual farm in its totality should be considered in designing the most suitable systems of agriculture (or in a narrow sense, the cropping pattern). The essential role in this exercise is supposed to be played by

agricultural and social scientists. Their guidance should be sought for developing alternate interventions in the resource units. This team must analyse the strength and weakness of the agro-climatic situations vis-a –vis the development needs of a region and should ensure viability of development plans specific to the given situation.

The Committee for delineation of agroclimatic zones in Kerala identified some of the critical agronomic conditions (land qualities) which enable specific cropping patterns. They are temperature regime, moisture availability during summer months, drainage conditions during rainy season, sunlight availability, and susceptibility to soil erosion (Table 4). These qualities are the manifestations of land characteristics like altitude, rainfall, soil type and topography. For example, altitude decides the temperature regime and moisture availability is determined by rainfall, soil type and topography (hilltop, slope and the valley). Moreover, topography in conjunction with rainfall determines the extent of soil erosion and therefore the choice crops, which accelerates or minimises soil erosion.

Table 4. Relation between land qualities and land characteristics

Land qualities	*Determinants (Land Characteristics)*
Temperature regime	Altitude
Moisture availability during summer months	Rainfall pattern Topography (Hill top, slope, valley) Soil type (Texture, hard pans)
Drainage conditions during rainy season	Soil type (Texture, hard pans) Topography (Hill top, slope, valley)
Sunlight availability	Topography (Hill top, slope, valley)
Susceptibility to soil erosion (Surface run off)	Rainfall pattern Topography (Hill top, slope, valley) Soil type (Texture, hard pans)

8.3 Production possibilities

The production possibilities in terms of crops and animals which could be raised are dissimilar even on adjoining land facets such as a valley and a lower slope. For instance, valleys are conductive only to crops that tolerate waterlogging such as paddy, although with drainage support, moisture preferring crops such as banana, arecanut, coconut, etc can be grown. On the uplands, crops demanding well-drained soils such as pepper, ginger, etc and drought tolerant cashew and rubber are preferred.

Choice of crops is confined to those within groups and not across groups. For instance moisture demanding crops such as paddy, banana, vegetables etc are restricted to valley bottoms, and not to other environments while drought tolerant crops like rubber and cashew are confined to uplands and slopes. Shifts from moisture – preferring to drought – tolerant groups and vice versa is not feasible unless the agronomy is altered. Such alterations, either through drainage or lift irrigation, require massive capital investments and hence often become economically unviable.

Therefore the production possibilities are to be assessed on the basis of the moisture availability (length of growing period), soil fertility, drainage capability and

other agronomic factors prevailing on the different facets of the slope continuum under each of the agroclimatic configurations.

8.4 The strategy in resource use

In general Kerala has surplus of human power while land resource is limited. Hence priority has to be given to maximise production as well as employment from the scarce land resource. Four possibilities can be identified.

No	Strategy	Aim
1	Increase the number of cropping days and thereby increase the per day production	Minimise fallow periods on lands which are put to annual and seasonal crops (The summer fallow on paddy lands for instance)
2	Increase production through maximum utilisation of soil, moisture and solar energy	Inter-cropping on lands put to tree crops (multi-storey cropping)
3	Transform the under utilised human resource into value added products and increased incomes	Introducing animals and fish in the production process through recycling of resources
4	Adoption of eco-friendly management practices	Increase production and employment through organic manuring, manual weeding, integrated pest control etc

8.5 Development of farming systems for sustainable livelihood security

Sustainable livelihood security of the resource-poor households is improved by maximising income through increasing productivity of resources to which they have access, gainful employment within and without the farm sector, and by acquiring skills to add value to time. Resource-poor households resort to multiple means in putting the limited biophysical resources (land and water) and abundant human resources to multiple uses, in order to increase income. Though the scale is small, the opportunities they undertake are multiple. Farming systems integrating the use and management of both biophysical and human resources into combinations of products of crops, livestock, fruits, vegetables, agroforestry and aquaculture for maximising income and employment are to be fostered for the resource-poor farmers. Research, technology and support services for pursuing farming systems should be made accessible for augmenting the food livelihood security of the resource-poor.

8.6 Integrated Resource Management

In order to attain the objective of sustainable resource management, the currently pursued focus on maximisation of outputs or productivity through a specific or single use of the resource base has to be reoriented to the evolution of packages suited for the resource system as a whole.

Basically farmers in Keralam have evolved integrated systems of resource management. A holistic perception on the resource base spatially identified as watersheds, and an integrated systems approach to its management are imperative for the utilisation of the full production potentials and ensuring returns on a sustained basis. Technology

packages are to be evolved for the resource system as such and not limited only for utilising the individual facets within the slope continuum as is being practiced currently by and large. Technologies evolved on crop basis confine the application to the facets only and not to the system.

The inherent heterogeneity of the resource base of the farms, and the multiple uses to which they are put, in order to meet the multiple needs (seasonal, annual and perennial crops for food and cash; trees for fodder, fuel and timber; animals for food, draught power and cash; and fish for food and cash) of the family, demonstrate the symbiotic relationships exist between the various activities and the linkages, backward as well as forward, in resource use. In order to augment the synergy in resource use and thereby maximise income and employment, the land-plant-human production chain has to be expanded to land-plant-animal-fish-human.

What is argued is the integrated use of land, water and human power for increasing production and income from a systems perspective instead of the currently pursued truncated, disjointed single pronged activities like cropping, animal production, or fish production. Such an approach to resource management is imperative for generating maximum employment opportunities and increasing income from limited land resource.

8. 7 Technology Generation and Infrastructure Development

The multiplicity of crops and products in the farming systems of Keralam, though small scale in operation, demands not only complex operational and management skills, but also necessitates technology generation and support services for such systems. The scope of agricultural research is not limited to crops but should encompass all biomass production activities based on land and water embracing tree, animal and fish production apart from crops. Further, not only that research has to aim at maximizing the productivity of individual or specific commodities and products, but also all production possibilities and value addition through the given resource base. *Therefore, problem identification should not just be confined to the specific commodity but to the system as a whole especially the interdependence in resource use and synergy in production.*

The heterogeneity of resource base very often restricts the validity or applicability of the findings of pure-crop research or livestock research! Added to that the long life span of perennial crops (which in fact dominates the cropping system comprising over four fifth of the net cropped area) compounds the problem as research takes much longer gestation period to produce outputs (coconut research is illustrative).

Unorthodox research methodologies such as "reverse agronomy" (to borrow a term from industry – "reverse engineering") may have to be developed. That is,

- locate good performing farms and farmers, plants and land use systems
- Identify the biophysical and socio-economic factors that have contributed to high performance
- Systematically analyse and find out the determinants of sustainability
- Recombine and test them for replicability in other locations

Very often, there is conflict between physical and social assessment of land use options within a given area. The local community may decide, for socio-economic

reasons, their own farming alternatives, irrespective of recommendations made. In order to link, in a mutually reinforcing manner, the ecological security of the agro-climatic zones and livelihood security of the local population, it is essential that the land use options must ensure ecological sustainability, economic viability, social acceptability and gender security.

Selected watersheds / farmsteads in the study area can be developed and maintained by the scientists of the Kerala Agricultural University as models for agri-horti-silvi-pisci-pastural systems where complementary or symbiotic effects and mutual dependence of different components of specific farming systems can be brought to light for replication elsewhere.

Resource Integration Models, will render infrastructure support and technology transfer costly. The plethora of agencies that are proliferating the agricultural and rural development sectors in Keralam seldom reach the level of panchayats leave alone individual farms. Therefore it will be the duty of NRIM team to facilitate necessary infrastructure for successful implementation of the models.

9. CONCLUSION

The realisation of holistic and integrated development of resources depends upon the synchronisation of four mutually supporting components viz. technology package, technology delivery, access to inputs and services, and community action. Since NRIM logically follows form and is corollary to the principle of decentralised planing and since the hall mark of NRIM is its orientation to local situations, there is much in common between these two approaches in terms of their objective and contents.

NRIM, as an exercise, is issue based and situation specific. The essence of NRIM is sustainability of land and water based activities, and since sustainability demands consistency between agricultural activities and land qualities, a correlation between the two constitutes the core of NRIM exercise. As a matter of fact, the recognition of the relationship between the natural phenomena and the imperatives of agricultural production as the guiding principle of agricultural planning constitutes the point of departure of NRIM from traditional commodity based planning, and hence lends a new and highly essential dimension to agricultural development in the state.

Since farmers are the ultimate decision-makers only a fair combination of farmers experience and NRIM team's expertise can serve the purpose and goal of NRIM. Farmers do know the language of sustainable agriculture. What they do not know is the grammar and are therefore liable to err. In the same vein it can be said that the technique of planning used at present is usually not with tune and grammar. The NRIM team's role is to recast the planning strategies within the framework of a chaste language.

WATER MANAGEMENT ISSUES OF THE HUMID TROPICS: CASE STUDY OF KERALA

*E J James**

INTRODUCTION

Need for Integrated Approach

While studying the water resources of a region, land, water and biomass have to be considered together. An integrated approach has to be followed while suggesting water management strategies. A development strategy has to consider social, economic, environmental and institutional aspects for attaining sustainability. The present paper mainly highlights the water related issues of Kerala, with a view to point out the necessity for judicious or wise use of the water resources and scientific management of this precious gift of nature. Certain physical and socio-economic aspects of the region also may have to be kept in mind while analysing various aspects of water management. The case study of Kerala may also be useful in managing the water resources of other areas situated in the humid tropics.

Rainfall Distribution

Kerala State is situated in the humid tropics with two predominant rainy seasons, the south-west monsoon (June-August) and the north-east monsoon (September-November). On an average, the region receives 3000 mm annual rainfall, of which 60 per cent is obtained during the southwest monsoon, 25 per cent during the northeast monsoon and the remaining during the so called summer (January-May). Not only in time but also in space the rainfall varies (Fig 1). For example, while in certain areas Waynad and Idukki receive 5000 mm of average annual rainfall, Palghat and certain areas on the eastern side of the ghats receive only 2500 mm. There are certain areas in the Attappady valley with only 600 mm average annual rainfall. Generally, the highranges receive more rainfall than the other physiographic zones, mainly due to a phenomenon called orography – influence of undulating topography on rainfall. Areas on the eastern side of the Western ghats have less rainfall and are rightly called 'rain-shadow' areas; the rainfall in regions close to the gaps, such as Palghat, is also comparatively less due to escape of moisture-laden clouds through the gaps. While the temporal distribution of rainfall depends on the monsoon winds to a great extent, the spatial distribution depends on the configuration of land, especially the undulating topography of the ghats. The number of annual rainy days also show considerable variation from place to place. For example, Neriamangalam experiences 146 rainy days while just on its eastern

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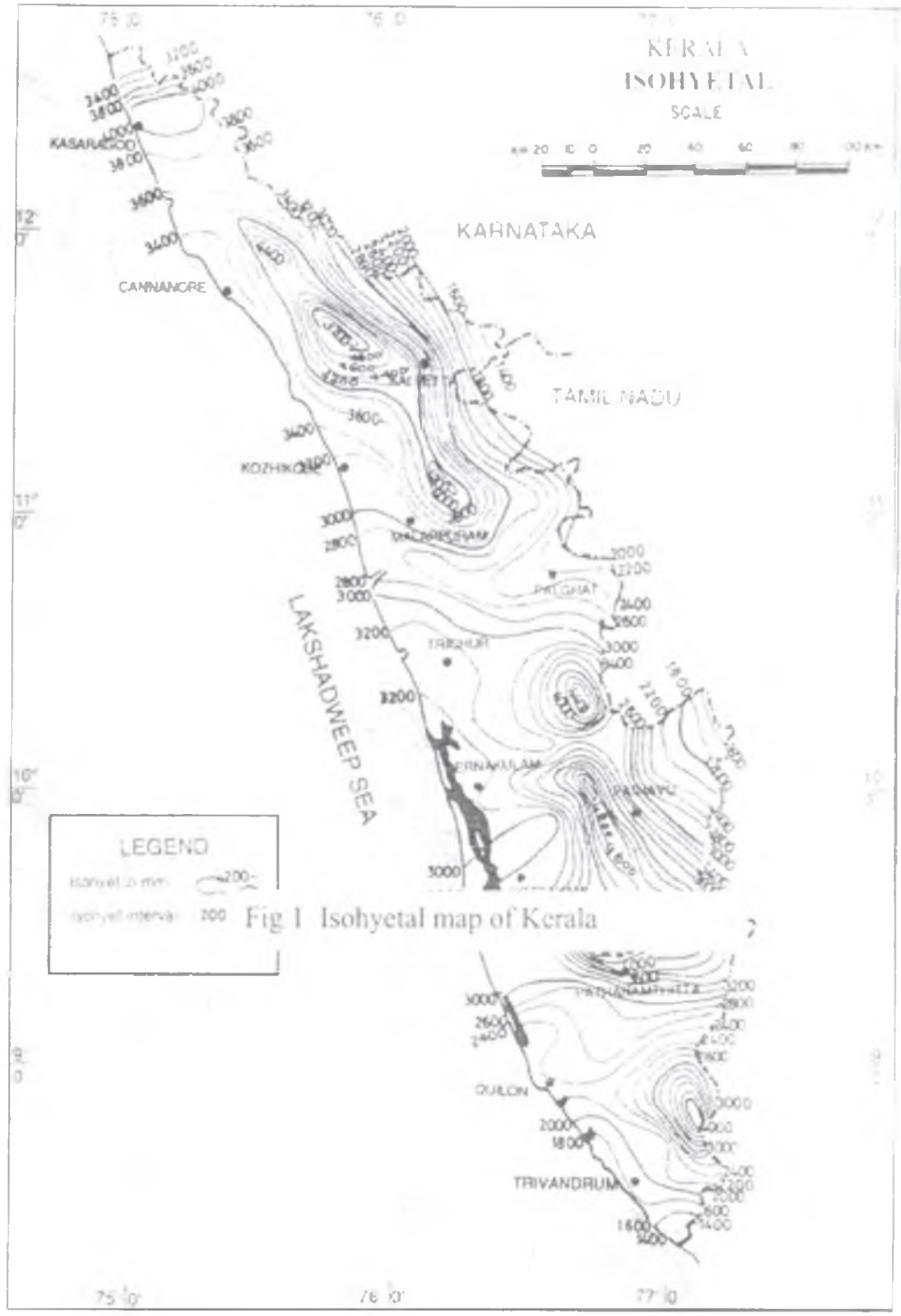

Fig 1 Isohyetal map of Kerala

side, Chinnar gets only 50 rainy days. The flora and fauna of Kerala very much depend on the rainfall pattern and availability of water either as rainfall or as streamflow, soil moisture, groundwater ,etc.

Geomorphology and Geology

Another factor which has a great impact on the hydrology as well as on other related environmental factors is the unique physiography of the region. The average width of the strip is around 50 km and three distinct parallel physiographic zones with more or less the same area are visible (Fig 2): (i) highland (above 75 m from sea level), (ii) midland (between

Fig 2 Physiographic divisions of Kerala

7.5 and 75 m) and lowland (between mean sea level and 7.5 m) (PWD 1974). The lowland is more or less a plain terrain with sediments of recent and sub-recent origin. This area is characterised by a number of estuaries, the west coast canal and typical low-lying areas. Most of the wetlands of the region are in this physiographic zone. Kerala has a thickly populated coastline of about 600 km and around half of this line is prone to coastal erosion. The major crops of this thickly populated lowland are rice and coconut. The areas lying below the mean sea level, especially Kuttanad and *Kol* lands, are also included in this physiographic classification. The midland is characterised by low hills and valleys, forming the unique watersheds or *elas* of Kerala with streams flowing through the valley portion. The lateritic hills and alluvial valleys are representative of these *elas* of midland. The valleys of the *elas* are cultivated with rice and hill slopes with coconut, arecanut, plantains, etc (Fig 3). The highlands are characterised by crystalline rocks of Archaean age with a number of mountain streams. The forests are mainly in the highlands. There has been considerable depletion in forest areas during the past few decades. The landuse in this area has considerably changed; plantation and spice crops have replaced large areas of forests. The studies show that this mono-cropping system has considerable environmental consequences.

Certain Unique Characteristics of Water Sources

There are 44 so called rivers in Kerala of lengths more than 15 km; 41 of them flow towards the west and the remaining 3 flow to the east. Most of these rivers are ephemeral because only input of water is from rainfall, mainly during the monsoons. It is important to note that these rivers are short and their basin areas are comparatively very small (Fig 4). The annual discharge from all the rivers of Kerala put together is estimated to be 78041 million m^3 while a single river like Godavari has an annual discharge of 105000 million m^3 (Rao 1979). In fact, Rao (1982) has stated that in view of the special problems of Kerala, any diversion of water from the west to east is not desirable. The transpiration from the natural trees and plants of uncultivated areas of this humid tropical region is estimated to be very high.

Kerala is one of the most thickly populated States in the country. Traditionally, most of the people were depending on homestead open wells for meeting the domestic water requirements. Even now, density of open wells is very high in Kerala, perhaps the highest in the country, with around 200 wells/km^2 in the midland and lowland (Fig 5) (CWRDM 1995). Even in an urban area like Calicut, more than 50 percent of the population depend on their wells (KARMA 1994). It is estimated that there are around 4.5 million wells in Kerala catering to the domestic water requirement of about two-thirds of the population of the State. The groundwater potential of Kerala is estimated to be around 8000 million m^3. Only a few blocks have been identified as grey.

WATER UTILISATION AND DEMAND FOR DIFFERENT USES

Drinking and Domestic Use

The limitations of the water supply sector of Kerala have been well recognised. There are over a dozen corporations/ municipalities/townships in the State with water supply levels below 70 lpcd (litre/capita/day). Out of the 9763 rural habitats, 228 are classified as Not Covered, 7444 as Partially Covered, 2091 as Fully Covered by pipe water supply. The Government is in the process of handing over all drinking water supply schemes, except the larger ones, to the local governments. Sectoral Reforms are also picking up in the State. Kerala Water Authority is now concentrating on major water supply schemes; Kerala Rural

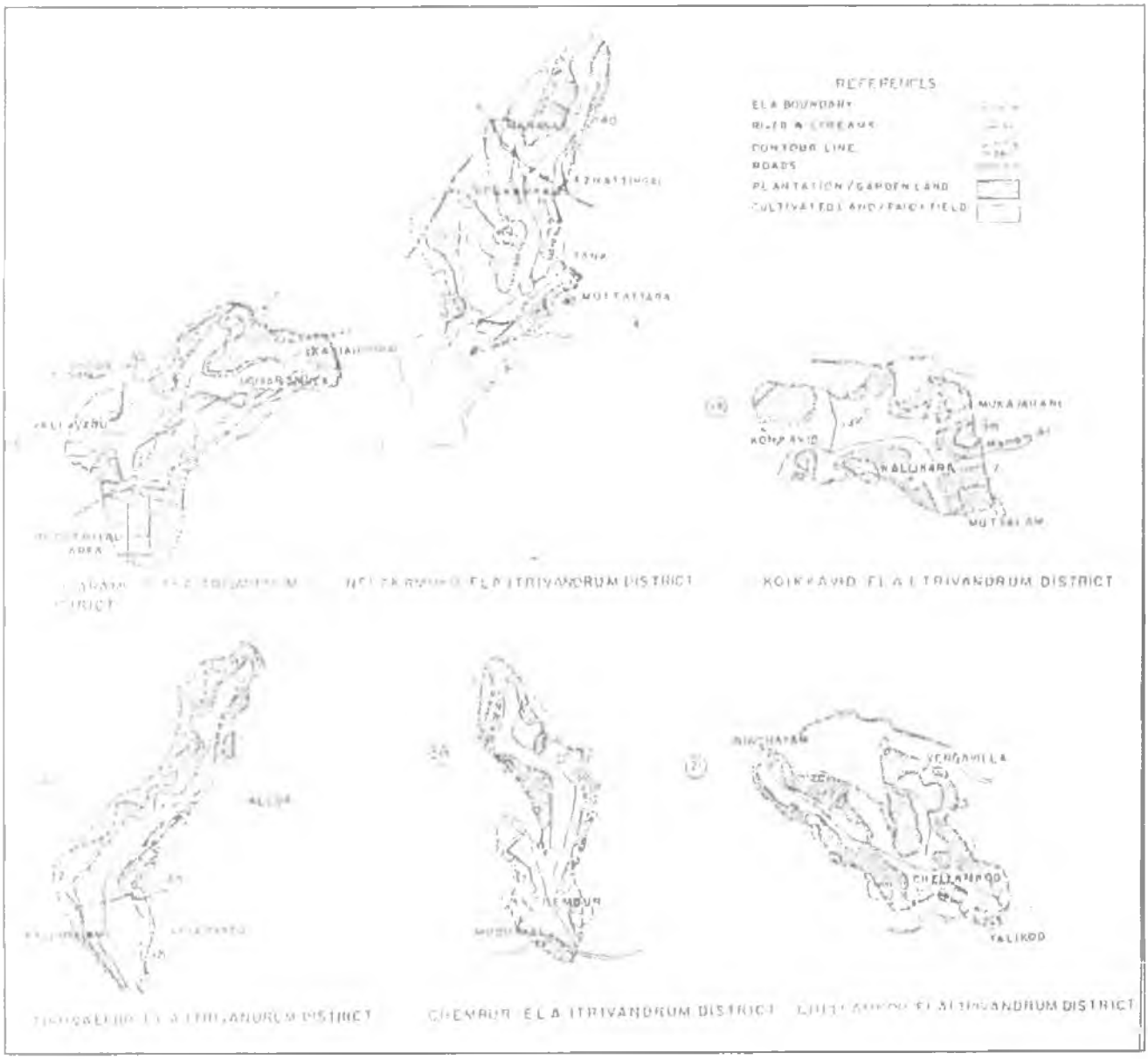

Fig 3 Selected small cultivated watersheds

Code No	Name of River	Code No	Name of River
1	Periyar	23	Anjarakandy
2	Bharathapuzha	24	Keecheri
3	Chaliyar	25	Mahe
4	Pamba	26	Peruvamba
5	Kallada	27	Shiriya
6	Muvattupuzha	28	Puzhakkal
7	Achencoil	29	Pallikkal
8	Chalakudy	30	Nileswar
9	Valapattanam	31	Chittari
10	Kadalundi	32	Kavvayi
11	Meenachil	33	Mogral
12	Karuvannur	34	Tellicherry
13	Manimala	35	Tirur
14	Karamana	36	Mamom
15	Vamanapuram	37	Kallai
16	Ithikkara	38	Manjeswar
17	Korapuzha	39	Uppala
18	Kuttiyadi	40	Ayroor
19	Chandragiri	41	Ramapuram
20	Neyyar	42	Kabbini
21	Kuppam	43	Bhavani
22	Kariangode	44	Pambar

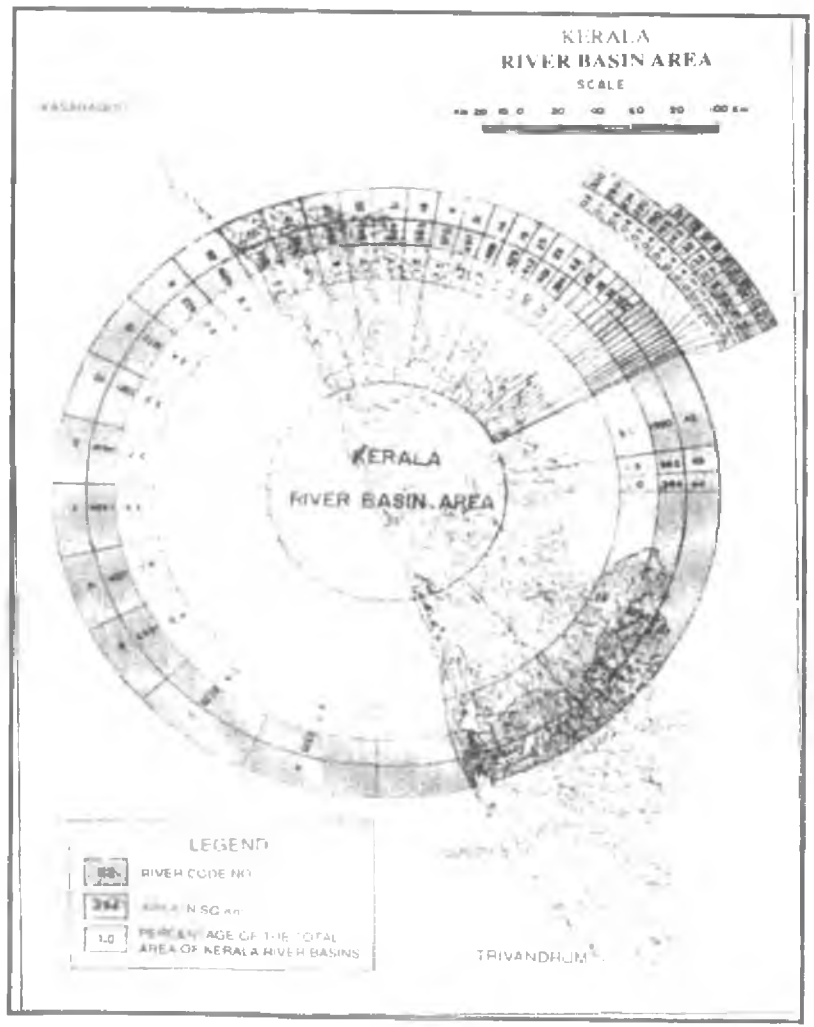

Fig 4 River basin areas

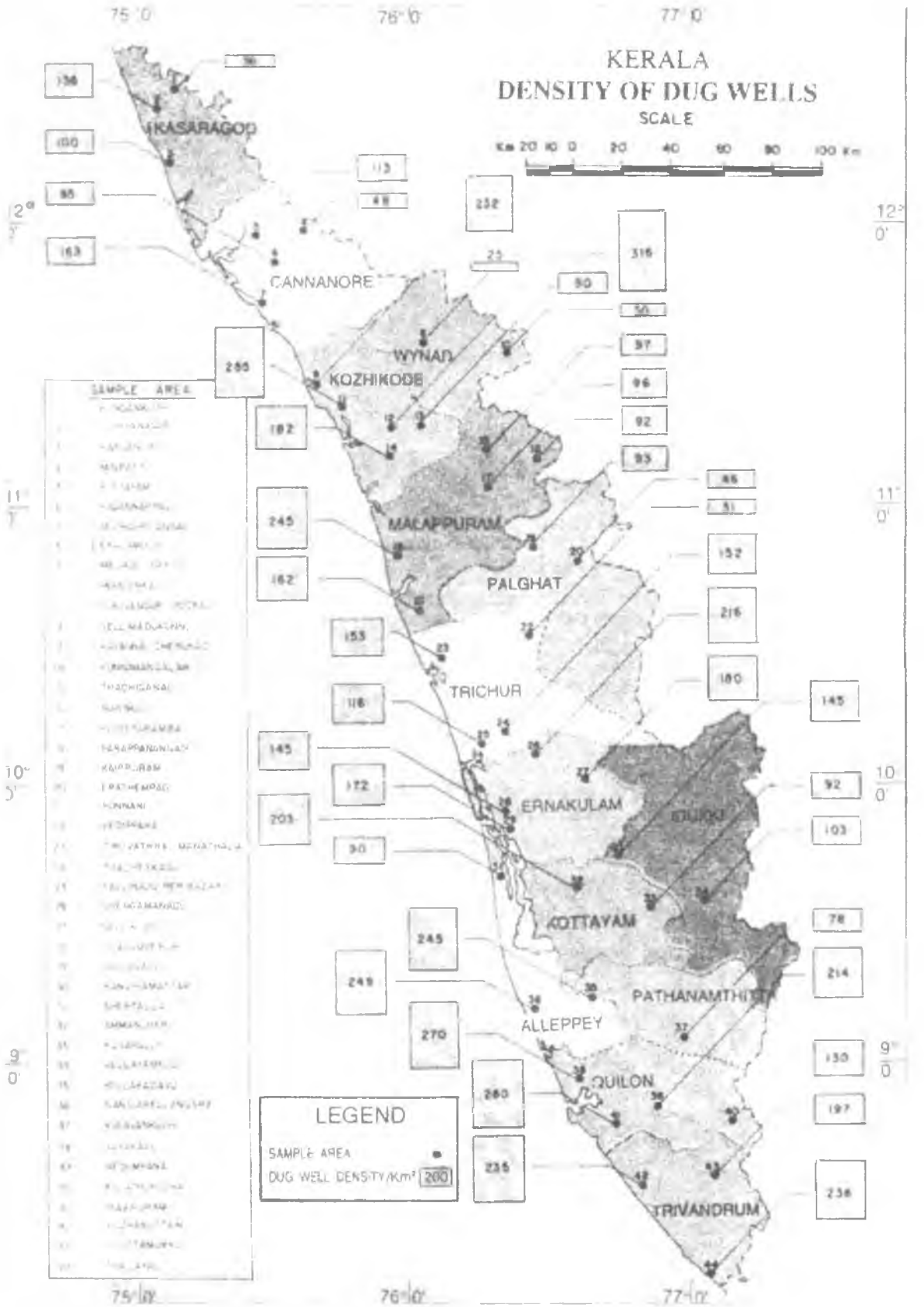

Fig 5 Density of dug wells

Water Supply and Sanitation Agency focuses on water supply systems for small communities; local governments are carrying out schemes based on traditional sources and rain water harvesting; and the Ground Water Department is focusing on drilling of borewells and providing handpumps. In the schemes under KRWSA and Sectoral Reforms, beneficiaries are contributing to the construction and maintenance of the schemes. The necessity to provide domestic water according to the standards specified by BIS has been recognised. At 160 lpcd, the total requirement of the State in this sector is worked out as 6675 mld in 2010. There is a need to rejuvenate/sanitise at least 50 per cent of the open wells to cater to the potable water requirements. Users will have to be encouraged to take up such rejuvenation activities.

In addition to developing the traditional sources like wells, tanks, ponds, springs, *surangams,* etc, roof-top rain water harvesting is also being promoted now-a-days for meeting the domestic water requirements.

Industrial Uses

In order to encourage industrial development, the need to focus on water supply for meeting the industrial requirements has been recognised. There are only limited facilities now to treat the industrial effluents. Recycling of water with the help of effective treatment measures requires consideration.

Agricultural Uses

There is a need for providing irrigation to plantation crops to achieve increase in yield. The net area irrigated in Kerala is estimated to be 3,81,041 ha of which 1,04,967 ha is the command of canals, 7,557 ha that of minor lift irrigation, 49,972 ha that of tanks and ponds, 1,15,703 ha that of wells and 1,02,842 ha that of other sources. Balance area of the existing wetlands to be irrigated is about 2.5 lakh ha and that of gardenland, about 5 lakh ha. The storage capacity of major/medium irrigation projects of Kerala is about 1,500 million m^3. During the past two decades, this figure has been almost constant. There is a need to develop the potential for minor irrigation/local level water resources development since it is environmentally safe and most often very efficient. It is estimated that there is a potential for making water available to 10,00,000 ha through local level water resources development.

Hydroelectric Power

Considering the high hydro-power potential of the State and also the advantages associated with it such as least impact on environment, suitability for meeting the peak demands and the non-consumptive use of water, stress may be given to hydroelectric power development in the State. The total identified hydroelectric power potential of Kerala, including that of the completed small/medium/major projects, is around 5,000 MW. Most of the river basins are yet to be investigated to assess the total hydel potential of the State. The present installed capacity of the hydroelectric projects is 1835 MW. The live storage capacity of the reservoirs of the hydroelectric projects owned by Kerala State Electricity Board is around 3500 million m^3. From these reservoirs, the average water utilisation per year is about 10,000 Mm^3. This quantity is inclusive of the repeated utilisation of the tailrace.

Inland Navigation

The west-flowing rivers offer navigation facility at their lower reaches. In addition to the west coast canal, there are several cross canals and link canals in the State. The total length of the waterways in the State connecting ports, industrial and commercial centres works out to 1,600 km. A stretch of the waterway of the State also has been declared as National Waterway 3. Innovative projects are to be taken up in a time-bound manner to improve the inland waterways in the State, which are in a state of neglect.

Other Sectors

The other water use sectors, which are potential in the Kerala context, are: inland fisheries, aqua-tourism, water sports, etc. The management of biodiversity, especially in the aquatic ecosystems, is a major factor to be considered in the context of Kerala State. The prevention of salinity intrusion and pollution concentration in the water bodies, especially in the coastal belt, can be considered as priorities.

Major/medium irrigation projects and large scale irrigation facilities are only a few decades old (Fig 6). Earlier, plantation crops were irrigated using homestead open wells following basin irrigation. Low-lying areas, especially those cultivated with rice, were in earlier times irrigated by traditional water lifting methods using baskets, buckets, wheels, etc. There is a great scope for developing the traditional sources like tanks, ponds, springs and *surangams* of Kerala.

MAJOR LIMITATIONS IN PLANNING

Limitations Defined

The water resources development and management strategies of the State have not yielded anticipated results, mainly because of the following three factors:

(i) Sufficient data on hydrologic and other related parameters were not available and wherever available or could have been estimated using certain techniques, necessary attention was not given to this basic input for planning;

(ii) Integrated river basin plans were not formulated and projects were taken up in an adhoc and arbitrary basis, and the case was not different in connection with small watersheds also; and

(iii) Most of the projects formulated and executed did not give due consideration to factors pertaining to sociology , economics and environment .

The limitations stated above are illustrated with some examples from the region.

Absence of Hydrologic Data Base

Most of the major/medium irrigation and hydel projects of the State were planned and executed in the absence of sufficient data on streamflow. For formulating atleast some of them, reliable rainfall data from their catchments were not available. The methods and techniques used to derive streamflow information from rainfall were crude. As a result of this, some of the projects were either over-designed or under-designed. Moreover, in the

Fig 6 Major/medium irrigation projects and their command areas

absence of proper data, attempts were made to exaggerate the benefits for justifying the cost and for showing returns. These exercises have again lead to adhoc augmentations, additional works, etc. Proper operation rules could not be evolved in the absence of sufficient information. In the whole process, one may find that not only hydrological but also socio-economic and environmental aspects, which are vital for such projects, have been overlooked. The Central machinery was also perhaps not looking into the merit of the project and their benefits. Sustainability was not at all a criterion in the earlier water resources development ventures in the State. The ill-effects of these decisions have now been recognised by almost all concerned, including the public. Attempts are being made to rectify these problems in a participatory mode.

Lack of Basin Plans

Lack of integrated basin planning and management has lead to a number of problems which have bearings on sustainability and environmental safety. A basin plan is one in which upstream and downstream availability and demand are given weightage; water quantity and quality aspects are given due consideration (James 1991). The basin is considered as a system and different scenarios are simulated. Even for one project, a number of alternatives are worked out and the optimal one selected considering all relevant aspects. These exercises were not carried out in the planning stage of most of the projects.

In the Kerala context, the Periyar basin may be taken up as an example to illustrate the limitations of basin planning. Water from the upper part of the Periyar was permitted to be diverted to the east (present Tamil Nadu) in the last century. For power generation, Idukki reservoir was conceived and executed. The stored water from the Periyar was diverted to Moolamattom power house in the Muvattupuzha basin for gaining more head. Finally, the tail-race joins the Muvattupuzha river. A number of hydel projects upstream along with some irrigation projects downstream came into existence in the Periyar. Though one of them was designed with an objective to allow water for flushing out salinity in summer, it is rarely operated in that mode. All these developments upstream deprived the water availability downstream, for drinking and industrial purposes. The major industrial complex of Kerala, near Alwaye, depends on the lower stretch of Periyar as also a major chunk of population of Greater Cochin and Alwaye areas. Because of unplanned developments, downstream requirements suffered. In order to overcome the problem, adhoc measures, such as construction of barrages to prevent salinity intrusion, were resorted to. Such measures make the river stagnant; pollutants discharged either just upstream or downstream are not flushed out and the regime of the river gets slowly altered. Inland navigation in the stretch is obstructed in summer and the quality of groundwater in the islands downstream gets affected. Such development attracts several litigations and other legal complications; the Panchayats even went to the court questioning the use of sand from the stretch of river in their jurisdiction for constructing temporary barrages. Moreover, the tail-water of Idukki project discharged into a small stream near Moolamattom contributed to bank erosion, and a change in the regime of this streamlet has taken place. This case study illustrates the ill-effects due to lack of basin planning and an integrated management plan. Similar is the case in certain other basins also, though the problems are not as complicated as that of the Periyar.

Socio-economic and Environmental Factors Overlooked

Regarding the social factors, fragmentation of agricultural lands due to legislative measures as well as partitioning of properties among family members, especially in the context of joint families, brought in several limitations to agricultural practices. The use of farm machinery and mechanisation have been almost impossible. The small-size of land holdings did not present an ideal situation for rice cultivation; most of the major/medium and even minor irrigation projects were originally meant for irrigating only rice. Small-size farms could not provide for the livelihood of families, and therefore, most of the farmers went for other occupations and agriculture became part-time occupation for many of them.

The thickly populated State required large areas of land for housing. Most of the people in the area had a tendency to go for houses in independent plots. This resulted in increase in land value and large-scale reclamation of rice fields. Under such circumstances, irrigation projects meant exclusively for rice had no relevance and meaning. Therefore, water resources development for irrigation did not attain all the envisaged goals. Of course, some of these projects have now started catering to plantation crops also. The achievements in the command areas of major/medium projects were not sufficiently encouraging due also to lack of participatory irrigation management.

The Thanneermukkom barrage, constructed to prevent salinity intrusion into the Kuttanad belt, adversely affected the backwater fisheries, and also contributed to the environmental degradation of the area both due to intensive application of agrochemicals and lack of flushing (James 1996). In an area, where agriculture and fisheries were co-existing, these two interests became conflicting. The wise use of this wetland was not achieved.

Socio-economic factors were not fully considered in other sectors also, such as hydro-electric power generation, fisheries, inland navigation, eco-tourism, etc.

No environmental impact assessment was carried out in the case of most of the existing water resources development projects. This has lead to several adverse impacts and even some of these projects are not sustainable. It is in this context that the water related environmental problems of Kerala region have to be analysed.

WATER RELATED PROBLEMS, THEIR CAUSES AND MAGNITUDES

Problems in Nutshell

The important water related environmental problems of Kerala are listed below:

- Frequent floods and droughts
- High rate of sedimentation and debris slides
- Salinity intrusion into rivers and groundwater aquifers
- Lack of flushing and concentration of pollutants, especially in the lower stretches of rivers
- Coastal erosion
- Water logging in command areas

- ❖ Changes in different phases of hydrologic cycle due to large-scale reclamation of wetlands

- ❖ Over-exploitation of groundwater from certain areas

- ❖ Pollution of surface and groundwater sources

Floods, Droughts and Sedimentation

Though it may not be possible to change certain factors contributing to frequent floods and droughts, like spatial and temporal distribution of rainfall, geology , geomorphology etc, it is definitely possible to have a planned landuse as well as development and conservation activities. If proper planning is done with regard to landuse, soil conservation and developmental activities in a river basin, it may be possible to a great extent to control floods, droughts and high rate of sedimentation.

It is reported that during the 1924 floods, most of the areas in the erstwhile Travancore and Cochin States came under water, either under flood water or sea water. The rain continued for 9 days, leading to deaths of hundreds of people and thousands of cattle and other animals. Most of the deaths were reported from the highranges. The year 1961 witnessed not only a long duration flood but also an intensive one, caused by heavy rainfall for 7-10 days in the last week of June. The annual rainfall in 1961 was 56 per cent above the annual mean. The maximum daily rainfall values recorded in 1961 at Calicut, Cochin and Trivandrum are: 234 mm, 186 mm and 136 mm respectively. The highest daily rainfall recorded in the history of rainfall data collection at Calicut, Cochin and Trivandrum are: 470mm (May 19, 1992), 240 mm (April 3, 1991) and 400 mm (October 18, 1964) respectively. In the 1961 floods, the worst affected basin was that of the Periyar. Most of the roads were submerged. More than 100 deaths were reported from different parts of the State. Over 50000 houses were damaged and more than 50000 ha land seriously affected. During the 1992 floods, maximum rainfall was recorded on October 10,1992 at Punalur, 270 mm. The floods took away about 100 lives; 7500 houses were washed away. The total loss to the State due to this flood is estimated to be above Rs 1000 crores. On July 10, 1997, 279 mm of rainfall was recorded in 24 hours in Calicut city, which lead to severe floods.

Though the existing reservoirs are not originally intended to contain floods, they can be operated in such a manner that they contain atleast a small portion of flood waters during critical times. Certain multi-purpose projects with capabilities to contain floods also may be planned for future, upstream of highly flood-prone areas.

The Western ghats region, especially in Idukki and Wynad districts, are more prone to the debris flow or the so called 'landslides'. On an average, 5 people die every year due to debris flows. Some of the recent debris flows were in Moolamattom (September 1988), Illappilli (October 1991) and Adimali (July 1997) in central Kerala and Padinjarathara (June 1992), Pazhukadavu (June 1992) and Adakkakundu (Jun 1993) in northern Kerala. A recent debris flow in Trivandrum district caused considerable havoc including death of several members of a family, who assembled there for a function.

The water scarcity in summer, identified as droughts, is mainly reflected in dry rivers and lowering of water table. This adversely affects the drinking water sector. During the drought

years, 15-20 per cent of the homestead open wells dry up, affecting about 3 million people. Most of the larger water supply schemes depend on surface water sources. When these sources either dry up or do not yield water to the requirements, most of the drinking water supply schemes fail to cater to the requirements of the people. In addition, it has impact on agriculture and to some extent on hydro-electric power generation. Not only rice crop but also plantation and spice crops of Kerala get affected during dry years; in some cases, perennial crops totally perish. The drought conditions in the Bharathapuzha basin during 1983 and 1987 can be used as an illustration. Damage due to water scarcity is given in Tables 1 and 2. The droughts experienced in 2003-04 have caused considerable hardship to local people and have damaged large areas under perennial crops in the State. The fluctuations in annual rainfall and seasonal groundwater table in Kozhikode district, as an example, are given in Figs 7 and 8.

The studies on forest hydrology (James et al 1987) have shown that:

i) One-hour unit hydrograph of dense forest catchments of 2 km^2 area has a lag time which is 35% more than that of exploited catchments and this indicates that soil moisture and groundwater storage in the initial period of a storm is high in forest catchments (Fig 9);

ii) The behaviour of hydrographs also establishes that the vegetal growth smoothens the peak flow, thereby taming flash floods;

ii) The streamflows in dense forest catchments of 2 km^2 area were found to be perennial, while in the partially exploited catchments the flows stopped in February and in fully exploited ones in December;

iii) The soil moisture attained its maximum value during north-east monsoon period, especially in the month of November, which finding is corroborated by maximum values of runoff coefficients only in late November;

v) The role of vegetation in recharging groundwater table also has been observed;

vi) The studies in Silent Valley show that density of stream channels is less in thickly vegetated areas; and

vii) The observations on sediment accumulation have brought to light that the sediment accumulation from dense forest catchments is only one-sixth of that of fully exploited catchments (Fig 10).

The results of studies show that vegetation has a major role to play in controlling floods and sediment yield from the catchments, and also in maintaining groundwater level and soil moisture content. The studies on forest hydrology also throw light on the interception losses for typical forest areas in Kerala; about 10% of rainfall is lost as interception asvaporation of rainwater collected on leaves/canopy.

The high rate of sedimentation from the Western ghats is mainly due to the changes in vegetation pattern and various developmental activities, such as construction of buildings, roads etc. From the studies conducted at CWRDM, it is indicated that the average sediment

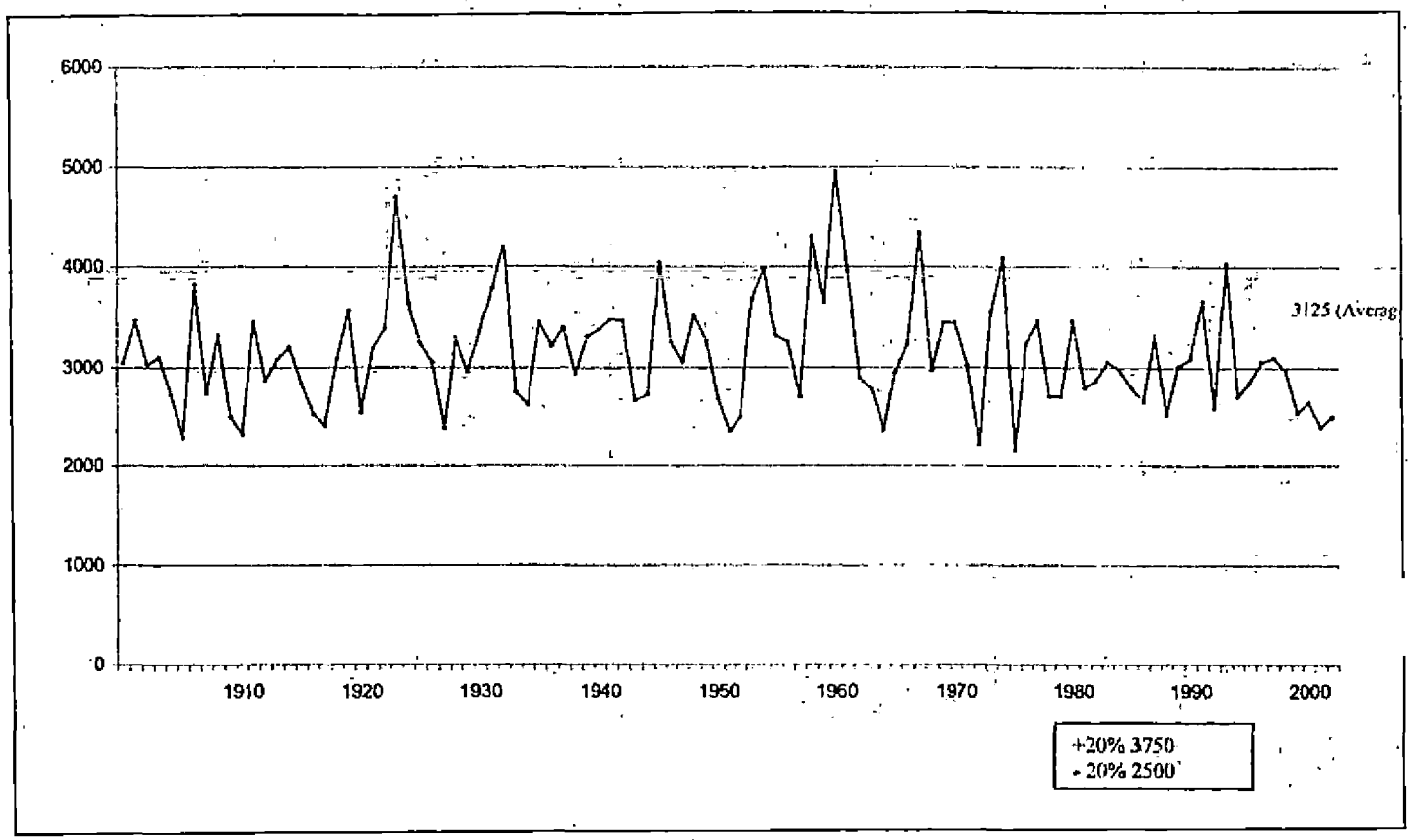

Fig 7 Rainfall variation in Calicut

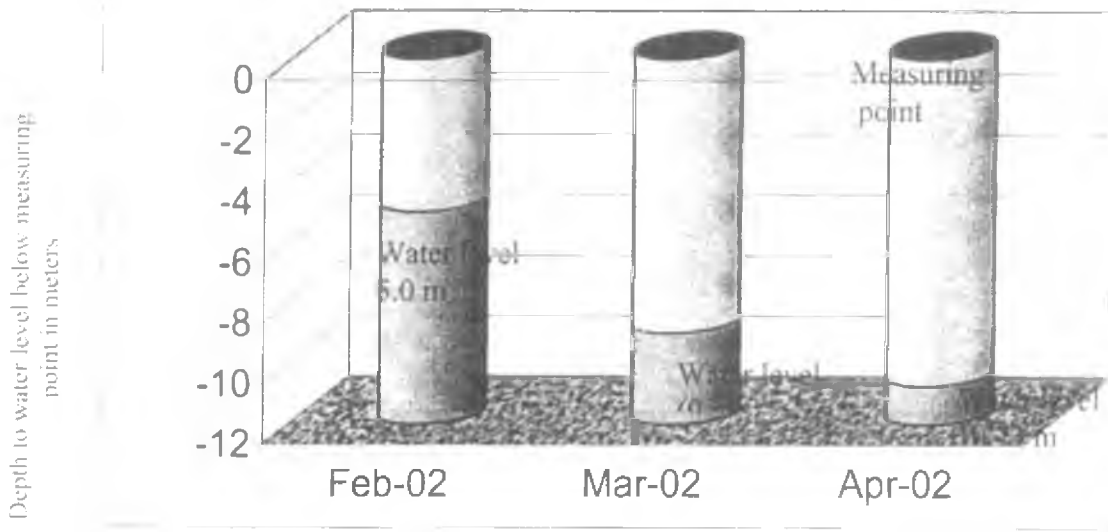

Fig 8 Groundwater fluctuation in Pantheerankavu, Kozhikode

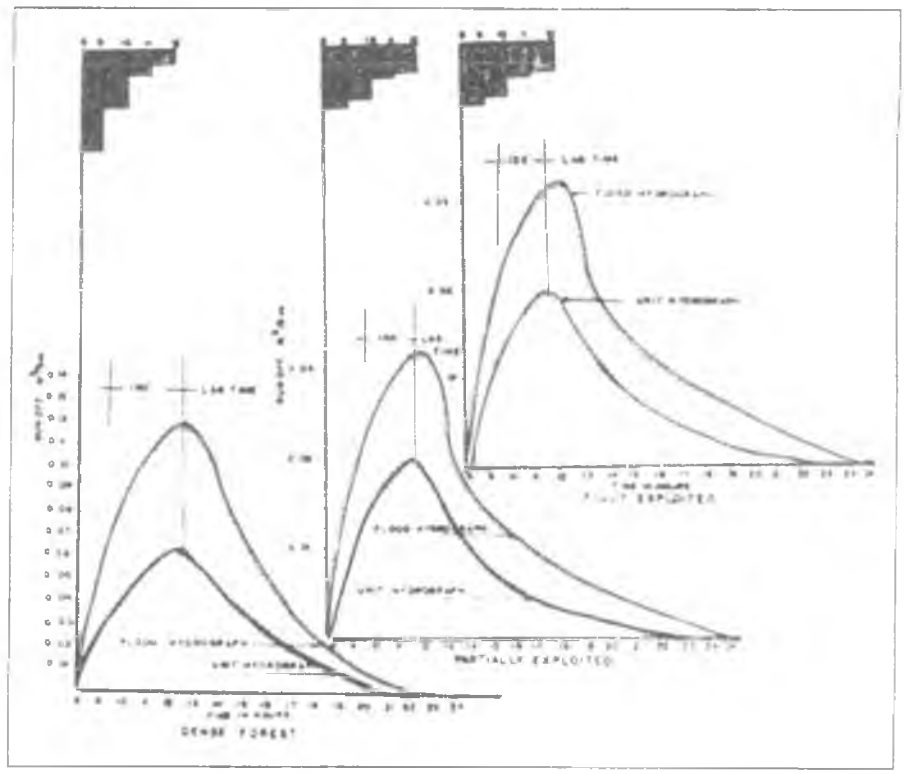

Fig 9 Unit hydrograph - 1 hour duration

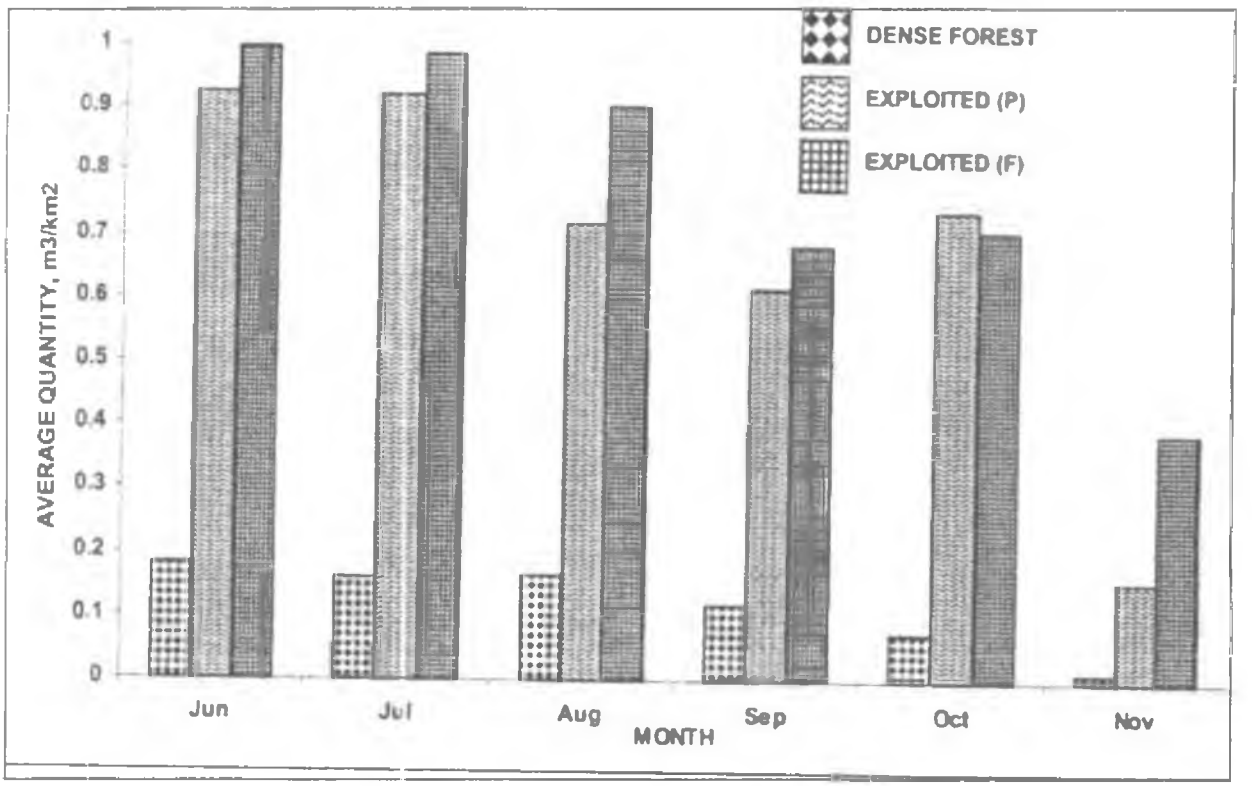

Fig 10 Accumulated sediment load

yield from the Western ghats is 15-20 tonnes/ha/year (CWRDM 1992). An integrated watershed management practice may be one of the solutions to conserve soil and water.

Fig 11 gives a histogram of streamflow at a site in Bharathapuzha; it is seen that the summer flows are considerably less than the monsoon flows (CWRDM 1987). Fig 12 gives the flow duration curve for two in the same river; it is indicated that availability in time has limitations. Fig 13 gives a typical weekly flow hydrograph for a watershed of 4 km^2, as an example (CWRDM 1990). Fig 14 gives a flood frequency curve evolved for the State (James et al 1992); the return periods can be estimated from this. Fig 15 shows the reduction in capacity of the Peruvannamuzhi reservoir of an irrigation project, due to sediment deposition (CWRDM 1992).

Salinity Intrusion

The State of Kerala with an average width of slightly over 50 km has 44 rivers, of which 41 originate from the Western ghats and flow to the Lakshadweep sea. These short, fast-flowing, monsoon-fed rivers often encounter salinity intrusion into their lower stretches during the summer months. When the fresh water flow reduces, two major problems are encountered in these water bodies: (i) salinity propagates more into the interior of the river, and (ii) the flushing of the system becomes less effective. Both these aspects have an impact on irrigation, drinking and industrial water supply schemes situated in the downstream reaches (James 1996). Detailed investigations have been carried out to understand the mixing and circulation at the river mouths in south-west India (James 1989). The coastal belt is the most thickly populated area on this coast with the density in certain pockets reaching upto 5000/km^2. Important cities like Greater Cochin, Calicut, etc are situated in the coastal belt, on the banks of estuaries.

Based on the studies conducted with the help of mathematical models, it is found that the salinity in the Beypore estuary propagates to a distance of 24 km upstream, thereby creating problems to the water supply scheme to the Calicut corporation area (Fig 16) (James and Sreedharan 1983); the flushing time in summer from a distance of 20 km from the mouth is 20 days and more, creating pollution concentration in the lower stretches. These problems are acute in some of the estuaries nearby important cities and industrial complexes. Problems of salinity intrusion are also encountered in the Periyar, Meenachil and Kuttiyadi rivers, which have been studied in detail (James 1985).

The present measures for preventing salinity intrusion into the intake points of drinking water supply schemes is by the construction of temporary barrages, which prevent the flow and create ecological problems, especially concentration of pollutants upstream of the obstruction. Areas upstream of Thanneermukkom barrage in the Vembanad and Pathalam barrage in the Periyar are typical examples (James 1996 a).

It has also been observed that over-exploitation of groundwater in certain coastal stretches has contributed to entry of salinity into the coastal aquifers from the sea. Though this tendency is mainly observed during the summer months, when recharge is practically zero, there is a possibility for perpetuation of the problem due to increase in withdrawal rate to cater to the requirements of dense coastal population.

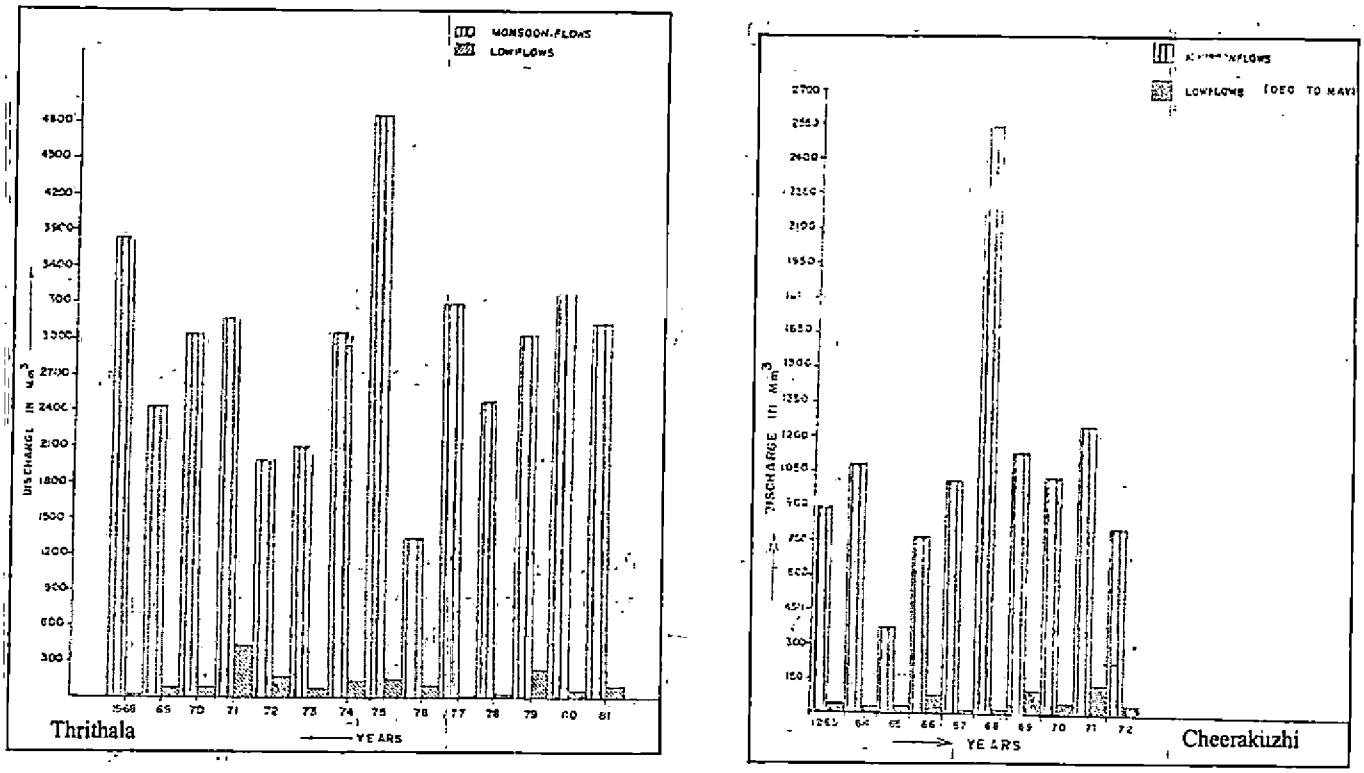

Fig 11 Histograms of streamflow for two stations in Bharathapuzha

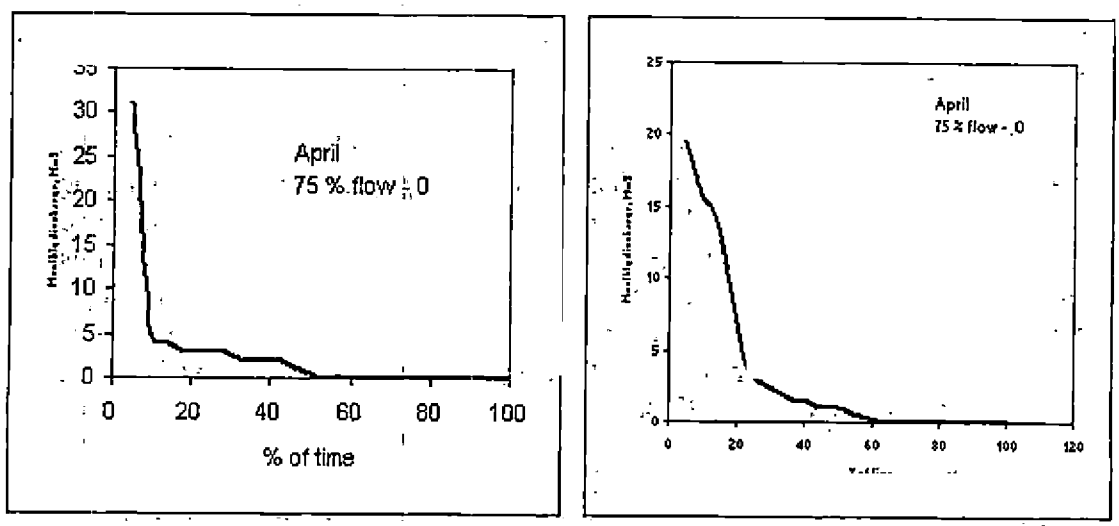

Fig 12 Flow duration curves for two stations Cheerakuzhi and Thiruvegapura in Bharathapuzha basin

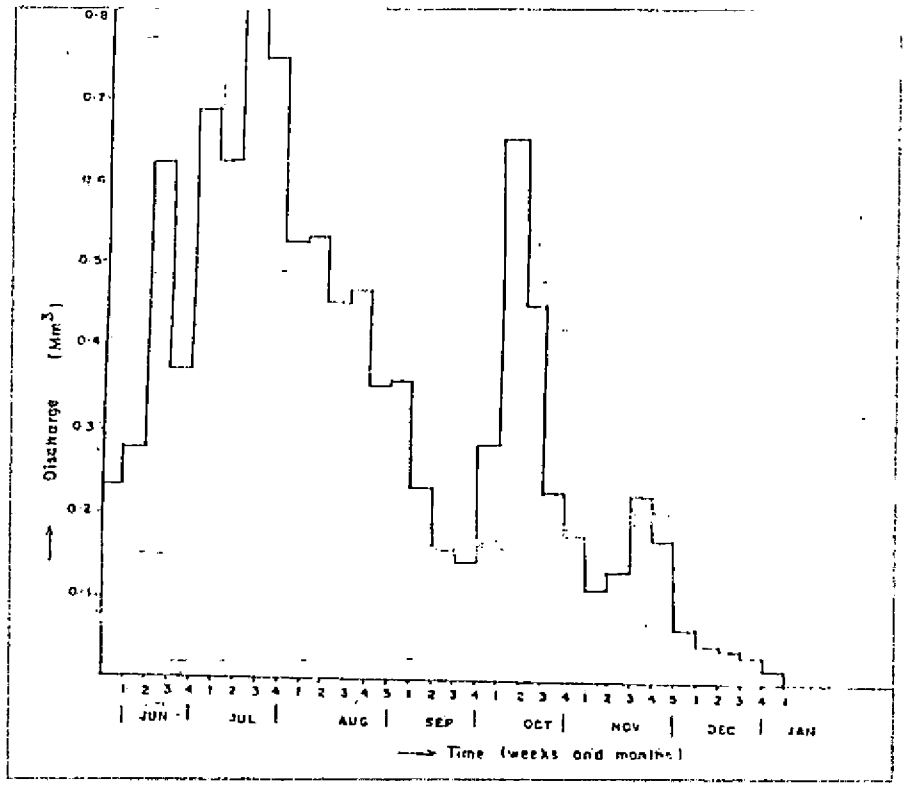

Fig 13 A typical weekly flow hydrograph for a small watershed of 3 sq km in Calicut

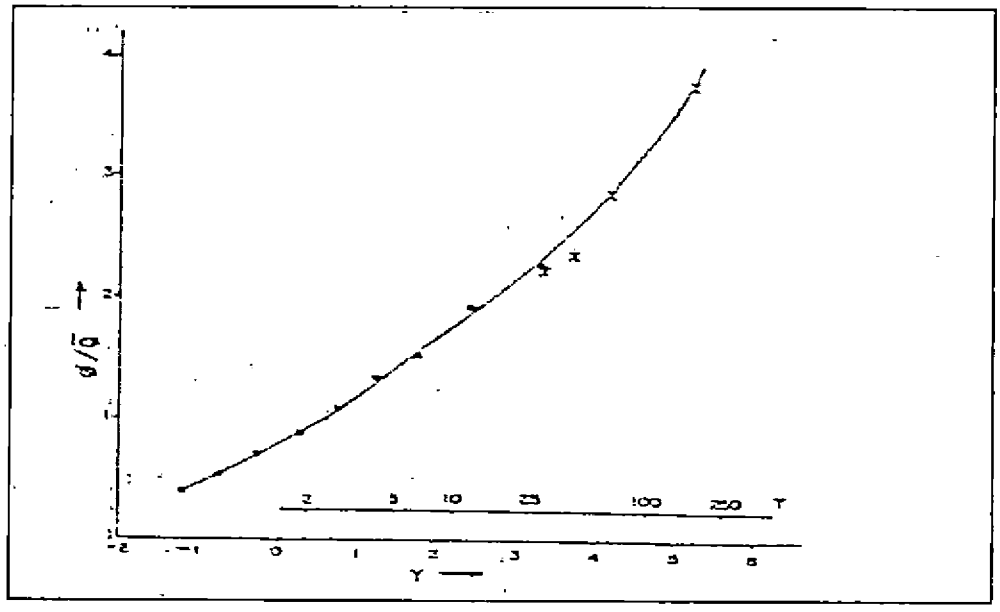

Fig 14 A flood frequency curve for the State

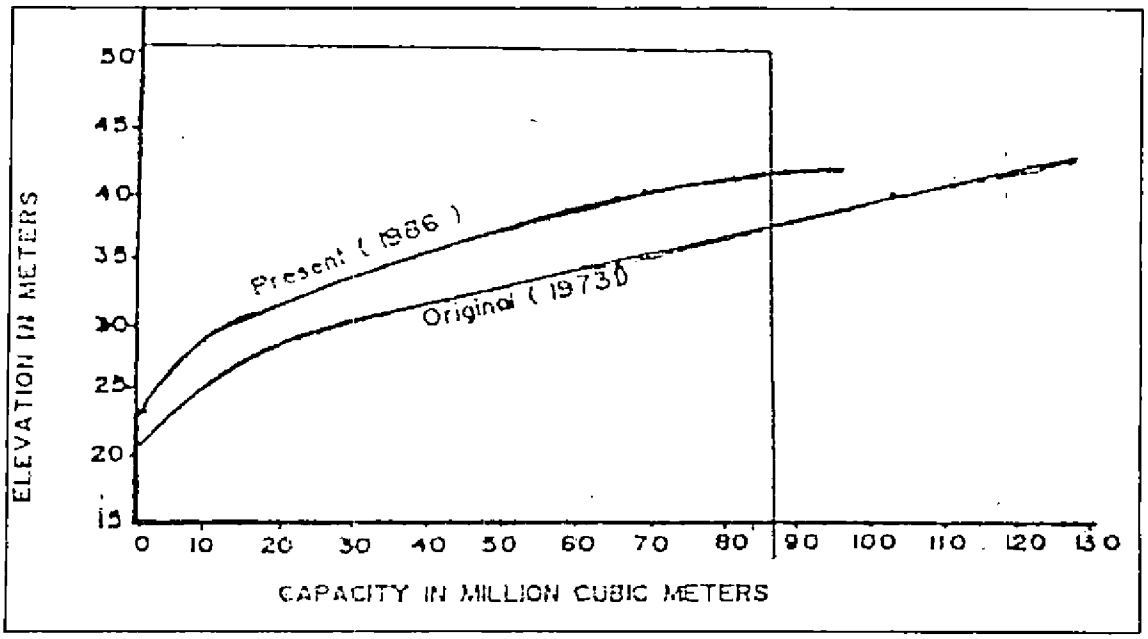

Fig 15 Reduction in the capacity of Peruvannamuzhi reservoir

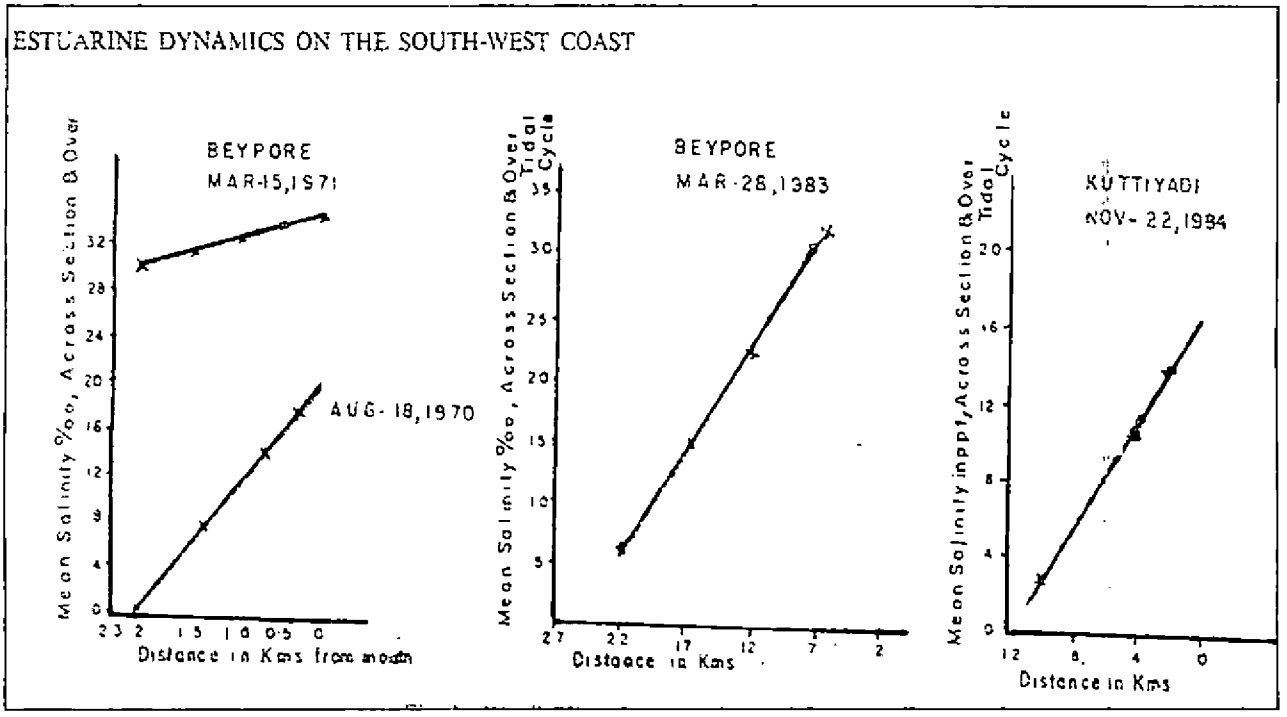

Fig 16 Calculated distribution of salinity in the Beypore and Kuttiyadi estuaries

Coastal Erosion

Out of the 560 km straight stretch of Kerala coast, about 370 km is subject to coastal erosion of various magnitudes (Fig 17). Comparison surveys for 36 km length of shore in two sections show that there is consistent retrogression of shoreline during the past one and a half century, which works out to an yearly rate of 5.2 m at Chellanam and 3.1 m at Thottappilly; seasonal change of shoreline is also observed (PWD 1974). Erosion is generally observed during May-September, followed by a period of accretion.

Coastal erosion is due to the material energy imbalance caused by various forces, natural and artificial, in action on the coast. The causes of severe coastal erosion in Kerala are due to one or a combination of the following factors:

i) early onslaught of monsoon and subsequent high and steep waves, and rise in water level
ii) turbulent zones near Lakshadweep
iii) geological factors
iv) sea level rise
v) level of backshore
vi) lack of littoral supply
vii) laterite cliff erosion
viii) reaction of beach to protection works, etc.

The erosion tendencies may increase with man-made activities, such as urbanisation, construction of dams, prevention of soil erosion in the midland and highland belts, development of harbours, etc (Baba 1979).

The mudbanks play a decisive role in the stability of Kerala shore: (i) trapping the littoral material and erosion of the down-drift region, (ii) accretion in the mudbank area, and (iii) refraction and diffraction on its sides. It is observed that the areas seriously subjected to erosion are those on the southern sides of the mudbanks.

Waterlogging

Waterlogging in the commands of major/medium irrigation projects is a known problem and is a global one. In a country like India, 6 million ha is waterlogged while the irrigation potential created is only 56 million ha. Though a reliable estimate on waterlogged areas in the commands of major/medium irrigation projects in Kerala is not available, it has been observed that only around 400 ha of land in the commands of Malampuzha and Kuttiyadi irrigation projects are waterlogged; this is based on one of the research projects carried out in the Centre for Water Resources Development and Management. The problem as such is not very severe at present. In a State like Kerala, with dense population and high land value, waterlogging problem has to be given due attention.

Waterlogging caused by irrigation are due to: (i) high density of irrigation, (ii) wrong and defective methods of irrigation, (iii) improper maintenance of natural channels, (iv) hydraulic pressures from saturated areas at higher elevations, (v) heavy seepage losses from canals, (vi) absence of drainage canals in irrigated areas, (vii) silting of canals and vegetal growth.

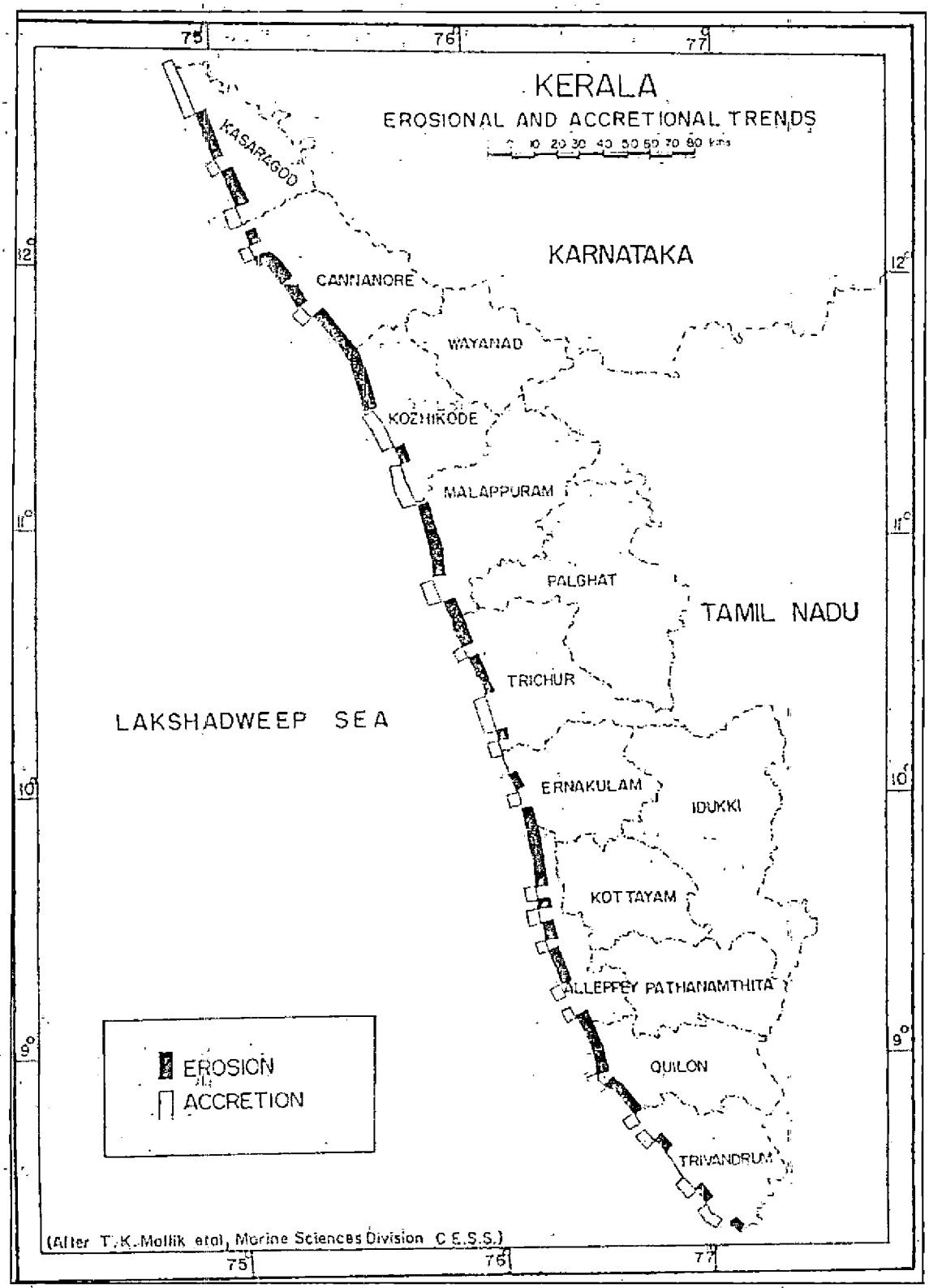

Fig 17 Locations of erosion and accretion on the Kerala coast.

Hydrologic Modification to Wetlands

Wetlands help in controlling floods, recharging groundwater and maintaining water quality. Considering the role of wetlands as source, sink and transformer, these are called the 'kidneys of nature'. Ditching and draining are hydrologic modifications to wetlands, specifically carried out to dry them out. Reclamations destroy or change the character of most of the wetlands of Kerala.

Canals and ditches are dredged for three primary purposes: (i) flood control, (ii) navigation and transportation, and (iii) industrial activity. Large-scale reclamation works are mainly for human settlements, cultivating plantation crops and construction of roads and industrial complexes. Other human activities also have caused significant changes to the wetlands. These changes lead to land clearing and subsequent erosion, through hydrological modifications such as stream channelisation and dam construction. Increase in erosion in the uplands leads to increased deposition of sediments in the wetlands, such as forested swamps and coastal marshes. This increased accumulation of sediments can cause increased bio-chemical oxygen demand (BOD) and can alter the hydrologic regime of the wetlands over a relatively short time. Stream channelisation and dams can lead to a change in the flooding frequency of many wetlands and thus alter the input of nutrients. Dams generally serve as nutrient traps, retaining materials that would otherwise nourish downstream wetlands. Impoundments upstream reduce the downstream flows considerably during the summer months and enhance the salinity intrusion problem. In some areas, stream channelisation has lead to stream down-cutting that ultimately drains wetlands.

Most of the rice fields in Kerala are reclaimed for settlements, industrial purposes and cultivation of plantation crops. Around 30 per cent decrease in the area of rice fields are observed during the past one decade and a half. The present trends indicate that there will be a total disappearance of rice fields by the first decade of the present century.

The case study of the Vembanad backwater may serve to illustrate the reclamation tendencies of wetlands in Kerala. Shrinkage of Vembanad wetland to 37 per cent of its original area due to land reclamation has been the most important environmental consequence of human intervention in this water body. About 23105 ha land has been reclaimed from the backwater during 1834-1984. Incentive given by the government after the Second World War by way of interest-free loans for intensive rice cultivation initiated reclamation activities. During the period from 1941 to 1950, almost all shallow regions of the wetland were reclaimed by constructing 'bunds'; or embankments. It is estimated that 21 per cent reclamation took place during the span of last 15 years. The depth reduced by 40-50 per cent in all zones, except between Aroor and Wellingdon Island and the Cochin port zone. The water carrying capacity of the system reduced to 0.6 km^3 from 2.4 km^3; this has several adverse impacts on the flood absorption capacity of the wetland.

Over-exploration of Groundwater in Certain Hydrogeological Zones

It has been reported that over-exploitation of groundwater in certain hydrogeological zones has contributed to permanent lowering of water table and salinity intrusion into coastal aquifers. The midland and lowland belts have an average of 200 open wells per square kilometre in atleast some of the areas surveyed. There are some areas in Kerala where bore wells withdraw water directly from the water table. This has been observed from some areas

near Calicut corporation, resulting in excessive lowering of groundwater table. It is also noticed that uncontrolled sand removal from the river beds also results in lowering of groundwater table in the nearby areas.

Pollution of Surface and Groundwater Sources

The Periyar, one of the largest river systems of Kerala, is considerably polluted with effluents discharged from major industries located on the banks. These industries discharge hazardous pollutants like phosphates, sulphides, ammoniacal N, fluorides, heavy metals, and insecticides into the downstream reaches of the river. Apart from major industries, coir-retting by conventional methods also adds to the pollution. A temporary barrage is constructed in summer at Pathalam in one of the branches of Periyar, to prevent salinity intrusion into the upstream reaches. The enormous quantities of wastewater discharged daily into this branch of the river (around 10 million m^3) is not flushed out, leading to stagnation and pollution build-up to high toxic levels. This water is found to be highly acidic (pH 1.9), loaded with ammonia, flourides and phosphates, resulting in massive fishkills.

The Vembanad backwater system is a receptacle of a large variety of industrial effluents, domestic sewage from Cochin and a string of small towns nearby. Cochin city alone generates 2550 million litres/day of wastewater that directly enters into the backwater untreated. Total dissolved solid content of water in this zone is as high as 53750 mg/litre during summer and comes down to 160 mg/litre during the rainy season when the flushing is much better. The existing sewage treatment plant in Cochin covers only a small fraction of the population. The pollution load from Cochin corporation and Alappuzha town are 1,95547 kg/day of BOD and 64,237 kg/day of BOD respectively. Annual fertilizer consumption in Kuttanad is: 8409 tonnes of N, 5044 tonnes of P and 6786 tonnes of K. Pesticides/fungicides/weedicides are applied to the tune of about 500 tonnes/annum.

The observations in the Vembanad backwater system indicate that faecal coliform bacteria is very high. The quality of water is very poor near Alappuzha ammonium concentration went upto 2 mg/litre and nitrate values upto 30 mg/litre.

The other water bodies in the State have also started showing symptoms of pollution; the Chaliyar is yet another example. The Sasthamkotta lake and Pookot lake also need close watch and monitoring. The pollution of groundwater sources, especially bacteriological contamination, are reported from certain urban areas in Kerala. Once polluted, it will be very difficult to improve the quality of groundwater sources.

MANAGEMENT STRATEGIES

Data Requirements

Necessary data on hydrologic and other related parameters, especially water quality status, are not available for proper planning and management of the water resources of the State. No attempt has so far been made to prepare integrated river basin plans considering the availability of water, its demand as well as socio-economic and environmental factors. There has been no co-ordination in the water related activities of a single basin, thereby depriving certain reaches of either required quantity or quality of water. Most of the major/medium projects have been executed without carrying out detailed environmental impact assessment.

be classified under: (i) physical system, (ii) biological system consisting of aquatic and terrestrial subsystems, and (iii) human system consisting of production and socio-cultural subsystems. All the data collected from the field and generated by mathematical models are to be made use of to develop a Geographical Information System (GIS) in order to achieve proper planning and management of water resources systems.

Solving Drinking Water Problems

The drinking water and sanitation sectors deserve immediate concern from the point of view of a clean environment. About 70 per cent of the population of Kerala depend on homestead open wells for drinking water . The estimates show that about 15 per cent of the villages in Kerala do not get any benefit of protected water supply. In partially covered areas, 15 per cent get only less than 10 litre/day and 55 per cent get less than 20 litre/day. If the State moves in the same pace, it will take more than 50 years to provide safe drinking water for the entire population, for which it will cost Rs 3000 crores at the present rate. Considering these aspects, it is suggested that safe drinking water may be provided only in areas where available well water is not capable of catering to the needs. In areas with wells which dry up in summer, water supply can be restricted to only summer months. Areas requiring immediate attention can be made out from the records pertaining to lorry supply of water. The projects are to be repaired and maintained by ensuring user participation. Enhancing the capabilities of a scheme, mostly to upgrade from one level of supply to another (stand pipes to yard pipes or yard pipes to house connections), has to be done by the people themselves. The selection of a sustainable source, whether it is a well, stream, spring or tank, has to be done after scientific investigations. Existing two dozen or so reservoirs, meant for irrigation and hydel power generation may also cater to the drinking water requirements, though they have not been originally designed for this. The purpose should be to provide water to more people than to a few at a higher level of supply. It is observed that lack of sanitation measures in Kerala is responsible for contamination of many a drinking water source.

Controlling Salinity Intrusion

The salinity intrusion into the lower reaches of west-flowing rivers during summer months causes problems to irrigation, drinking water and industrial water supply schemes. It will be ideal if flows are maintained in summer by natural or artificial means to reduce this problem. The present practice of constructing temporary barrages, obstructing the entire flow and flushing, is not desirable. If required, submerged barrages or barrages with gates can be adopted to control salinity intrusion problem. If river basin plans are evolved considering the downstream requirements, the salinity intrusion can be checked to a great extent. Necessary provision for flushing out the pollutants also may be incorporated right at the planning stage. The groundwater sources in the coastal belt also may be utilized very carefully so that salinity intrusion problem does not crop up in this thickly populated belt.

Preventing Coastal Erosion

It is estimated that 370 km of the coast of Kerala is vulnerable to erosion. Though structural measures have helped in preventing coastal erosion to a certain extent, a few limitations are pointed out. These include removal of sand through backwash from the beach in front of the wall undermining the sand from the bottom of the sea wall, and damage to armours by breaking of waves over the sea wall.

There is a need to assess the performance of existing coastal protection works, especially since a few of them have served for 100 years; some have failed within a short period; and some others are reported to cause problems to the coastal belt. These structures are highly expensive, and therefore, economical designs will have to be evolved causing minimum problems to the coastal environment. Studies may also be carried out to find out methods and techniques which are inexpensive, simple and which may require only local materials for construction. The performance of biological barriers for coastal protection may also be evaluated. Artificial nourishment has proved to be successful for the Kerala coast.

The coastal zone management strategies will of course reduce the losses due to erosion; the possibilities for a sea level rise also may have to be kept in mind while formulating management plans.

Management of Wetlanc

The wetlands are mainly used for the following purposes in the State:

(i) Agriculture,
(ii) Pisciculture,
(iii) Reclamation for housing and industrial purposes,
(iv) Disposing of waste materials,
(v) Discharging industrial effluents and municipal wastewater,
(vi) Wood seasoning,
(vii) Feeding waters for ducks,
(viii) Dumping dredged spoil,
(ix) Coir retting, and
(x) Recreational purposes such as hunting and fishing.

The wetland management so far concentrated only on the water body as such. The need for integrated management, considering the river basins, has been recognized (James 1994). Only such an approach can lead to the wise use of these important water bodies of Kerala. A management strategy should be developed for the wetlands such that there is a control over discharging industrial effluents and municipal wastewater and disposing waste materials into the wetlands. Reclamation of wetlands for industrial, settlement and plantation crop cultivation purposes should be restricted by strict licensing measures. Dredging of wetlands should not be encouraged.

The action plans for wetland ecosystem, recommended by the National Wetland Management Committee, include: (i) survey and documentation; (ii) weed control; (iii) notification of the wetland as an ecosystem selected for conservation and development; (v) erosion control-catchment area treatment, checkdam construction, limited dredging. regulation of inflows and outflows; (v) pollution control from habitats, industry and agriculture; (vi) limiting the fish catch; and (vii) awareness programmes.

River Basin/Watershed Management

A river basin or a watershed is a natural integrator of all hydrologic processes within its boundaries, and therefore, may be considered as the logical physical unit for planning

optimum development of soil and water . The lack of such a planning is reflected in many of the river basin development projects in Kerala, which have caused a number of socio-economic and environmental problems. Therefore, an integrated river basin planning and a coordination among all concerned agencies are called for. The State Water Policy of Kerala also envisages such an integrated basin planning (State Water Policy 1992). It is also desirable that a River Authority is established in the State for achieving integrated development and management of the river basins. Such a body will also ensure coordination among the user departments. The new trends in the development of water resources are reflected in Fig 18.

Since more and more stress is on micro-level planning and small water resources development projects, there is a need to view small watershed management with the following objectives (Chow 1964):

(i) To protect the land against all forms of soil deterioration;
(ii) To rebuild eroded and depleted soils;
(iii) To build-up soil fertility;
(iv) To stabilise critical runoff and sediment producing areas;
(v) To conserve grasslands, woodlands, and wildlife lands;
(vi) To conserve water for beneficial use;
(vii) To provide needed drainage and irrigation; and
(viii) To reduce flood and sediment damage.

Several field applications, which may be followed in agricultural watersheds, are:

(i) Terraces and diversions,
(ii) Grass covered water ways,
(iii) Graded stabilization structures,
(iv) Farm and estate ponds,
(v) Structures for temporary flood water storage,
(vi) Channel works,
(vii) Drainage practices,
(viii) Subsurface dams, etc (Dept of Agriculture 1990).

The choice of the management practice will depend on the information on different phases of the hydrologic cycle. A coordinated effort of engineers, agronomists, silviculturists, farmers, geologists, hydrogeologists and economists is called for an integrated management venture. These activities in the long run is expected to lead to sustainability (Fig 19).

In the Kerala context, concerted effort is required to make optimum use of the created irrigation and hydel potential. The major/medium projects already taken up may be completed on a priority basis. However, scientific operation rules may be introduced for achieving optimal use of the created potential. While taking up future projects, detailed Environmental Impact Assessment (EIA) is a necessity.

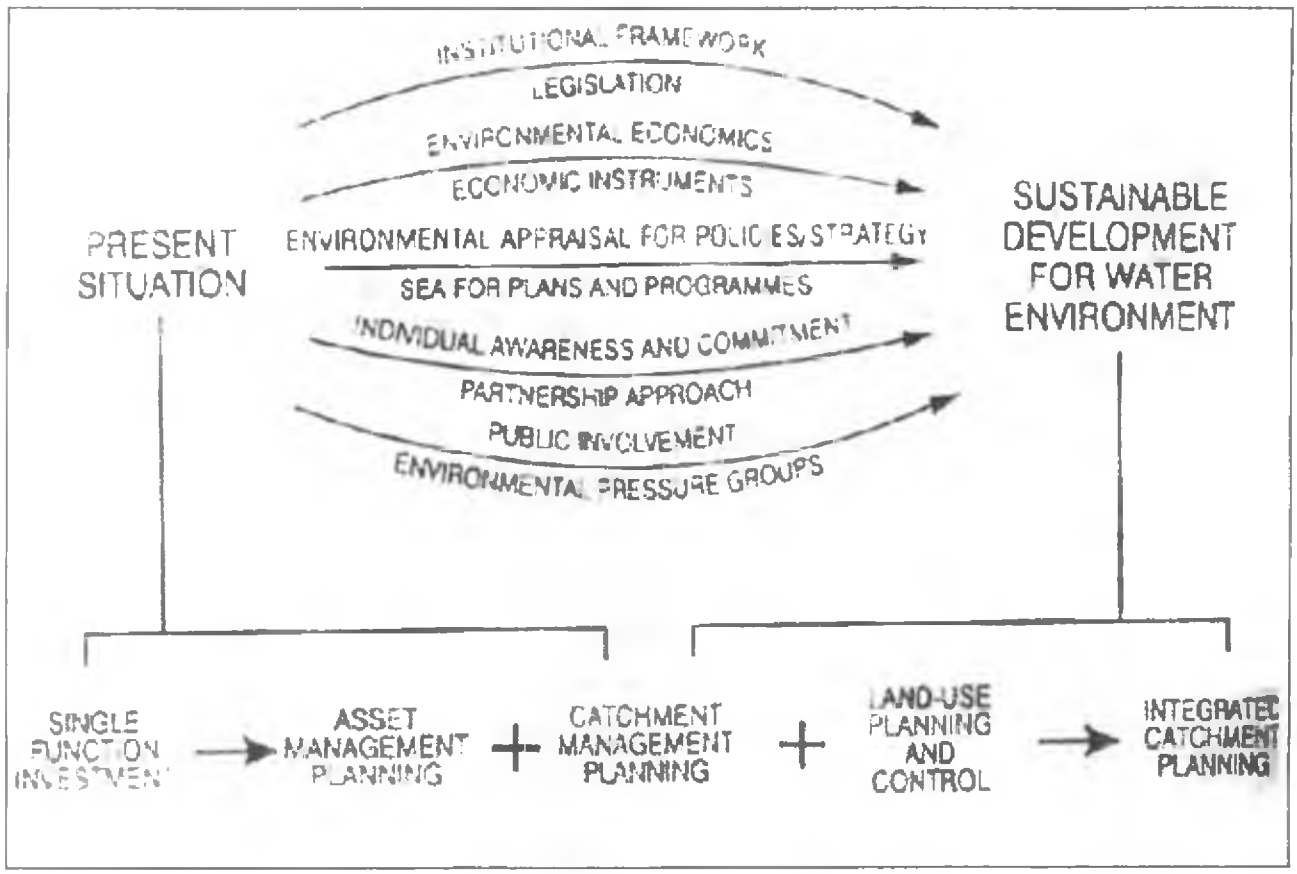

Fig 18 New trends in the development of water resources

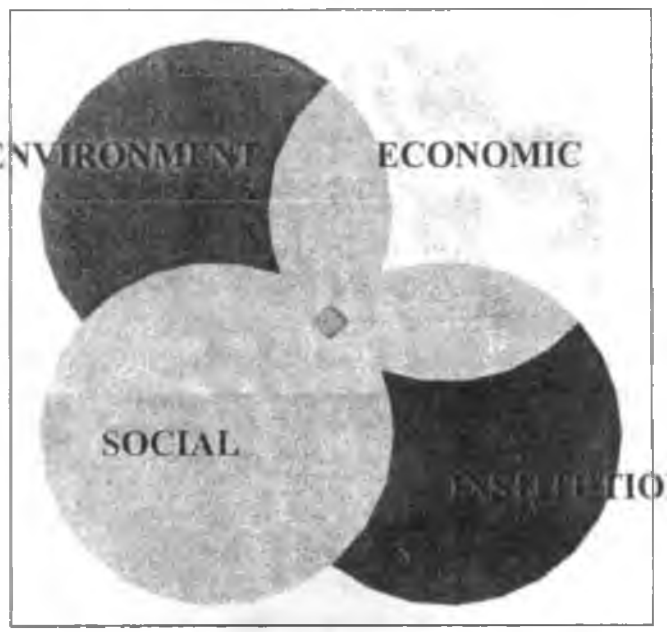

Fig 19 Components contributing to sustainable development

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Table 2 Damages due to water scarcity on crop production in Bharathapuzha basin during 1987

Crop	Area damaged, ha	Production loss, million tonnes	Value of loss in lakhs, Rs
Paddy	46804	91624	4581.20
Coconut	7651	32149 (000 nut)	642.98
Banana	2091	11500	575.00
Pepper	1165	128	62.36
Tapioca	288	3824	39.00
Pulses	5099	4334	281.71
Seasamum	706	211	21.10
Vegetables	1444	1345	47.01
Arecanut	1085	141050 (000 nuts)	20.03
Cardamom	817	32	5.57
Rubber	850	..	288.32
Cocoa	167	57	12.65
Clove	7	0.4	0.52
Nutmeg	33	11.5	8.28
Sweet potato	1048	50.38	75.57
Groundnut	8747	3806.00	380.60
Total	78003		7049.00

Source: Directorate of Agriculture

are available in Kerala. In addition, ducks, quails, guinea fowls, turkey, geese etc. are being maintained.

Chicken Breeds

The chicken population can be broadly classified into two types. Indigenous (Desi) and Exotic (Improved).

The indigenous birds are active, hardy and withstand varying climatic conditions. The desi birds are not of a single entity. They have some common traits such as compact body size and low body weights in both male and females. These birds have a low breast-bone with a compact covering of feathers which lie close to the body.

An exhaustive survey of indigenous breeds has not yet been made in our country. However, 18 breeds of indigenous type are on record in India. Of these, Aseel, Kadaknath, Naked neck, Tellichery and Nicobari are widely reared in Kerala.

Exotic Chicken Breeds

Exotic breeds can be classified according to their place of origin. They are mainly of four important classes as detailed below.

1. Asiatic (other than India) - Brahma, Langshan and Cochin.
2. American - Rhode Island Red, New Hampshire, Plymouth Rock and Wyandotte.
3. English (including Australia) - Sussex, Orphington, Australorp, Cornish and Dorking.
4. Mediterranean - Leghorn, Minorca, Ancona, Spanish, Andalusian and Buttercup. Under Mediterranean class miscellaneous ones such as Bantams and Spanish Fowl are also seen.

Among the exotic breeds, Leghorn is the most popular and is widely utilized for egg purpose and Plymouth Rock, Cornish and New Hampshire are used for meat production. Rhode Island Red and Australorp are utilized in crossbreeding for rural poultry production in Kerala. Out of the exotic varieties of chicken, the available breeds in Kerala are less than ten in number. All these breeds can be considered as adopted natives. The characteristics of exotic chicken breeds are the same as in their country of origin. However, the production performance vary with the environment and management.

Exotic breeds and strains of chicken population have flourished well in the entire country in several belts. These poultry pockets have developed in different regions in the country due to entrepreneurship, availability of cheaper inputs, financial resources through public incentives, marketing facilities and more favourable climatic condition. On the other hand, Kerala is an exemption to this phenomenon because of adverse factors viz, limited space, non-availability of inputs and high labour costs and subsequent high production cost.

4. **Tellichery** :- These birds are found in the Malabar region of Kerala (North Kerala). The body is round in shape and the birds have black skin. However, the plumage colour varies from black to gray, sometimes with various combination of colours. It lays tinted eggs and is small to medium in size. The male bird weighs around 2.0 kg and the female around 1.5 kg. The breed is extensively used for medicinal purpose in the Indian system of medicine.
5. **Nicobari** :- This chicken breed is a native of Nicobar group of islands. It posses a stout neck which is sometimes bare, short legged, small in size compared to other desi fowls. The bird is somewhat round and compact in appearance. There are many varieties viz; white, black and brown.

Of the indigenous chicken breeds, Tellichery alone belongs to Kerala state. This breed needs to be characterised, evaluated and conserved.

ORNAMENTAL CHICKEN

Many ornamental chicken breeds are bred and reared in Kerala. These breeds have attracted the human attention because of the certain peculiar physical characters. The common ornamental chicken breeds are listed below.

1. Silky

The Silky breed is characterized by the silky appearance of the body feathers. The feathers lack the barbs and barbicels, which gives the feathers the peculiar appearance. They also have a crest on the head and the shanks are feathered. Silky also have blue colored ear lobes and black colored skin, face and comb. The birds are small in size and have a compact body. Different varieties in Silky are White, Orange and Black.

2. Polish

Polish breed is characterized by the presence of a tuft of feathers on its forehead. The feathers are long and it may even cover the face of the birds. The birds are medium in size and body is elongate. The body colour varieties are White, Black and Buff. The cap feathers may be the same colour or different. The birds are docile and attractive.

3. Cochin Bantam

The bantams of Cochin breed is another popular fancy breed in Kerala. They weigh 700-900g only. The shanks are feathered and they fully cover the legs. The body feathers are black and have a greenish sheen all over the body. The comb is single and ear lobes are red in color. The birds are active and attractive.

4. Other Bantams

Fancy breeders of Kerala also rear various Bantam breeds. They are English Game, Booted, Polish, Japanese and Mille Fleur.

sexual dimorphism in body length. The drakes are usually bigger. The female Chara ducks are erect in gait and squat in posture. The general plumage colour of Chara female can be described as blackish brown in the back, tail and wings, wherein black is predominant over brown. The bill is shorter than that of the male and is yellowish black, yellow with black spots and sometimes only yellow in colour. The head is mainly brownish black. The average body weight at 20 weeks of age is 1650 g in drakes and 1550 g in female ducks.

Chemballi ducks

The Chemballi drakes are usually squat in posture and gait like Chara drakes. The bill is longer in drakes than in the females and is usually yellow with black spots. The feet are bright orange in colour. The head is dull greenish black. The neck is longer in drakes than in the females and has brown plumages with full or half white bands. The body length in male and female is almost similar in measurement. The majority of the drakes have brownish black plumage over the back region and the rest has light brown plumage. The average body weight at 20 weeks of age is 1650 g in drakes and 1500 g in female ducks.

The major difference between the 'Chara' and 'Chemballi' drakes is in the plumage colour of the head region. it is lustrous greenish black in 'Chara' and dull greenish black in 'Chemballi'

The female 'Chemballi' duck has eret gait and is little squat in posture. The general plumage colour of 'Chemballi' female is brownish black and brownish grey in back, tail and wings, wherein brown is predominant over black and grey. The bill is generally yellowish black, but yellow and yellow with black spots are also seen. The feet are dull orange in colour. The head is primarily brownish black and the neck is brown with or without white band. The back and tail coverts are mainly brownish black.

Turkey

Turkey farming is almost non-existent in Kerala but it is gaining momentum due to its delicious meat qualities. Limited flocks are available at the Kerala Agricultural University Poultry Farm, Mannuthy and Regional Poultry Farm under Animal Husbandry Dept., Govt. of Kerala at Kollam. In addition, some farmers keep turkeys for meat purpose and as hobby. As the land holdings are limited in Kerala, it could not make headway. Broad Breasted Large White, Broad Breasted Bronze and Beltsville Small White are the varieties of turkeys seen in Kerala.

Japanese Quail

Japanese quails belong to the class 'Aves', family 'Phasianidae' and genus 'Coturnix'. They are hardy and easy to handle and can adopt to varied environment. It is a fast growing bird with short generation interval and a high rate of lay. Because of

MARINE FISHERIES OF KERALA

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Introduction

Kerala, located along the southwest coast, flanked by the southeastern Arabian Sea, has a unique position among the maritime states of India by virtue of its lead position in marine fish production in the country. The state has a coastline of 590 km, a shelf area of 1.26 million ha in the 0-50m and 3.59 million ha in the 50-200 m depth zones. The southeastern Arabian Sea, part of the Malabar upwelling zone that extends from Cape Comorin in the south to Ratnagiri in the north, is one among the most productive areas of the world. The marine meteorological features, here, are the most fascinating. The monsoon, non-existent elsewhere in the world, is characteristic. The annual cyclic upwelling associated with the southwest monsoon and the ensuing primary and secondary production sustains a rich and diverse marine flora and fauna. The formation of mud-banks at certain centres during the southwest monsoon along the coast of Kerala is also a unique feature, with no parallel elsewhere in the world. The marine biodiversity is rich and the exploited fishery resources include a variety of finfishes and shellfishes. The marine ornamental fishes, corals, sponges, gorgonids, marine mammals, and turtles and, among the flora, the seaweeds also add to this rich biodiversity. The fishery resources have been in exploitation from time immemorial. However, the exploitation and planned developmental activities in the fisheries sector acquired momentum during the plan periods. The sector contributes to 3% of the state's economy and provide employment to 1.77lakh active fishermen and an equal number of them are engaged in post-harvest and ancillary industries (Anon, 2003). The total fishermen population is about 8.28 lakhs. There are 222 fishing villages, six fishing harbours, 4 are under construction now and another 6 are proposed to be constructed. The state, now, occupies the foremost position in marine fish production, contributing upto 30% of the total marine fish landings in India (Scariah *et al.*,1999). The production from the marine sector in recent years is estimated to be 5.6 lakh tonnes Not only in marine fish production but also in fisheries developmental activities and in foreign exchange earnings, the state has been a role model for other maritime states. The state earned a maximum of Rs.1171 crores during 2000 from export (Rs.816 crores in 2001-02). This is 16.6% of the total exports from India. However, the stagnation in marine fish production in recent years is a concern to all stakeholders. The State's share in the national exports has been declining drastically over the recent years with the figures dipping from 27% in quality terms in 1991 to 15% in 2003. In quantity terms also, the share value has declined from 25% in 1991 to 17% in 2003. The complex ecosystem of the coastal seas is getting degraded over the years due to multiple factors such as the prevailing open access system, unscientific exploitation of the living resources threatening the biodiversity, sectoral conflicts, slackening in the implementation of management interventions, marine pollution and other interference. In the open access system wherein the resources are multispecies, multi-gear deployment, over capitalisation, lack of awareness among the

bengalensis (Big black clam), *Anadara granosa* (Cockle); mussels such as *Perna viridis* (Green mussel), *P.indica* (Brown mussel); *Pinctada fucata* (Indian pearl oyster), *P.margaritifera* (Black-lip pearl oyster); and edible oysters like *Crassostrea madrasensis* and *Saccostrea cucullata* (Fig.3). Among gastropods, two species of whelks, *Babylonia spirata* and *B.zeylanica* occurring in trawls are commercially important. The opercula of the species are said to have aphrodisiac properties and are exported to Gulf countries under the trade name 'Fish nail'. The sacred chank, *Xancus pyrum* are also caught occasionally in few numbers by the trawls. Apart from these a variety of gastropod shells form by-catch in the trawl. Many of these are thrown overboard except in some places like Neendakara and Sakthikulangara they are brought ashore. However, a well-established shell industry as along the southeast coast is lacking here as ornamental varieties are comparatively less compared to the southeast coast.

Kerala, with a production of 58,800t is the second top producer (1996-2000) of bivalves. The country exported 580 t of bivalve products during 1995-99 and the state shared 9.2% of it. In the southern maritime states they are overexploited. Latest production figures are given in Table 1.

Crustaceans

Penaeid shrimps

Some of species that support commercial fisheries along Kerala coast are *Penaeus indicus* (Indian white prawn), *P.semisulcatus* (Green tiger prawn), *P.canaliculatus*, *Metapenaeus dobsoni* (Flower-tail prawn), *M.monoceros* (Speckled prawn), *M.affinis* (Jinga prawn), *Parapenaeopsis stylifera* (Kiddi prawn), *Trachypenaeus curvirostris* (Rough prawn), *Solenocera choprai, Solenocera hextii, Metapenaeopsis andamanensis* and *Penaeipsis jerryi*. Recent production figures are given in Table 1.

Non-penaeid prawns

The deep-sea prawns that are exploited belong to this group which include *Aristeus alcockii* (Red-ring), *Heterocarpus woodmasoni, H.gibbosus, Plesionika spinipes* and *P.martia*. Though surveys during the late sixties have indicated the availability of these resources at 250m depth along the Quilon Bank and in the northern areas off Kerala, the commercial exploitation has started only by 1998. Nearly 10,000 t are annually exploited (Table 1). These deep-sea species have longer life cycle and show slow growth rate. The reduction in average length of these prawns shows the fishing pressure on the stock.

Marine crabs

Nearly 600 species occur in Indian seas, however, those commonly used for food includes the commercially important marine species such as the reticulate crab- *Portunus pelagicus* (Fig.4), *P.sanguinolentus* (Spotted crab), *Charybdis feriatus* (Cross crab), *C.annulata* and *C.natator*.The highest production of over 10,000 tonnes was noticed in

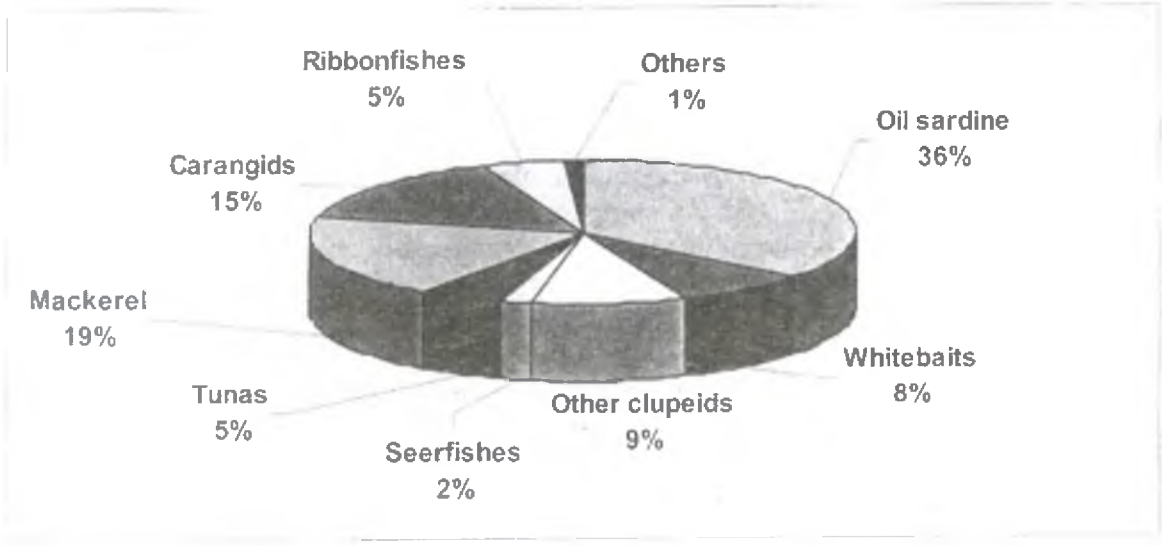

Fig. 1. *Percentage contribution of pelagic fishes*

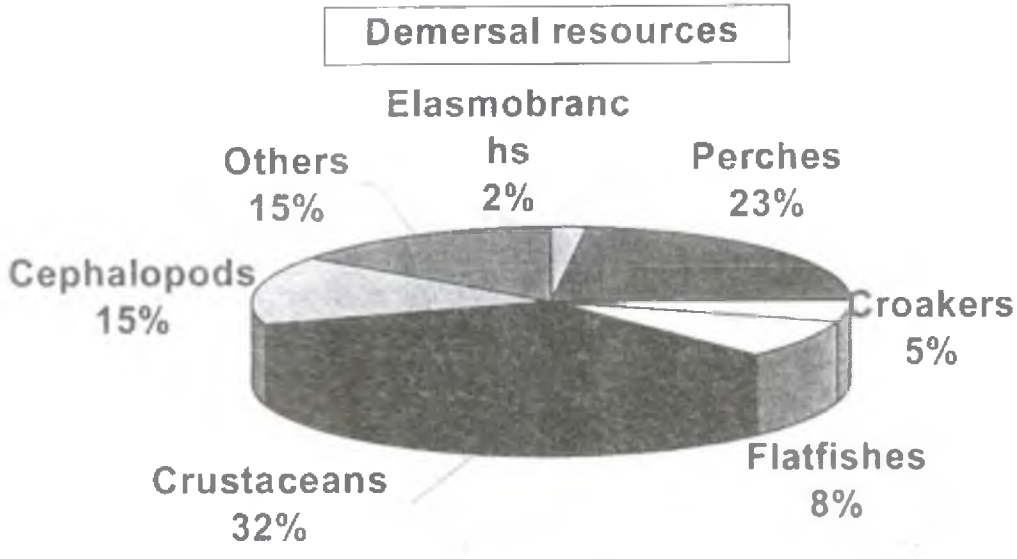

Fig. 2. *Percentage contribution of demersal fishes*

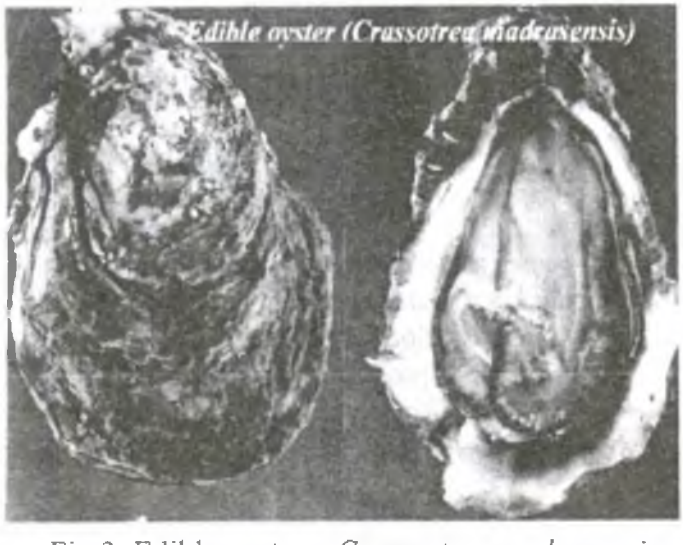

Fig.3. Edible oyster – *Crassostrea madrasensis*

the year 1997, thereafter the production decreased. Latest production figures are given in Table 1

Lobsters

The Scalloped spiny lobster *Panulirus homarus* (Fig.5) inhabiting the 1-10m zone is the most dominant species. *P.versicolor* and *P.polyphagus* also occur occasionally. The spiny lobster *Puerulus sewelli* occupies the upper continental slope between 175-200m depth off Kerala. The population has come down. The average production during the last decade was 310 t.

Ancillary resources

Corals

Gulf of Mannar and Palk Bay, Malvan, and the Gulf of Kutchch are known for corals. However, in Kerala corals are reported from south of Quilon to Enayam in Tamil Nadu. *Pocillopora* spp. is the most common form. *Acropora* is found with representation of atleast three species. *Pseudosiderastrea* and *Porites* spp. are also found. A recent study showed that 29 species under 17 genera of scleractnians occur in this area. Of these, 13 species belonging to 6 genera are hermatypes and the rest 16 species of 11 genera are ahermatypes. Exploitation of corals is common and has done much harm.

Gorgonids

Fifteen species of gorgonids belonging to 5 families and 11 Genera occur along the coast between Kanyakumari and Vizhinjam. They are *Solenoculaon tortuosum, Subergorgia suberosa, Muricella complanata, Echinomuricea indica, Echinogorgia reticulata, E.flora, E.complexa, Heterogorgia flabellumLeptrogorgia australiensis Ellisella andamanensis, Ellisella maculata, Juncella juncea, Gorgonella umbraculam, Gorgonella rubra* and *Scirpearia filiformis* (Fig. 6). The exploitation of gorgonids is not as intense as along the southeast coast of India.

Seaweeds

The coastline of Kerala is dissected with sandy stretches and natural rocks and also artificial granite sea walls on groynes and spurs which protrude into sea. In the southern part of the Kerala coast (Zone I) from Poovar to Thirumallavaram (80km) the coast is mostly sandy, but rocks of different kinds and granite stones are found in patches in the inter-tidal and sub-tidal zones and many species of green, brown and red algae are found to grow luxuriantly at Adimalathura, Chavara, Mullur, Vizhinjam, Varkala, Edava, Thangasseri, Tirumallavaram and Kovilthottam. Twenty-five species are found (Table 2).

North of Tirumallavaram (Zone II), the coast is sandy upto Parappanangadi (270m) but the sea wall laid with granite stones has helped seaweeds to grow. Eight species have been reported.

North of Parappanangadi (Zone III) upto Cannannore (84km), seaweeds grow abundantly on the rocks and granite stones at Kadalundinagaram, Elathur, Kadalur (Nandi) Tikkodi, Sacrifice Rock (off Payyoli), Madapalli, Mahe, Tellicherry, Dharmadom Island and Cannannore. Twenty-seven species are reported.

Beyond Cannannore (Zone IV) is mostly sandy upto Manjeswar (84km). Only *Ulva lactuca, Chaetomorpha antennia* and *Gracilaria corticata* occur dominantly.

The quantities of different groups of seaweeds comprising 35 species were: Green algae 245.9 t, Red algae 91.6 t and brown algae 18.1 t. The economically important seaweeds contributed about 15.3% and other seaweeds 84.7%. The individual values estimated for the commercially important seaweeds were: agarophytes 27t, followed by alginophytes of 18t and agaroidophytes 9 t as against the other seaweeds of 301 t (including edible species) making a total of 355 t for an area of 315,750 sq.m. The seaweed density works out to 1.13 kg/m2. The annual production for the entire coast is estimated around 1000t depending on the number of harvests the seaweeds usually sustain.

Ornamental fishes

Many of the marine food fishes are good aquarium fishes as well. They are quite adaptable, very sturdy and also grow very fast. Apart from these, the potential of a variety of marine ornamental fishes belonging to the families Holocentridae, Chaetodontidae, Ambassidae, Teraponidae, Apogonidae, Carangidae, Lutjanidae, Caesionidae, Gerreidae, Lethrinidae, Monodactylidae, Drepanidae, Platacidae, Scatophagidae, Pomacanthidae, Pomacentridae, Acanthuridae, Siganidae, Balistidae, Tetraodontidae, Ostraciidae and Syngnathidae available here has not been tapped.

Marine mammals

Twenty-two species of marine mammals are catalogued the seas around India. They frequent the coastal waters. The common species of dolphins available along Kerala coast are *Stenella longirostris* (Spinner dolphin), *Tursiops truncatus* (Bottlenose dolphin), *Delphinus delphis* (Saddleback dolphin), *Sousa chinensis* (Humpback dolphin) *and Neophocaena phocaenoides. Physeter macrocephalus, Balaenoptera borealis, B.physalis* and *B.musculus* are also reported from this area. They frequent the coastal sea for feeding or breeding, where they get entangled or entrapped in trawl net, gill net or purse seines. Accidental, single and mass, entangling of dolphins is common in Kerala and go unreported. The flesh has high demand and are relished by the local people at toddy parlor along the coastal belt. As all these mammals are protected under the Indian Wildlife (Protection) Act, 1972, fishing/trade of any type is illegal. An ambitious programme to monitor the level of xenobiotics in marine mammals inhabiting the Indian EEZ has already been initiated

Marine turtles

Though five species of marine turtles are found along the Indian coast, in Kerala mainly the olive ridley - *Lepidochelys olivacea* and the hawksbill turtle (*Eretmochelys imbricata*) are found. Mass nesting has been observed along the Kasaragod beach. It is noteworthy that the local NGO has been doing commendable service in protecting these mute creatures during the mass nesting period.

The potential yield

The exploitation of various marine finfishes and shellfishes has reached optimum level. The potential yield from Kerala coast is estimated as 8 lakh tonnes of which the contribution from the inshore waters is 5.7 lakh tonnes (Sudarsan *et al.*, 1990). The bottom trawling destroys annually 2.5 lakh tonnes of living organisms. The average edible portion of the by-catch is around 0.83 lakh tonnes. Adding this to the highest landings ever recorded from Kerala would work out to 7.6 lakh tonnes (Kurup *et al.*, 2003). The exploitation level around the potential yield calls for enforcement of strong fishery regulatory measures for conservation and sustenance of our fisheries wealth.

Evolution of exploitation of marine fishery resources

The marine fisheries wealth of the state has been in exploitation since ancient times and acquired momentum in the post-independent era. The progress of marine fisheries has been quite eventful with each epoch witnessing different innovations of harvesting practices in the gears and craft. The early sixties featured shifts from cotton to nylon nets. The mid-sixties ushered in mechanisation and increased use of trawl fishing mostly targeting shrimps, the major forex earner. Commercial purseseining aimed at harvesting small pelagics like oil sardine and mackerel was introduced during the late seventies. Another noteworthy feature was the motorisation of the country craft, which was initiated in the early eighties and gained momentum in the latter half of that decade. Added to this, the introduction of ring seine net was an epoch event that has transformed the marine fisheries scenario of the state. The mid-nineties witnessed the phenomenon of voyage and deep water fishing by trawl, gill net and hooks and line. Although the technological innovations introduced from time to time have helped augmenting the total production, in the open access system, they have also given rise to sectoral conflicts among various stakeholders. Prior to seventies, the fishing activities on the west coast of India used to be suspended during the southwest monsoon period from June to August. This practice was being followed traditionally since several years and this cessation of activities acted as a measure for the conservation of the fishery resources. Serious concerns were raised during the mid-eighties about the sustainability of the exploited resources and the ecosystem degradation allegedly due to increased fishing pressure by the mechanised sector. The artisanal sector whose sustenance depended on the small pelagics and other nearshore resources felt threatened by the reported incursions of the mechanised sector into their regions of exploitation. This prompted the Government of Kerala instituting various committees at different periods to assess the status of fishery which culminated into promulgation of Marine Fishery regulation Act aimed at regulating and curbing fishing activities by certain gears and crafts at demarcated fishing zones. Accordingly ban on fishing by purseseining during June to August came into force and a partial ban on trawling was introduced in 1988. During the last five years a uniform trawl ban, for 45 days from 15 June to 31 July, days is being followed all along the

Kerala coast. Almost all the 14 expert committees appointed, right from the Kalawar Committee in 1984 to the latest Dr. Meenakumari Committee in 2001, had given more or less the same recommendations in connections with resource management. They include trawling ban, strict regulation of crafts, ban on outboard machines during monsoon, ban on sale of juveniles and ban on ring seine. Apart from the partial implementation of the trawling ban, none of these recommendations has been implemented. Considering the volatile nature of the coastal area, decision to implement any intervention could be taken only step by step and that too after much cajoling.

Kerala Marine Fishing Regulation Act

As early as 1897, the erstwhile British Government visualized the need to impose some regulatory measures to control fishing activities in the country. However, the Indian Fisheries Act of 1897 expressly banned only the use of explosives and poisons to catch fish and provided for the enactment of rules and regulations by respective State Governments. The Government of Kerala passed the (KMFRA) Marine Fishing Regulating Acts in November 1980.

The most salient regulations of KMFRA and the amendments made are:

- Prohibition of trawling by mechanised boats along the entire coastline of the state from Kollenkode to Manjeswaram during June to August.
- Prohibition of all fishing vessels fitted with mechanised propulsion except motorised country craft from the shore upto 30m line in the sea along the coastline of the state from Kollemkode to Paravoor –Pozhikkara having a length of 78 km and the area upto 20m line in the sea along the coastline from Paravoor – Pozhikkara to Manjeswaram having a length of 512km.
- Prohibition of the use of bottom trawl gears having less than 35mm code end mesh sizes.
- Prohibition of the use of Purse seine, Ring seine, Pelagic trawl, Mid-water trawl and Mini-trawl in the territorial waters of Kerala.
- Prohibition of the operation of the bottom trawls from sunset to sun rise.
- Regulation of the number of fishing vessels of less than 43 feet beyond the territorial waters.
- Prohibition of fishing by fishing vessels fitted with mechanical means of propulsion of 25 GRT.
- Imposition of pre-requisites for bottom trawlers operating beyond territorial waters such as the engine fitted in the boast.
- Shall have a maximum of 160 HP, the hull should have a length of not less than 43 feet and provided with 500m wire ropes and other life saving devices. Accordingly, the Government of Kerala banned purse seine, ring seine, mini-trawl, mid-water trawling, pelagic trawling and night trawling in the territorial waters off Kerala.

In order to ameliorate the dwindling nature of the fishery in Kerala and impose proper conservation measures for sustainability of the fisheries wealth, various Expert Committees were also appointed from time to time. Based on the recommendations of Balakrishnan Nair Committee (1985), the Govt. of Kerala has imposed a ban on trawling during the monsoon months every year from 1988, for a duration from 15th June to end of July.

Lack of a marine surveillance system and machinery to take stringent actions to book the offenders has remained as stumbling blocks in effective implementation of various measures. At present the state has only one marine police station at Fort Kochi. The Government will soon set up 28 marine police stations in the state. It is common that mechanised vessels encroach and do fishing (day and night) in areas marked for motorised and traditional sectors. Success of implementation of regulatory measures largely depends on the active involvement of the fishermen. Such a conflict management system with the total involvement of fishermen, administrators, politicians and planners would work effectively as against the exclusively administrative approach being followed now. The self regulation formulated by fishermen themselves as in the case of management of purse seine operation in Karnataka, sharing of day and night fishing between the artisanal and mechanised sectors in Tamil Nadu have been successful in the conflict management. The activities of NGOs like the Green Seas at Munambam in Cochin and the *Kadal kodathies* in Kasaragod, though have limitations, are commendable in creating awareness among the stakeholders. It is, therefore, clear that the management of fisheries cannot be considered only a matter concerning administration or biology or resource assessment, but as an integrated approach taking into account the sociological, economical and developmental objectives and priorities as well. Gone are the days of emphasis on exploitation of known resources and coverage of unexploited fishing grounds has become inescapable. Apart from knowledge of the grounds, training in new methods of fishing such as longlining and squid jigging, upgradation of existing vessels or acquisition of vessels equipped to cover fresh or relatively unexploited grounds, availability of shore facilities for imparting value addition to processed products and strengthening linkages for effective domestic as well as export marketing, have emerged as aspects of paramount importance for the earnings of stakeholders to move up.

Trends in production of marine resources

In view of the controversy over the imposition of the trawl ban since the year 1988, the annual production of various resources is grouped into two phases for an in depth analyses. Phase-I from 1981 to 1987 represents the pre-ban period and phase-II from 1988 onwards when the ban was introduced. The marine fish production (pelagic & demersal) in the state increased from about 2 lakh tonnes annually in the early sixties to 5.6 lakh tonnes in recent years with an all time peak of 6.6 lakh tonnes during 1990 (Figs. 7 & 8). The spurt in production (about 4.69 lakh t) during 1989 and 1990 recording an all time high of 6.63 lakh t appeared to be due to the bumper landings by the ring seines that were introduced two years earlier to the trawl ban.

Fig.4. Reticulate crab – *Portunus pelagicus*

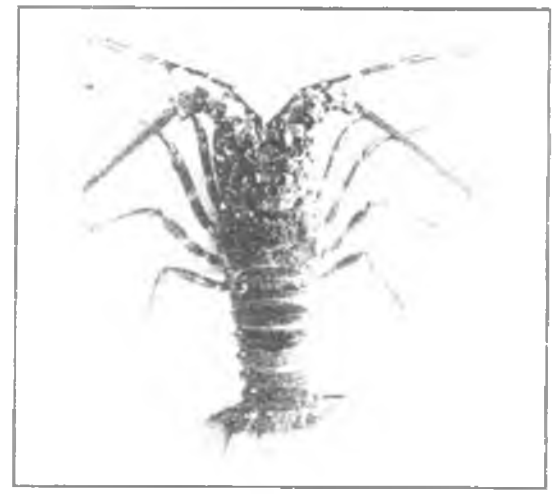

Fig. 5. Scalloped spiny lobster – *Panulirus homarus*

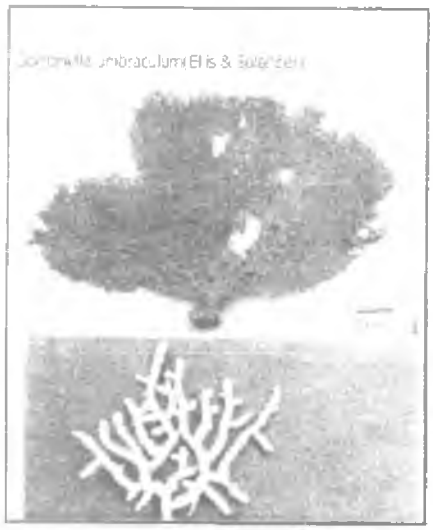

Fig. 6. Gorgonids - *Gorgonella umbraculum* (upper panel) and *G.rubra*

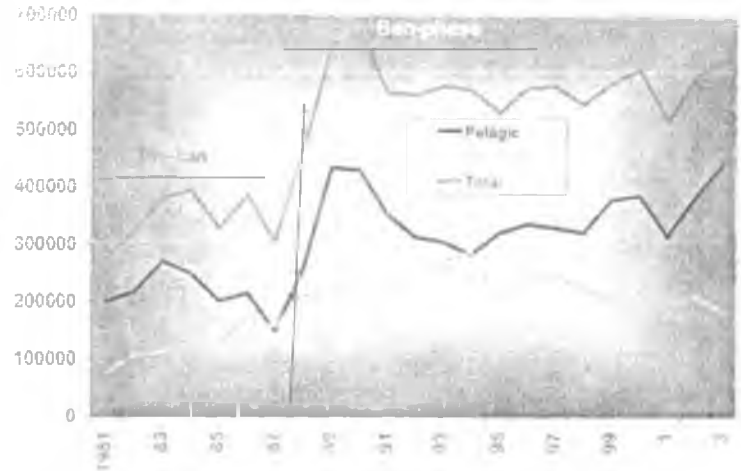

Fig.7. Marine fish landings (pelagic, demersal and total) in Kerala

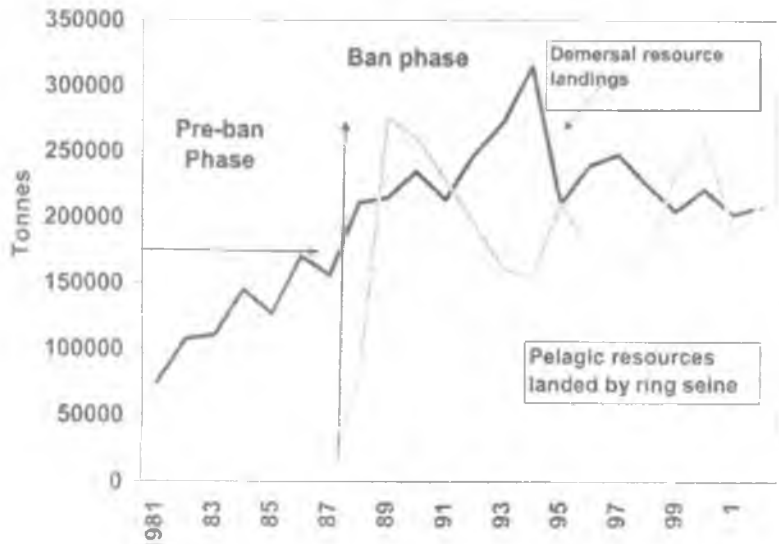

Fig.8. *Demersal fish production* vs. *pelagic resources landed by ring seines*

The pelagic fishery resources constituted (Av. 59% during 1988-02) by oil sardine, whitebaits, mackerel, seerfishes, tunas, carangids and the ribbonfishes dominate the marine fish landings in the state. The annual average landings during the seven-year period before the ban were 219,000 t against 351,000 t during the ban period. The pelagic fisheries contribute to nearly 59% of the total marine fish production in Kerala. The contribution of major groups/species that constitute the pelagic and demersal resources are given in Figures 9 and 10.

The pelagic fishes showed wide fluctuations in their annual landings (Figs. 10 & 11). Though there was improvement in the annual production of mackerel, whitebaits, and carangids, ribbonfishes and tunnies during the ban period, the increase could not be sustained. Of late, a decreasing trend is visible (except ribbonfishes).

The landings of demersal resources have been on the increase since 1981 reaching an all time peak of 2.73 lakh t in 1994, during the ban phase. Thereafter the production fluctuated with an annual average of about 2.1 lakh tonnes (Figs.7 & 8). Penaeid prawns, perches and cephalopods form the bulk of demersal landings (Figs. 12 & 13). Others include elasmobranchs (Fig.11), catfishes, croakers, goatfishes, rock-cods, lizardfishes and soles.

The landings of most of the demersal resources have shown decreasing trend during the post-ban phase. Resources like sharks and catfishes have been declining irrespective of the ban period.

Mechanised/motorised sectors

The total landings by the mechanised sector comprising the trawlers, purseseiners, gillnetters, etc during the ban phase was much higher compared to pre-ban phase (Yohannan *et al.*, 1999; Ammini, 1999). This was mainly duo to increased landings by the trawler as a result added effort input through multi-day operations (Fig.8). Demersal component of the trawl landings accounts for about 80% of the total demersal landings in the state. The production from the mechanised sector increased from the year 1988 and reached a peak of about 3.25 lakh t by 1994, but subsequently started declining. This trend was seen in trawl landings also. The trawl landings after a peak of 3.17-lakh t in 1994 declined to 2.2-lakh t by 2002.

From the year 1988, the motorised component of the artisanal sector became a major contributor accounting for more than 50% of the total landings in the state. The contribution from this component though increased from 1.3 lakh t in 1985 to 3.9 lakh t in 1988 &1990, subsequently started declining and then peaked to 3.6 lakh t by 2002. These variations in the catch of this sector that targets the small pelagics are purely related the decadal trend in abundance of stocks of oil sardine, mackerel and whitebaits. The ring seine contributes more than two thirds of the motorised landings. The higher landings during the ban-phase were mainly due to increased effort by the motorised and mechanised (especially multi-day) sectors.

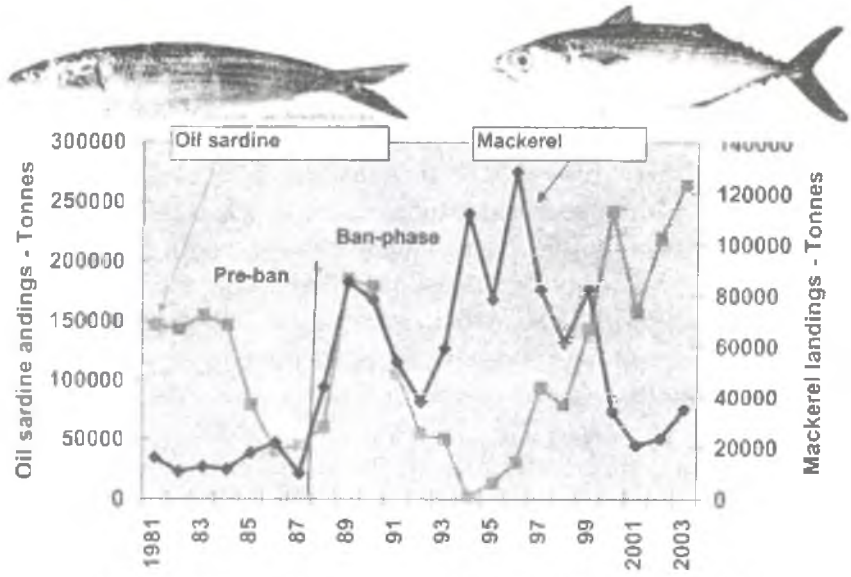

Fig.9. *Oil sardine and mackerel landings in Kerala*

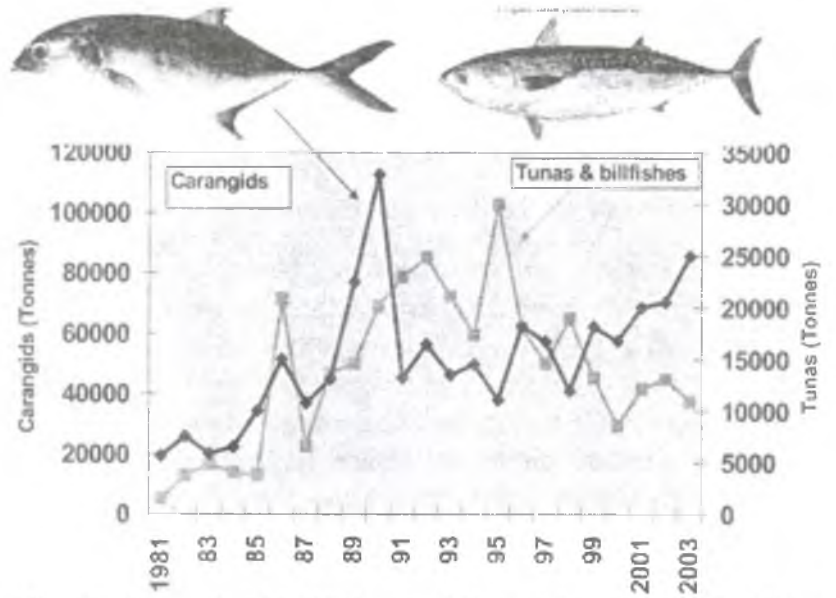

Fig.10. *Tunas (and billfishes and Carangid resource landings*

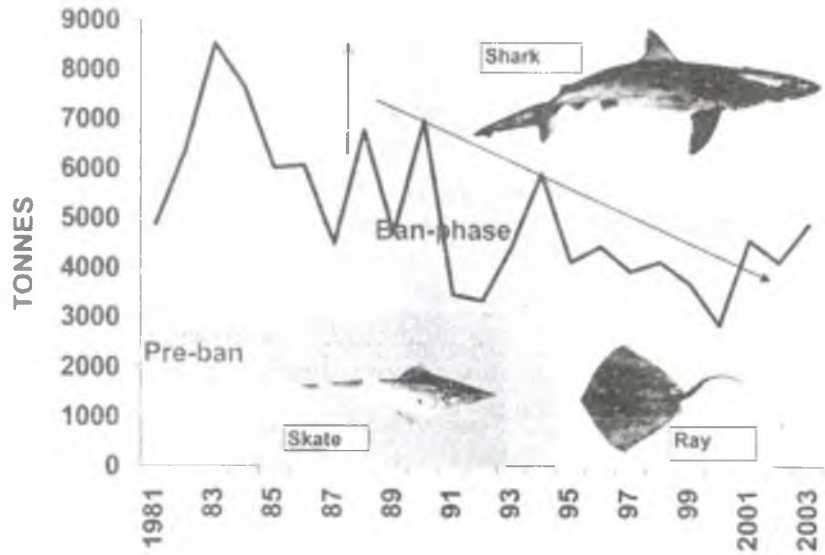

Fig. 11. *Landings of elasmobranchs in Kerala*

Pattern and change in effort input

During 1993-96, out of an average catch of 5.5 lakh t of fish landed, the trawls contributed to 48.4%, large seines (purse seine and ring seine) 30.8%, boat seine 4.1%, gill net 9.2% hooks and line 3.8% and other gears 1.9%. There are nearly 4500 trawlers operating from various fisheries harbours in the state. About 80 purseseiners (base at Cochin), 500 gillnetters, 5100 motorised crafts and 25,400 traditional units are also operated. The traditional sector employs a variety of gears. The mini trawl, a small version of the 2 –seam, non-overhanging high opening trawl gear, numbering around 5000 is mostly concentrated in and around Alleppey District. Mostly, they are operated at 11-15m and the catch is constituted of juveniles of prawns and fishes. Introduction of a new craft, presently numbering around 180, with inboard engine for operating large sized ring seine units during the ban period has become controversial. The carrier units allow these vessels to do stay fishing during the period. No effort has been made by the authorities to classify this craft under either traditional or mechanised categories. This is at a time when there is some consensus among the fishermen themselves regarding the need for observing a fishing holiday. The motorised and traditional sector fishermen have already expressed their protest against this. The crisis may deepen in the near future.

The number of unit operations has plummeted from 7.25 to 3.71 lakh unit operations per year. The time spent in fishing by trawlers also decreased from 5.34 million hr to 4.12 million hr during 2002.Though the catch per unit effort increased from 332 kg in 1988 to 594 kg in 2002 the catch per hr decreased t from 77 kg to 54 kg. The ring seine also showed a similar trend wherein the number of unit operations decreased from 2 million in 1997 to 1.38 million in 2002 and fishing hours from 7.3 million to 5.2 million respectively. However the c/hr increased from 259kg to 553kg. The contributions from the non-motorised artisanal craft have also been gradually declining from about 1.78 lakh tonnes in 1981 to 0.37 lakh t in 2002 as a consequence of motorisation and thereby marginalisation of this sector (Figs. 14, 15, 16 &17).

Biological perspectives

Single species pelagic resources show wide annual fluctuation in stock abundance compared to multispecies resources. The total fish catch is a product of total productivity of the area. The decline in the stock of one species may help another species to increase. In a tropical ecosystem, nature has provided variable time slots and optimum conditions for each species to survive and is best exemplified by the inverse relation in abundance of oil sardine and mackerel in Kerala. This must be true with all organisms in the ecosystem. One of the most important biological characteristics, which determine the success of fishery, is the spawning and subsequent recruitment. In tropical marine finfishes and shellfishes, as in Kerala, the spawning is generally protracted and fractional spawning is common. While most of the species spawn during monsoon months they also spawn during other periods with varied intensity. Spawning activity of not only finfishes and shellfishes, but also of the diverse organisms in the sea takes place mainly during the monsoon. This starts during the pre-monsoon and continues upto post-monsoon with interannual variations. The inshore areas are nursery grounds for a majority of species. The onset of the southwest monsoon, the process of upwelling and consequent primary and secondary production is favourable to the spawning, survival of young ones and recruitment. The fishing activity (some of the gear are 8 mm mesh) during the period

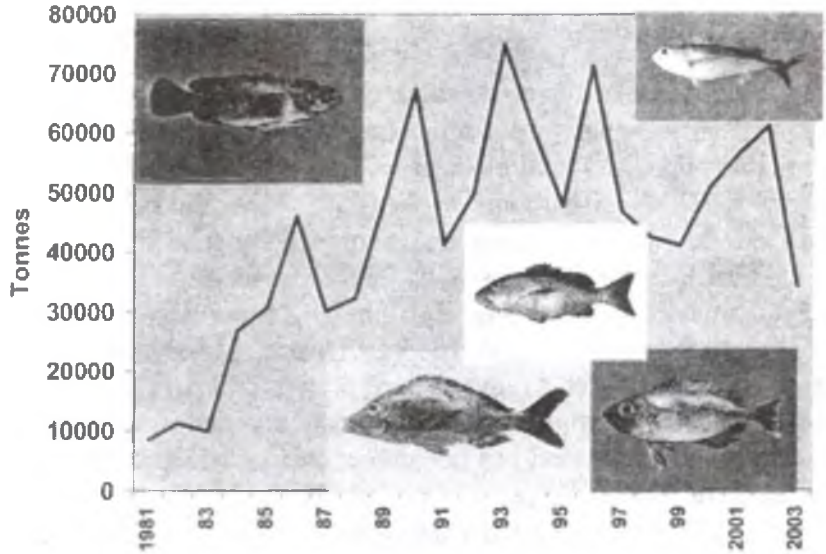

Fig.12. *Landings of perches in Kerala*

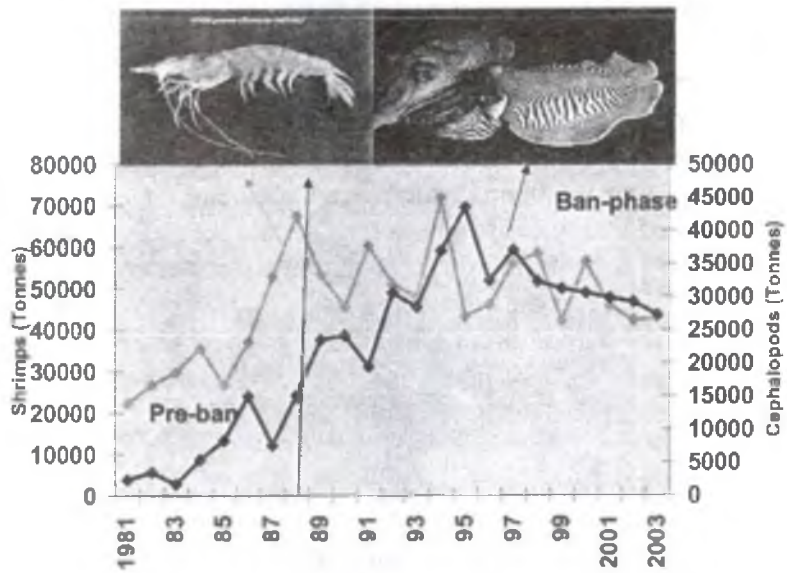

Fig. 13. *Shrimp and cephalopod landings in Kerala*

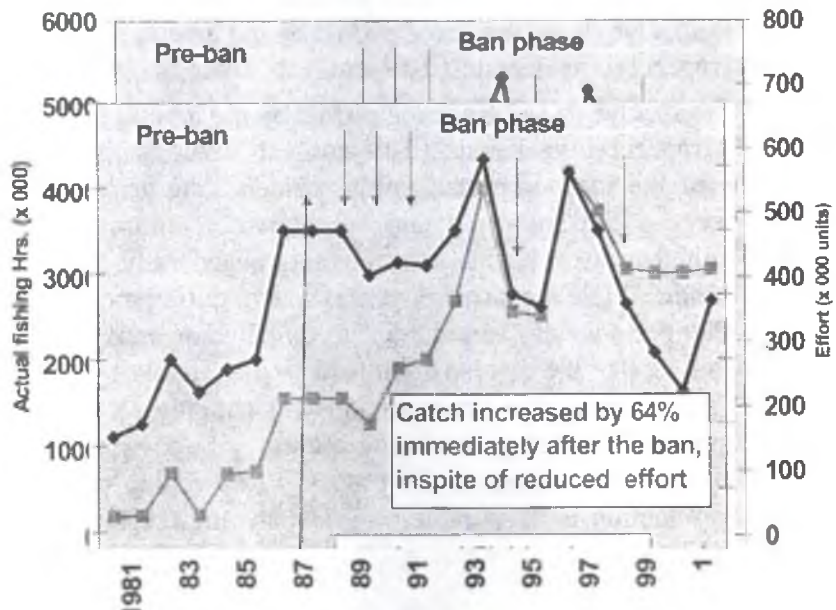

Fig. 14. *Trends in trawl effort in Kerala*

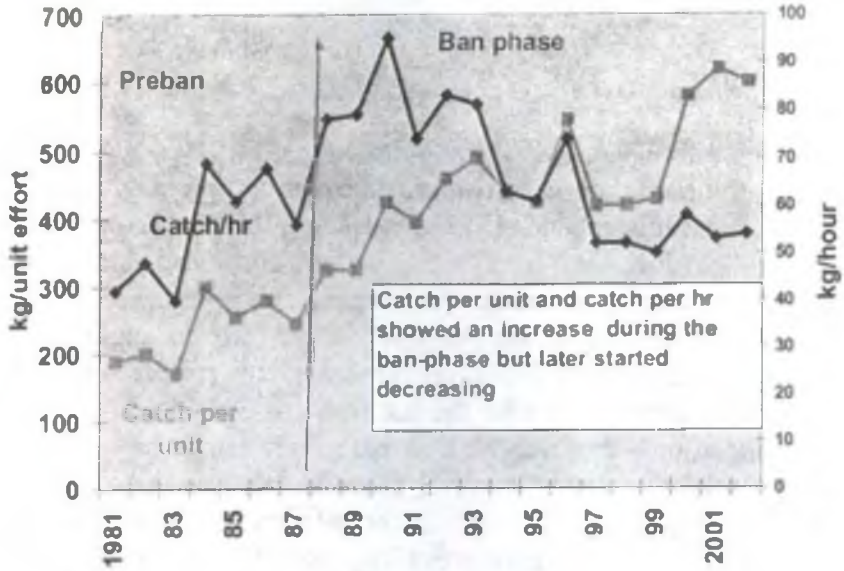

Fig. 15. *Trend in the catch rate of trawlers in Kerala*

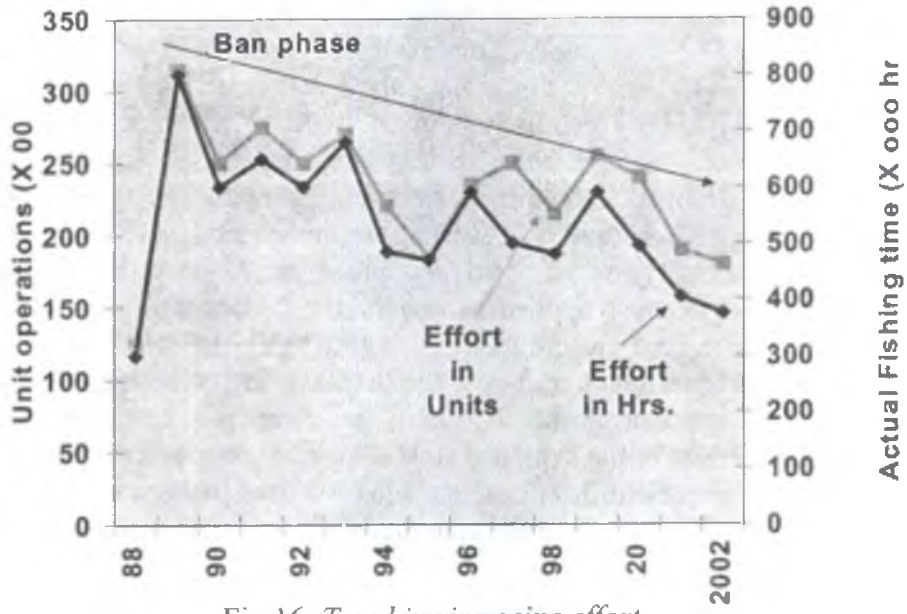

Fig.16. *Trend in ring seine effort*

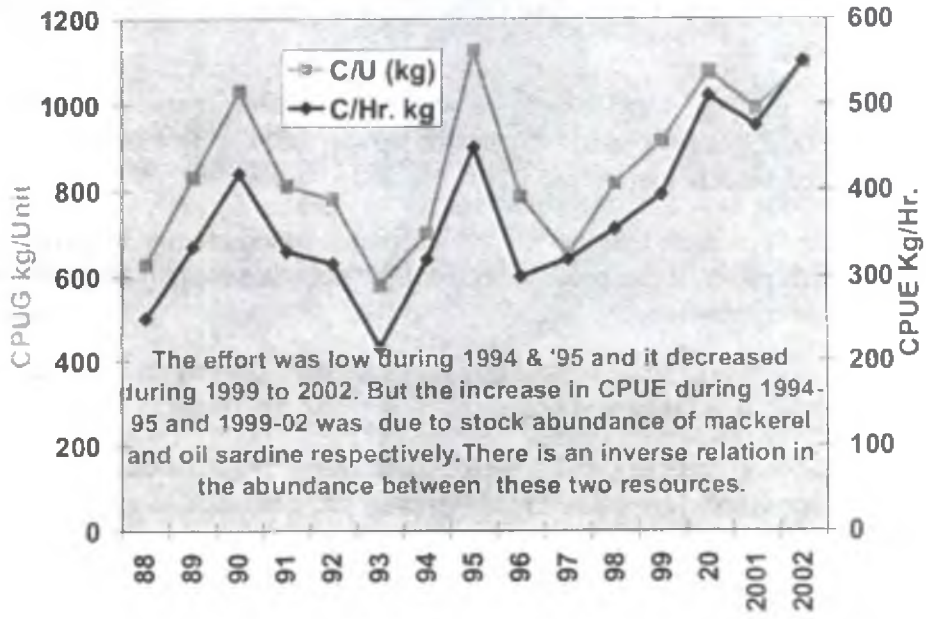

Fig. 17. *Trend in catch rate of ring seine in Ker*ala

results in exploitation /destruction of spawners, juveniles and pre-adults of a number of commercially important finfishes and shellfishes leading to great economic loss. Night fishing is common. Trawling that scourge the bottom destroys/dislocates the benthic fauna delinking the interconnectedness in the complex ecological chain, forgetting that for every species whose existence we put into danger, we endanger ourselves. No resources can withstand harvest for 365 days. The resources require respite. Only after the last tree has been cut down, only after the last river has been poisoned, only after the last fish has been caught, only then will we find that money cannot be eaten. So, if for no other but the purely selfish reason of survival, there is only one thing we can do: start taking optimum and giving back. This requires formulation of a Fisheries Policy, which has been kept in abeyance considering the prevailing socio-economic-political issues.

The Central Marine Fisheries Research Institute has, over the years, painstakingly built up a time series database on the resource size, dynamics, exploitation rates and replenishment capacities of exploited marine fishery resources of the country. The Institute is proud to reiterate that, this is the only agency with such a massive and time series data which have been profusely utilised (without which it would have been impossible) by various commissions, fishery experts, fishery managers, planners administrators, industrialists and other government agencies and relied upon to take decisions, in preparing reports and in suggesting recommendations. In an effort to strike a balance between maximization of yield and profit and conservation of stocks, the scientists of the Institute have applied non-equilibrium production models to arrive at optimum period of seasonal closure of the fisheries along the west coast. Besides the optimum fleet sizes for different craft-gear combinations in several maritime states have been resolved. The seasonal closure is one of the commonly employed management measures for conservation of the exploited stocks, to rejuvenate the ecosystem and ensure sustainable yields. If the scientific advances made by marine biologists can be turned into policies, fishermen could catch far more than they do today while causing less damage to the marine ecosystem.

The Institute has made in-depth analyses on the exploited marine living resources of Kerala with reference to the pre-ban (1981-87) and post-ban (1988- till date) periods. The salient findings are:

- Immediately after the trawl ban there was a perceptible increase in the demersal fisheries catch (365 days minus 45 days of ban period) during 1988-94 onwards and then it showed a fluctuating trend.
- Resource trends indicate that the fate of the fishery would mainly be governed by the success or otherwise of the production from the pelagic resource assemblage, which are not caught by trawlers.
- The landings of the major demersal resources including prawns and cephalopods have shown declining trend in recent years.
- Trends in the total landings and those of the major exploited resources indicate that the fishery as a whole has reached a 'no-growth' stage during the last five years.

- As a consequence of trawling ban, the juvenile *Karikkadi* (*Parapenaeopsis stylifera*) that was discarded by the industry earlier got chance to grow into bigger size and its annual mean size was found to improve by 5mm during the ban period. A similar trend was observed in finfishes and shellfishes.

- The unlimited entry of innovative gears such as the ring seines, inboard ring seine units mini-trawls, small meshed nets, night fishing, etc and encroachment of mechanised vessels in the shallow and areas marked for other sectors need to be controlled. The disproportionate harvest of young fishes (growth overfishing) has to be curtailed. The netting of juveniles and their wastage are common during the post-ban period resulting in significant damage to the stock, economic loss and curtail employment avenues.

- A 20% reduction in fishing effort which corresponds to level of effort resulting from the present 45 days of ban is expected to yield proportionate increase in the catch. However, complete closure of fishery including all fishing activities for 60 days during June-July would result in conservation of the resources and rejuvenation of the ecosystem. The traditional sector fishermen have to be rehabilitated providing alternate source of employment or other vocations. The State Government, on a war footing, has to formulate a series of action plans in this direction. These welfare measures could be met from the amount realised as cess from export earnings. When we make profit through trade/export of fish and fishery products, or relish the seafood at home or dine in posh hotels under chandeliers and grand settings, let us not forget the fishermen. Less privileged, they are engaged in fishing far out in a most hazardous working environment to earn a livelihood for them and their family. They need our care and attention as they are in utter penury during the ban period. The society has a moral obligation to rehabilitate them.

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Table 1. *Major exploited finfishes, shellfishes and their production trends – 2002 & 2003*

PELAGIC Finfishes			DEMERSAL Finfishes		
	2002	2003		2002	2003
CLUPEOIDS			ELASMOBRANCHS		
Wolf herring	594	727	Sharks	1,788	3,260
Oil sardine	17,0,351	2,41,338	Skates	597	182
Other sardines	3,576	15,985	Rays	1,769	1,267
Hilsa shad	6	0	EELS	347	156
Other shads		210	CATFISHES	298	277
Anchovies	17	1	LIZARDFISHES	7,615	10,686
Coilia spp	1	0	PERCHES		
Setipinna spp.	0	0	Rock cods	9,925	5,272
Stolephorus spp.	16,107	25,466	Snappers	1,951	715
Thrissina spp.	13	0	Pigface breams	512	103
Thryssa spp.	5,728	5,063	Threadfin breams	32,828	23,163
Other clupeids	3,577	3,612	Other perches	18,361	9,412
Bombay duck	54	0	GOATFISHES	16	1
Half beaks and full beaks	799	2,216	THREADFINS	23	194
Flying fishes	36	85	CROAKERS	6,858	8,982
Ribbonfishes	32,581	17,459	SILVERBELLIES	6,329	5,168
CARANGIDS	1		WHITEFISH	344	608
Horse mackerel	2,484	5,048	POMFRETS		
Scads	23,627	14,463	Black pomfret	648	282
Leather-jackets	264	572	Silver pomfret	541	306
Other carangids	18,364	16,014	Chinese pomfret	23	1
MACKERELS			FLATFISHES		
Indian mackerel	21,754	30,930	Halibut	171	95
Other mackerels	0		Flounders	23	2
SEERFISHES	65		Soles	17,526	21,964
S.commerson	2,606	9,624	MISCELLANEOUS		
S.guttatus	83	97	Total		
S.lineolatus	14	0	Shellfishes		
Acanthocybium spp.	55	14	CRUSTACEANS		
TUNNIES			Penaeid prawns	42,429	42,716
E.affinis	7,843	10,639	Non-penaeid prawns	10,914	10,472
Auxix spp.	6,280	9,416	Lobsters	334	386
K. pelamis	1,160	623	Crabs	4,962	5,531
T.tonggol	425	636	Stomatopods	6,723	5,319
Other tunnies	1,345	1,716	MOLLUSCS		69
BILLFISHES	1,732	1,679	Bivalves	327	16
BARRACUDAS	4,487	4,227	Gastropods	594	402
MULLETS	150	30	Cephalopods	32,306	28,421
UNICORN COD	0	0	MISCELLANEOUS	3709	2205
MISCELLANEOUS			Total		
Total	3,26,179	4,17,890	Grand total	5,36,970	6,05,523

Table 2. *Species of seaweeds and their distribution along Kerala coast*

Species	Zone I	Zone II	Zone III	Zone IV
Ulva lactuca				
U.fasciata		-		-
Enteromorpha intestinalis			-	-
E.compressa			-	-
Chaetomorpha antennina				
C.linum		-		-
Bryopsis plumosa		-		-
Caulerpa peltata		-		-
Padina gymnospora		-		-
Chnoospora minima		-	-	-
Sargassum wightii				-
S.berberifolium		-		-
Gelidium pusillum				-
Jania rubens		-		-
Grateloupia filicina				-
G.lithophila				-
Gelidiopsis variabilis		-		-
Gracilaria corticata		-		
G.millardetii		-		-
Hypnea valentiae		-		-
Centroceras clavulatum		-		-
Ceramium rubrum		-		-
Spyridia filamentosa		-	-	-
Acanthophora spicifera		-		-
Cladophora fascicularis	-	-		-
Caulerpa sertularioides	-	-		-
C. taxifolia	-	-		-
Dictyota dichotoma	-	-		-
D.barteyresiana	-	-		-
Padina tetrastromatica	-	-		-
Spathoglossum asperum	-	-		-
Pterocladia heteroplatos	-	-		-
Gracilaria foliifera	-	-		-
Laurencia sp.	-	-		-
Biomass (tonnes)	84.5	179.4	73.6	17.7
Area (sq.m)	75,750	144,000	78,000	18,000

(Source Krishnamoorthy *et al.* 1988)

NATIVE CATTLE GERMPLASM OF KERALA

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Livestock industry is an economic activity, which relates to the country's strength for augmenting food production, rural-development and equitable distribution of income. The National Commission on Agriculture suggested that in India, 70-75% of the households possessing milch cattle belong to vulnerable category of small farmers, marginal farmers and landless agricultural labourers. Thus the ultimate aim in planning is not merely to get a higher production but to achieve a significant and sustained increase in the farmers income mainly for the small holders. Animal and its products play a crucial role in agriculture and rural economy. The contribution of livestock to Agriculture Domestic Production (AGDP) was 14% in 1980-81 as against about 24% at present.

The Indian sub continent is well known as a rich reservoir of genetic diversity in livestock. India is the habitate for 26 cattle breeds which forms 10% of cattle breeds in the world and has 7 buffaloe breeds which is recognised as best in the world. It also possesses 26 breeds of goats and 23 sheep breeds. In India 80% of cattle and 65% of buffaloes are described as non-descript (Acharya 2000). This native cattle though lack a description excel in draught capacity, exhibit a distinct superiority in utilising poor quality feed and are better adapted to withstand heat and show high resistance to tropical diseases. These animals have special physical features and are adapted to hard work and tropical stress. These are developed because of local agriculture operations and management practices existing in different areas.

Indian cattle are generally explained as milch type, Draught type and Dual type; the buffaloes as Riverine and Swamp type. The NBAGR, an APEX co-ordinating and monitoring agency of Government of India is surveying, the various species of livestock to evaluate its status in our country. The cross breeding using exotic breeds for quick initial gain has led to dilution of various indigenous breeds and many of them are getting the threaten to extinction.

Kerala, a narrow strip of land in the southwestern part of Indian Peninsula is bordered in the East by the Western Ghats and in the West by the Arabian Sea. Kerala situated between 76° 23' and 77° 23' E longitude and 9°44' to 10°18' N latitude on the Northern Hemisphere. This state has a total geographical area of 38.66 lakh hectares. The total area has been arbitrarily divided into low land area (3.98 lakh hec.) Mid land area (16.23 hec) and high land area (18.65 lakh hec.). This state has abundant rainfall, which comes to 3125-nim average (per year). The climate is hot and quite humid. Kerala is not considered suitable for dairy forming. From time immemorial the cattle and buffaloes of this state were described as small. The Western Ghats of Kerala sustains rich biodiversity of flora and fauna. Among domesticated fauna, cattle, buffaloes and goats assure importance for resistance to many tropical diseases and also abiotic stresses like water and fodder scarcity. Many medicinal properties have been attributed to these fauna and their products.

Adequate efforts have not been made to identify the merits of these animals, their sustainability in the home tract or to describe them. During last decade scientists of Centre for Advanced Studies in

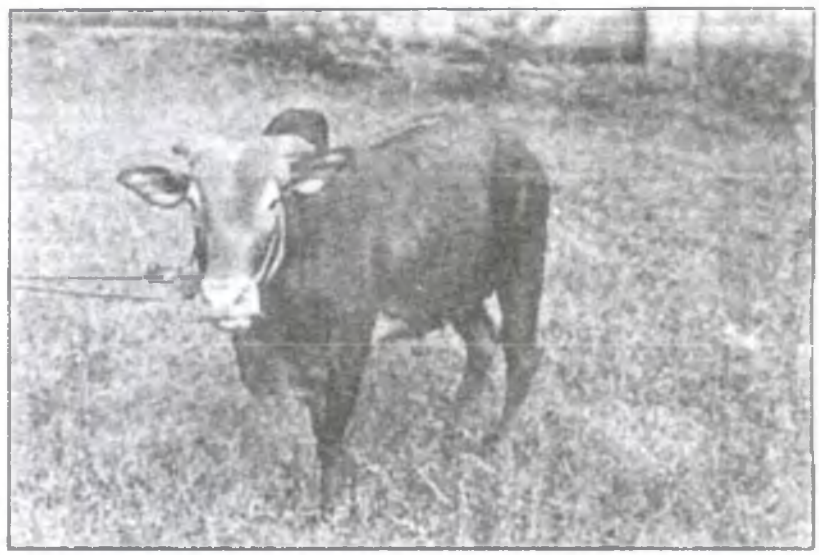
Animal Genetics & Breeding of College of Veterinary & Animal Sciences in Kerala Agricultural University took initiative to identify such groups and to describe and conserve them. This paper includes the documentation of such effort.

The first description of dwarf cattle of Kerala is that of Aiya (1940). He described the cattle of Kerala as small, poor milk producers and poor workers. The legendary Vechur Cattle were described by Velupillai (1940).

VECHUR CATTLE

Vechur cows were considered the pride of Kerala. The Vechur derived its name from that of a village in Kottayam District of Kerala. The Vechur Village is in the banks of one of the fresh water lakes namely Vembanad Lake near Vaikom of Central Kerala. The home tract of Vechur Cattle is a unique agricultural tract called Kuttanad, distributed over 79 villages, which fall in the districts Alappuzha, Kottayam and Pathanamthitta of Kerala.

Vechur cows in the field are maintained as house cows. The farmers preference for this cow had been due to their relatively high milk yield compared to other local cows of Kerala. Most of the owners of Vechur cattle are middle class farmers and environmentalists. The fodder available in the house premises, kitchen waste and rice gruel and little oil cake are the feed given to these animals. The milk of Vechur cows was considered to have medicinal value and used extensively in Ayurvedic system of medicine. The easy digestibility considered on Vechur milk is due to the small size of fat globule.



Fig(1) VECHUR

The Vechur animals are very decile. Very prominent hump in males and small hump in females is the description for Vechur breed. The Naval flap is small and the rump is described as triangular. Dewlap of male is very prominent and those of female is medium. Vechur animals generally have single colour with red, black and sandal white shades. The tail is long and may touches the ground in females.

This breed is described as the smallest of Indian Cattle breeds. The average height of male is 89.43 ± 6.55 cm and that of female is 87.75 ± 0.77 cm. The average body length is 101.43 ± 3.20 cm and 102.25 ± 1.52 cm for male and female respectively. The body weight is 170 kg. And 130 kg. For male and female adult animals. The body weight at birth recorded was 11.5 kg. For male and 10.5 kg for female calves.

The horn of vechur animals are either brown or black in colour. The average length is measured as 11.09 ± 0.99 cm. This can be curved or straight. The orientation is characteristic with curving foreword, then downward and backward with pointed tips. In some cases the horns are very small and stumpy.

Long and narrow head with long forehead is one of the characteristics of this breed. Average face length is 34.59±6.24 cm. The eyes are prominent and blackish in colour. The ears are medium in size with an average length of 16.64±0.15 cm with horizontal orientation.

The udder is symmetrical and medium in size. Prominent milk vein is one of the characteristics of this breed (Iype and Venkatachalapathi 2001). The average lactation milk yield recorded in Vechur cattle is 561.1 ± 13.8 lt. in a length of 242.0 ± 9.4 days. The average daily milk yield is 2.5 – 3.5 lt. per day with a peak yield of 4.1 ± 0.9 lt. The Vechur milk is well known for the fat %. It shows a fat % of 4.5 to 5.0%. The mean fat globule size reported was 3.2 μ with a range of 2.5 μ to 40. (Venkatachalapathy & Iype 1999). This fat globule size is higher than that of goat and lower than that of cross-bred cows and buffaloes. Thus this milk is recommended for infant feeding. The easy digestibility and high fat control of the milk fetch higher price. The preliminary study on Iodine Value indicates that Vechur milk have less unsaturated fatty acids compared to other cattle breeds.

In â lacto globulin locus, it has 3 phenotypes AA, AB and BB with A & B alleles. The A variant at â lacto albumin and â Lacto globulin locus had much higher frequency than other Indian, exotic breeds of cattle and crossbred cattle of Kerala. The B variant in Vechur Cattle was lower in frequency compared to other Indian breeds.

At present more than 20% of farmers prefer to have indigenous cows and the Vechur cows becomes the choice for them. Thus for many, the Vechur animals values beyond monetary standards. Steps should be taken to make Vechur cattle available to those who wish to have them.

HIGHRANGE DWARF CATTLE

The high altitudes of Kerala are places in Idukki and Wayanad districts. In these districts the local animals seen in the tea estates from Chenthallur to Vandiperiyar are known as – High range dwarf cattle. These animals are mainly reared by the Estate workers. These animals are isolated from other groups and developed special characteristics. At present they are maintained for supplementary income to the estate works. The habitat of this group is part of highlands of Kerala. The mean height of this land from sea level is around 1500 m.

Fig.(2) HIGHRANGE DWARF

These animals are present in pockets separated by geographical barriers. This cattle are usually let loose to the adjoining forest area for grazing in the morning and they return to their Kutcha open shelters in the evening so only night shelter is provided. Generally these animals are maintained in a zero in put system. The main income from these animals is by selling the calves and male animals for meat purposes during festival season. These are treated as asset to the poor estate workers.

The high range cattle are smaller in size with moderate temperament. This animal bears moderately developed hump and medium sized dewlap similar to that of zebu cattle. The ears are horizontal with an average length of 15 cm. The face length varies from 40-75 cm.

The colour is very prominent and distinct. More than half of the animals is brown or shade of brown colour. This colour is generally rare in Indian cattle. This may be because of infiltration of exotic genes from breeds like Brown Swiss, which was used for breeding in early years. The horns are long straight and generally black in colour with upward pointed ends. The average size of the horn is 15-20cm.

In high range cows the udder shape is generally round with cylindrical teats. Medium sized milk vein is seen. The milk yield range from 2 to 3 lts. per day and the peak yield noted is 3.5 lts in rare cases. The fat percentage recorded is 4.1%. The merit of this genotype is the high value recorded in all milk constituents like Fat % 4.48 ± 0.12. Total solids 13.78 ± 0.29 and SNF% 9.26 ± 0.25. Protein % 3.18 ± 0.06. Lactose % 3.79 ± .04.

KASARAGODE CATTLE

Kasaragode is the northern most distinct of Kerala. This is a comparatively dry land with laterate soil. A particular type of cattle seen in this area is known as Kasaragode cattle because it possess certain characteristics which make it distinct from other group of cattle and they are better adopted to dry land with laterate soil. These animals are larger than Vechur cattle but smaller than most Indian Cattle breeds.

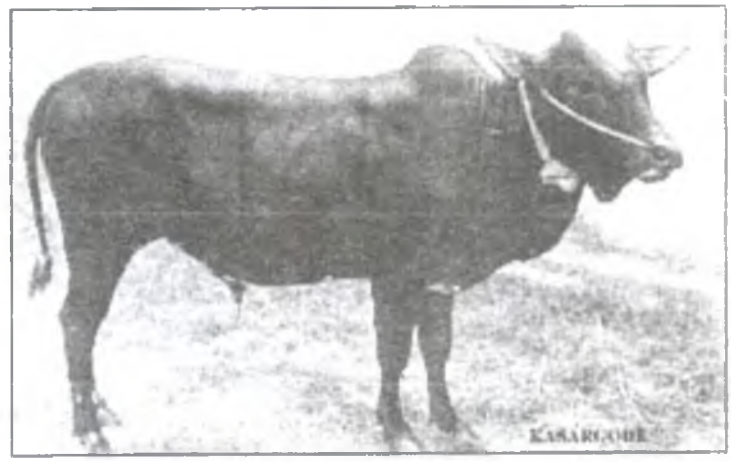


Fig.(3) KASARGODE

The Kasaragode cows produce only small quantity of milk, which is used for household purposes. Usually these animals are maintained as an organic manure producer. The Gobbara system seen in these areas show how these animals are well utilised. Tree leaves are spread on the floor as litter material in cowsheds. This will collect urine & dung. Fresh layer of leaves is added frequently and these are renewed once or twice in 2-3 months, which are used as manure for arecanut plantations. These are of high organic value. These animals are maintained as meat animals than milch animals.

The cows are normally docile in temperament. A large hump is a characteristic feature of these animals and the dewlap is medium in size. The naval flap is present on medical aspect of the body, which is very prominent in males.

The predominant colour of Kasaragode carttle is black and its shades like grey. The colour of eye and eyelids are black in majority cases. The ear is horizontal in position with an average length of 15.13±0.07 cm. These animals were observed to have medium hair with sheen as glossy and dull.

The average height recorded for these animal were 91.21±0.44 cm and length as 91.09±0.41 cm. Thus the height and length of body are in very close values. This trend is a characteristic feature of dwarf cattle when compared to other Indian breeds of cattle. The face is long with an average length of 34.85 ± 0.02 cm.

Generally Kasaragode animals are low milk producers. The udder is round and they possess a cylindrical and funnel shaped teats. The average daily milk production is below 2 lts. and the peak yield recorded is 2.5 lts. per day. The fat percentage recorded was 3.85 ± 0.13% and other constituents of milk are total solids 13.50 ± 0.25 SNF % 9.56 ± 0.18 Protein % 3.41 ± 0.08 and Lactose % 3.79 ± 0.05%.

These animals possess short and stumpy horn. In majority cases these are oriented as lateral pointed feature. The colour of horn is black. These animals are maintained in large number by certain group of people as a source of manure.

VATAKARA CATTLE

A type of small cattle seen in and around Vatakara area of Calicut District and some areas of Malappuram District, Kannur District form this group of cattle. These are maintained by certain group of people where the dairy industry is less remunerative and less profitable because of many reasons like cost, marketing, transportation etc. The Vatakara animals are mainly maintained as house cows and the milk product is mainly used for home consumption only.

Fig.4 VATAKARA

These animals are let loose to the uncultivated paddy fields and the main source of roughage is the grass of coconut gardens where the animals are tethered to the trees. Concentrated feeding is very limited and the rice gruel available in houses is given as a source of concentrate.

Generally these animals are small and the temperament is tractable. Usually they possess a small hump and dewlap but relatively large naval flap.

The horns are short with black or brown colour. There are two types of horns, one with straight pointed tips and other curved forward. The prominent colour is black or shades of black. Generally the coat colour is solid without patches or spots. The eyelids are black and 78% of these animals have black hooves also.

The average height of Vatakara cattle is 96 ± 0.15 cm and body length is 99 ± 0.28 cm. The ears are horizontally placed with an average length of 10.86 ± 0.8 cm. Generally these animals are low producers. The shape of udder is bowel shaped and possesses cylindrical shaped teats. The milk veins are very small in most of the animals.

The daily average milk production is 2 – 2.5 lit. and fat % $4.37 \pm 0.07\%$. The other constituents are total solids $13.36 \pm 0.19\%$, SNF $9.02 \pm 1.25\%$, Protein $3.41 \pm 0.12\%$, Lactose $3.99 \pm 0.5\%$. The Vatakara animals are the main source of milk for houses where modern dairy management activities are rare or not economical.

KUTTANAD BUFFALOES

In Kerala the buffaloes are mainly used as work animals since they are small and poor milk producers. These animals are mainly grouped as swamp type buffaloes.

The breeding tract of Kuttanad buffaloes is Kuttanad area, which is situated in Kuttanad and

Alappuzha Districts. The Edathua and nearby villages of Alappuzha district and Thalayazham and nearby areas of Kottayam district are the exact area where these animals are seen. At present these animals are very few in number and the survey shows the number is around five hundred only.

Fig 5 KUTTANAD

These buffaloes are mainly used for ploughing and possess characteristics, which are suited for the paddy fields of Kuttanad, which is very marshy. The females are maintained to produce males only. Generally these animals are housed in open sheds and during work season they fetch good return to the owners.

In general these buffaloes are described as small in size. The temperament is moderate. The position of the tail tip is at hock level and the tail switch is black in colour in majority of animals.

The average height of these animals is 109.02 ± 0.78 cm and the body length 111.01 ± 1.12 cm. The face is long with a length of 41.98 ± 0.45 cm. The ears are horizontally placed and the average length is 22.56 ± 0.24 cm. This value reveals that Kuttanad buffaloes are the smallest of the described buffaloes in the world.

The coat colour is described as grey in colour. The most identifiable mark of these buffaloes is the presence of chevrons.

Like swamp buffaloes and Surti and Badawari breeds of reverine buffaloes, the Kuttanadu buffaloes have two white lines, one at brisket region and the second seen in the upper part of ventral side of neck. The marking in the brisket region is large and extends between two armpits. The marking at the upper neck area is short and is seen just below the joint of neck with head. The farmers consider these white marking as the mark of purity of he animal (Anil Kumar 2003).

These buffaloes possess long and curly hair. They have black muzzle and the eyelids are black in colour. The hooves also show black colour. The colour of horn is light black. This has triangular appearance with a wide thick flat base. It usually ends in sharp points. The horns are directed slightly outward, then backward, upward and finally inward.

In generally these are very poor milk producers. The udder is round and possesses cylindrical or funnel shaped teats. The milk production is only 1 – 2 litre per day. The milk composition analysis reveals the following values. Fat % 6.10 ± 0.55, Total solids 17.40 ± 0.78%, SNF 11.30 ± 0.33%, Protein 3.90 ± 0.08%, Lactose % 3.20 ± 0.10%.

Though Kuttanad buffaloes are poor milk producers, they are well known for work in marshy lands of paddy field. Thus they are an asset to the owners which is very evident from the price during season and it may go upto Rs. 20,000 – 50,000 for one pair.

Another genetic resource available in Kerala is caprice species. The Malabari goat or Tellichen goat is famous as a dual-purpose breed of goat. The native tract of this genetic group is Malappuram and Calicut districts of Kerala. In many parts of Kerala the goat rearing or goat farming is a major source of income especially for marginal or poor farmers. Thus the goat has given the synonym 'Poor man's Cow'. Recently, a type of goat known as Attapady Black Goat attracted many scientists. This is meat type of goat and mainly reared by tribals of Attappady area. The black colour and other physical features make this distinct from other breeds and qualities for the approval as a breed though not yet recognised as a breed. The studies on goats in general revealed that its population size is decreasing drastically in every census and thus a scientific and enthusiastic effort is very necessary to maintain them in future.

Conclusion

The diversified genotype of each species is evolved through continuous natural selection process to adopt to all conditions existing in a particular geographical area and the management practices. Thus these have the unique qualities to sustain all hardships and possess many valuable genes like medicinal properties of dwarf cattle.

A forceful introversion of this genetic makes up for shorter gain without any emphasis on characterisation and conservation of the germplasm will result in irreversible reduction at nature's profusion of life forms.

Thus an earliest effort to preserve this genetic diversity is a need of the present century. All the institutions involved in these activities must be encouraged to continue their efforts in future also. Over and above it has been the conviction that 'we do not have the right to destroy what we inherited from our forefathers and we have to save them for our children'.

FOREST WEALTH OF KERALA

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Introduction

Forests are renewable resources encompassing millions of living organisms, both plants and animals. Unscientific exploitation of renewable and non renewable natural resources leads to their depletion. Among the renewable resources, plants are extremely important as they sustain human and other animal life over generations. Tropical rainforests are the most biodiversity rich vegetation type in the world. Although they constitute only seven percent of the total forests of the world, they harbour 56% of the known plants and animals. Unfortunately tropical rainforests are disappearing at an alarming rate than any other plant communities in the world. At the same time, attempts were also made to bring more areas under forests.

During the last decade the annual rate of forest cover change in India was +0.1 per cent which probably gives us some satisfaction in comparison with the global figure of –0.2%. But that is no consolation if we compare our achievement with that of our neighboring countries such as China (+1%) and Bangladesh (+1.3%) (FAO, 2001). Also, the dense forest cover in India is only 12 per cent of the land area which is much less than the target of 33 per cent. As India's forests are rich in biodiversity, it is important to focus on the protection of pristine, untouched forests. However there is not much information about such forests which probably do not account for even 3.5 per cent of the country's land area (Agarwal et al, 1999).

Situated along the southwest corner of India, bordered by the Lakshadweep sea, the state of Kerala has an area of 38,863 km^2. The varied topographical features, high rainfall and geologic conditions have favoured the formation of different ecosystems from shola forests on the mountain valleys to the mangrove forests along sea coasts and estuaries. The most outstanding feature of the state is the presence of tropical rainforests along the windward side of the southern Western Ghats, which is lying parallel to the west coast. In the rain shadow region of the Western Ghats, the vegetation is dominated by dry deciduous forests and scrub jungles. The wet lands are mostly confined to the low land region of the state.

Kerala has a total forest area of 11125.5 km^2 of which 9400 km^2 forms the effective forest area (Kerala Forest and Wildlife Department, 1999).

According to Chandrasekharan (1973), the area under forests got progressively reduced from 12,850 km^2 in 1940 to 9,770 km^2 in 1965 and 9,400 km^2 in 1970. The extent of forest area of the state estimated by different agencies are given in Table.

Table 1. Extent of forest area in Kerala

Year	Area under Forest (km^2)	Percent of geographical area	Source
1973	9400	24.10	Resources survey Forest Department (1973)
1983	11229	28.90	Administrative report Forest Department (1983)
1983	6628	17.00	Landsat studies (1983)
1993	10292	26.50	Forest Survey of India Record (1993)
1992	9400	24.10	Forest Statistics, Kerala (1992)

The extent of forests in different districts of Kerala is given in Table 2.

Table 2. Extent of forests in different districts (in km^2)

District	Geographical Area*	Forest area (Legal)*	Actual Forest area	% of actual forest area to geographical area	% of degraded forests to actual**
Kasargod	1992	110.71	64.62	3.24	64
Kannur	2966	230.09	163.17	5.50	68
Wayanad	2131	884.27	791.86	37.16	64
Kozhikode	2344	294.50	147.30	6.28	69
Malappuram	3550	760.31	756.99	21.32	59
Palakkad	4480	1604.06	1190.40	26.57	56
Thrissur	3032	1013.07	888.80	29.31	63
Ernakulam	2407	310.97	232.50	9.66	59
Alapuzha	1414	0.00	0.00	0.00	00
Kottayam	2003	100.84	54.02	2.45	57
Idukki	5019	2991.11	2679.00	53.38	56
Pathanamthitta	2642	1567.75	1330.20	50.35	69
Kollam	2491	862.08	736.00	29.55	54
Thiruvanathapuram	2192	493.16	403.07	18.39	56
Total	38663	11222.92	9437.93	24.28	--

*Kerala State Landuse Board 1995. Land Resources of Kerala, **Kerala Forest Research Institute

Forest Types

Champion and Seth (1968) recognized 28 vegetation types in Kerala, including both primary as well as secondary forests. This includes a few edaphic types such as Myristica swamp forests, Bamboo breaks, Reed breaks, etc.

The different forest types in Kerala according to the classification of Champion and Seth and the plantation established in forest land is given in Table 3.

Table 3. Major forest types of Kerala

Forest types	Area (km^2)	Percentage
Tropical Wet Evergreen and Semi Evergreen	3299	35.1
Tropical Moist Deciduous	4100	43.6
Tropical Dry Deciduous	100	1.1
Montane Sub-tropical Temperate shoals	70	0.7
Plantations	1701	18.1
Grasslands	130	1.4
Total	9400	100

Source: Kerala Forest and Wildlife Department, 1999

West coast tropical evergreen forests

Evergreen forests are characterized by the profusion trees and woody climbers, the canopy is almost closed. The lower shrubby layer is composed of mostly seedlings and saplings of tree species. Evergreen forests are found between 400-1300m above sea level. There is different in the physiognomy and species composition with change in altitude. Evergreen forests below 700 m occur mostly in patches, confining to the sides of water courses where the soil is rather deep. Though there is no marked dominance of any species in the upper stratum trees in the forests below 700 m altitude, there is dominance of certain species in the upper stratum trees above 700 m often forming definite associations. The important associations are i. Vateria calophyllum-Cullenia ii. Mesua-Cullenia-Palaquium and iii. Mesua-Palaquium. In evergreen forests above 1000 m there is dominance of trees belonging to Lauraceae. Epiphytes and mosses tend to increase with altitude.

The important tree species are Acrocarpus fraxinifolius, Ailanthus triphysa, Calophyllum polyanthum, Canarium strictum, Dipterocarpus indicus, Dipterocarpus bourdillonii, Dysoxylum malabaricum, Hopea parviflora, Kingiodendron pinnatum, Mesua ferrea, Cullenia exarillata, Palaquium ellipticum, Persea macrantha, Syzygium gardneri, etc.

The exploitation evergreen forests in the part, were mostly for veneering industry in the state. The tall straight unbranched boles of Vateria, Calophyllum, Dipterocarpus, Palaquium etc. are suited for plywood industry. Hardwood species like Hopea and Mesua were extracted for railway sleepers in the past.

West coast semi evergreen forests

This forest type is intermediary between evergreen and moist deciduous types with predominantly evergreen tree species. The deciduous species constitute 10 to 20 per cent of the trees. The lower shrubby stratum is composed of Acanthaceae, Zingiberaceae, Leguminosae, Malvaceae spp. Woody climbers as well as epiphytes are common. Semi-evergreen forests are found below 900 m above sea level.

The tree commonly met with are Antiracism toxic aria, Archicarps comedians spp. Zeylanicus, Artocarpus hirsutus, Bischofia javanica, Bombax ceiba, Carallia brachiata, Chukrasia tabularis, Diospyros buxifolia, Hopea parviflora, Polyalthia fragrans, Prunus ceylanica, Pterospermum reticulatum, Pterospermum rubiginosum, Pterygota alata, Terminalia bellirica, Tetrameles nudiflora. Toona ciliata, Vitex altissima etc.

Southern moist mixed deciduous forests

This forest type is a mostly seen below 800 m above sea level, During wet season because of the thick foliage, the canopy looks similar to that of semi evergreen forests, therefore scarcely distinguishable. However, during dry season they reveal their true identity as the trees shed their leaves. The leafless period varies from a few weeks to five months depending on the species. Bombax insigne, Hymenodictyon obovatum and Lagerstroemia microcarpa have a leafless period up to five months. Whereas Terminalia paniculata and Dalbergia sissoides, the leafless period is less than 2 weeks. The trees in general are tall and consists many hard and durable timber yielding species.

The dominant tree species are Albizia lebbeck, Albizia procera, Albizia odoratissima, Alstonia scholaris, Bombax ceiba, Bombax insigne, Dalbergia sissoides, Dillenia pentagyna, Gmelina arborea, Grewia tiliifolia, haldina cordifolia, Lagerstroemia microcarpa, Melia dubia, Pterocarpus marsupium, Stereospermum, Tectona grandis, Terminalia bellirica, Terminalia crenulata, Terminalia paniculata, Tetrameles nudiflora, Xylia xylocarpa, etc.

This forest type consists of several hard and durable timber yielding species like teak, rosewood, Irul, Venga, Chadachi, etc. Therefore, most deciduous forests have been heavily exploited for extraction of valuable timber.

Southern dry mixed deciduous forests

This forest type is mostly confined to the rain shadow regions of the Western Ghats. The forests in general are with small to medium sized deciduous trees. The undergrowth is often with thorny species.

The characteristic species in this type are Anogeissus latifolia, Boswellia serrata, Cassia fistula, Chloroxylon swietenia, Commiphora caudate, Diospyros cordifolia, Garuga floribunda, Hardwickia binata, Sapindus emarginatus, Shorea roxburghii, Sterculia urens, Strychnos potatorum, etc.

Southern montane wet temperate forests (Sholas)

This forest type is confined to the valleys or folds of hills above 1500 m. The trees are small and highly branched. The branches of trees are clothed with dense growth of mosses. Epiphytes are very common.

The characteristic species are Actinodaphne bourdillonii, Beilschmiedia wightii, Elaeocarpus munronii, Elaeocarpus recurvatus, Gordonia obtuse, Litsea wightiana, Mahonia leschenaultii, Michelia champaca, Neolitsea fischeri, Rapanea thwaitesii, Rhododendron arboreum etc.

Southern montane wet grasslands

Grasslands are confined to hills above 1500 m above sea level. The common grasses are Agrostis peninsularis, Apocopis courtallica, Arundinella leptochloa, Arundinella mesophylla, Chrysopogon aspera, Chrysopogon hackelii, Chrysopogon flexuosus, Digitaria wallichiana, Dimeria ornithopoda, Eulalia phaeothrix, Tripogon bromoides, Zenkeria elegans, etc.

The grasslands also supports several shrubby and herbaceous species such as Anaphalis lawii, Andrographis neesiana, Crotalaria spp., Habenaria spp., Hedyotis spp., Heracleum spp., Hypericum mysorense, Leucas spp., Osbeckia wightiana, Osbeckia leschenaultiana, Strobilanthes spp., etc.

Grasslands can be classified into two types viz; low level grasslands and high level grasslands.

a. Low level grasslands: These are sen distributed along with the evergreen forests at (1000-1800 m) at Silent Valley, Munnar, Wayanad etc. and repeated annual fires prevent these grasslands from progression towards woodlands. Those occurring in the margins of the evergreen forest very often get burnt and fire invades the evergreen forests.

The trees are pyroresistant with thick bark, and stunted growth. Given adequate protection from fire, as experienced in Silent Valley these grasslands can progress towards woodlands.

Flora consists of Careya arborea, Canthium dicoccum, Dalbergia latifolia, Phyllanthus emblica, Gordonia obtuse, Maesa perrottetiana, Phoenix humilis, Glochidion ellipticum, Wendlandia notoniana, Rubus ellipticus etc.

b. High level grasslands: These are encountered above 1800 m at Silent Valley, Munnar, Eravikulam, etc. and are characterized by dwarf, carpet like grasslands. Rainfall is quite high, often above 6000 mm and due to sloppy nature of the terrain run off is also heavy. Heavy wind and frost are quite common. The grasslands are interspersed with patches of evergreen forests commonly called as 'sholas'.

Important species inhabiting these grasslands are: Gaultheria fragrantissima and Strobilanthus spp. associated with grasses like, Arundinella fuscata, Chrysopogon zeylanicus, bothriochloa pertusa, heteropogn contortus and many herbaceous plants.

Sacred groves

Apart from the above mentioned legally notified forests, the state also has 361 low level forests, surrounding the temples, commonly called as 'Sacred Groves' which are afforded protection by the local inhabitants out of religious fervour. These are religiously protected areas harbouring a lot of plant animal diversity. They provide a countrywide network of protected areas wherein the inherent diversity of flora and fauna are preserved for present and future human use. They are often described as natural museums of giant living trees, treasurehouse of rare, endemic and endangered species, dispensary of medicinal plants, recreation center for urban life, garden for botanists, genebank of economic species, paradise for natural lovers and laboratory for environmentalists sacred groves are invariably associated with certain gods and goddesses and along with them certain species are also considered holy and protected (e.g. Aegle marmelos, Alstonia scholaris, Azadirachta indica; Butea monosperma, Calamus rotang, Crataeva religiosa, Elaeocarpus tuberculatus, Ficus religiosa, Mimusops elengii, Nyctanthes arbortristis, Ocimum sanctum, Santalum album, Saraca asoca and Syzygium cuminii).

These groves that are about 0.5 to five hectares in size are the habitations for nearly 722 species. Of these, 154 species are endemic and confined to only the low level, evergreen forests. It is worth mentioning here that species like, Blepharistemma membranifolia, an inland taxon belonging to the family Rhizophoraceae, Buchanania angustifolia (Aracardiaceae), Casearia wynaadensis (Flacourtian), Gymnacranthera canarica (Myristicaceae) and Syzygium travancoricum (Myrtaceae), all of which had a wider distribution in the past are now confined to 'Sacred Groves'. A few species belonging to Threatened' category of like, Cleome burmanni, Kunstleria keralensia and Pterospermum reticulatum have been reported from sacred groves thus emphasising their importance in conservation.

Kerala has 761 groves but most of them are quite small and fragmented. Only 361 groves exceed 200 m^2. Their distribution in various districts together with their extent are given in Table 4.

Table 4. Distribution of sacred groves in various districts

District	Size of groves (in ha)				
	<5	5-1	1-5	>5	Total
Alappuzha	42	3	4	-	49
Calicut	13	4	4	2	23
Cannanore	28	3	18	5	54
Ernakulam	4	1	1	1	7
Idukki	1	-	2	-	3
Kasargod	50	4	6	-	60
Kottayam	9	-	1	-	10
Malappuram	7	2	2	-	11
Palakkad	1	1	1	-	3
Pathanamthirra	30	2	-	1	33
Kollam	42	1	-	-	44
Thrissur	13	2	1	-	16
Thiruvananthapuram	42	1	-	-	43
Wayanad	3	-	-	2	5
Total	285	24	40	11	360

Rare and threatened plants

Due to degradation of forests mainly due to human related activities, a large number of plants have come under the RET category. According to Nayar (1997) 455 endemic species are belonging to the rare and endangered. Categories and some of them are presumed to become extinct. Therefore immediate efforts are necessary to relocate these species and adopt both ex-situ and in-situ measures. Table 5 provides the details of rare and threatened plants in Kerala.

Table 5. Rare and Threatened Plants in Kerala, IUCN (Revised Category, 1994)

Possibly Extinct	35
Critically Endangered	136
Vulnerable	147
Low risk	142
Data deficient	31
Not evaluated	5
Total	496

Source: Ahmedullah & Nayar, 1987; Nayar & Sastry, 1987, 1988, 1990; Nayar, (1997)

Forest plantations

Plantations were raised by clear felling the forests planted in the grasslands to meet the requirement of forest based industry and general-purpose timber. Teak is the most extensively raised plantation species. Other indigenous species raised in plantation are Ailanthus triphysa, Bombax ceiba, Gmelina arborea, and Hopea parvifolia. Exotics like Acacia auriculiformis, Eucalyptus grandis, Eucalyptus tereticornis, Grevillea robusta, Paraserianthes falcataria and Swietenia macrophylla are the important species raised in plantations.

The productivity of forest plantations in Kerala is far below the potential. For teak the average mean annual volume increment including thinning is 3.662 $m^3ha^{-1}yr^{-1}$. The maximum (4.484 $m^3ha^{-1}yr^{-1}$) and minimum (2.724 $m^3ha^{-1}yr^{-1}$) figures give an indication of the potential of achieving a higher value. For eucalyptus the figures are more alarming. For Eucalyptus grandis the present mean annual value is $10m^3ha^{-1}yr^{-1}$. Eucalyptus tereticornis gives a mean annual volume increment of 7.653 $m^3ha^{-1}yr^{-1}$ for seedling crop and 2.545 $m^3ha^{-1}yr^{-1}$ for coppice crop whereas our expectation for such pulpwood species is a productivity level above 30 m^3 $ha^{-1}yr^{-1}$.

Forest Resources – Non-wood Forest Products

Traditionally forest resources are classified as wood and non-wood forest products (NWFPs). In the forests of Kerala, there are about 750 tree species of which 35 per cent are endemic to the Western Ghats. These trees exhibit tremendous variations in height, density, hardness, texture, finishing qualities, durability, etc. They can be put to variety of end uses such as building construction, furniture, veneer and plywood, match wood and splints, packing

cases, tool handles, boat and ship building, turnery, carving, handicraft, sport good, musical instruments, etc.

The forest management practices followed was with emphasis on generation of income. As timber fetched more prices, they were considered as the major forest produce and others as minor forest produce. However, the role of minor forest produce or Non-Wood Forest Products is being increasingly understood during the last few decades. They provide a variety of products such as food, medicine, fibre, household articles, fodder, etc. Rural communities, especially the tribal who lives in or near the forests are the privileged gathers of NWFPs and their main source of income and sustenance.

Now a day there is a change of perception regarding NWFPs utilization. In the past, the rural communities exploited NWFPs mostly for their self-use. Due to the development of scientific knowledge, a variety of NWFPs are now raw materials for several industries. As a result the demand for the NWFPs has increased. At present in India 50 percent of the forest revenue and 70 percent of the forest export income come from the NWFPs (Krishnamurthy, 1993).

In Kerala, it is estimated that there are about 540 species yielding Non-Wood Forest Products of which majority of them are medicinal. Kerala, having a rich diversity of medicinal plants, also, has a rich tradition in Ayurvedic system of medicine and the well-reputed Ayurveda hospitals in India are in Kerala. It is estimated that Ayurvedic medicine worth Rs.200 crores are produced annually in Kerala. The herbs for the preparation of medicine are mostly collected form the forests and the demand is increasing every year. The increase in demand leads to over exploitation and even their depletion form forests.

Spices are the second largest category of NWFPs. Kerala has the unique distinction of being the home both king and queen of the species, the black pepper (Piper nigrum) and cardamom (Elettaria cardamom). The number of species and varieties reveals the richness and diversity of pepper germplasm. Piper nigrum has 35 cultivars. Other major spice is Cinnamon. There are 15 speceis of Cinnamomum beside the cultivated C. camphora, which yield camphor. Garcinia gummi-gutta yields the gamboges, Garcinia indica is the source of Kokkum butter, and the latex of Garcinia morella and G.wightii are used to extract natural dyes. The aril of Myristica malabarica, M. dactyloides, M. mangifica are valuable source natural dyes, much preferred in food industry. Apart from Elettaria cardamomum, the rhizome of Zingiber spp., Curcuma spp. is source of perfumes and dyes. Phyllanthus emblica and P. indofischeri are the source of gooseberry. The fruits of P. emblica exhibit great variation in size as well as yield several variations with regard to the size and taste of mango can be found in the forests as well as in homesteads. There are also other fruits yielding plants such as Spondias pinnata, Baccaurea courtallensis, Aporusa lindleyana, Musa acuminata, Schleichera oleosa, Artocarpus heterophyllus, A. hirsutus, and Ziziphus rugosa. There are about 95 species yielding edible fruits in forests.

Gum and resins, particularly black dammar and white dammar are important raw materials for varnish as well as incense. Animal products like honey, bee

wax and lac are valuable NWFPs. The oil obtained from seed of Mesua ferrea, Calophyllum polyanthum, Madhuca latifolia, Hydnocarpus pentandra, Pongamia pinnata, etc. are used for industrial and medicinal purpose.

Bamboo and rattans are important raw materials for cottage industry, and pulp industry. There are two bamboos viz. Bambusa bambos and Dendrocalamus strictus and 13 species of reed bamboos. There are 14 species rattans mostly used in the production of cane furniture.

KFRI (Nair et al, 2001) has estimated the bamboo resources of Kerala using remote sensed data, and field checking. The Olavakode region has the maximum quantity (34.03%) of bamboo among the five regions in the state. Most of the bamboo in this region is in Nilambur North and Nilambur south Forest Divisions and Parambikulam Wildlife Sanctuary. The Northern region accounts for 30.68% in the Northern Circle and Wayanad Wildlife Sanctuary. The Southern region comes third (21.72%) in terms of bamboo availability. The Trivandrum wildlife Division, Trivandurm and Achenkovil Forest divisions contribute the maximum. The Central region and the High range region contain 8.90% and 4.66% respectively. In this case also the Wildlife sanctuaries/National Parks of the region are included. Division wise, maximum quantity of bamboo is in the Wayanad Wildlife Sanctuary (16.21% of total) and North division (14.96%). This is followed by Achenkovil (7.89%), Parambikulam (5.99%), Nilambur South (5.74%), Wayanad North (5.28%), Trivandrum (2.76%) and Trivandrum Wildife (2.58%) Divisions. Other divisions have relatively less bamboo (Nair et al. 2001).

The total bamboo stock in the state would be to the tune of 2.63 million tones. This is much higher than that was reported to be available in 1997 (1.4 million tones). Based on present age distribution, it is evident that Parambikulam area will have fully grown bamboo clumps by about 2010. The availability of bamboo can fluctuate widely because of reasons like gregarious flowering, and utilisation plans should take this into account (Nair et al.. 2001).

Wild animal diversity

Next to plants, the large animals like elephant, tiger, monkeys and deer, etc. are the, ones which we normally associate with forests. However, there are a large number of other animal species in the forests, although our knowledge about them, particularly the smaller ones (mainly the invertebrates or animals without backbone) is very incomplete. Sometimes, from the literature it is also difficult to distinguish between species which occur in forest and which occur in the non-forest areas are also found in forest areas, although the reverse is not true. This is understandable because most of Kerala must have once been covered by forests. Table 3.6 shows the number of genera or species recorded from Kerala for the major groups of animals. This also includes some animals found in marine habitats because no separate listing can be quickly made. The above list admittedly underestimates the number of species, except in the case of larger mammals and birds which have been comparatively better studied. For most groups of animals, the information available is meager and widely scattered. Efforts are needed to assemble the scattered published information as well as to gather new information.

The status with respect to specific groups will be examined in later sections. It may be seen from Table 3.6 that for many groups of invertebrates we are able to give only the numbers of genera. Information does exist on the species identity, but considerable effort is needed to determine whether a particular species has been recorded from the forests of Kerala or not. This requires the effort of a large number of experts. Recent research on animal fauna of Silent Valley indicates that what we know is only a small fraction of what exists in this largely unexplored area. Many animal groups, particularly the, invertebrates, have not been studied at all, because of the, scarcity of taxonomists specialized in the various groups and the inadequacy of financial support. Unfortunately, in spite of the current worldwide interest and importance given to biodiversity, the research effort remains superficial, largely confined to promotion of gathering published data, with very little support to encourage primary taxonomic studies on specific groups of organisms, the foundation on which identification of species rests (Nair, 1997). Although very incomplete, we have presented the information given in Table 3.6 in order to emphasise the need for updating such information. The number of world species so far described, which is also incomplete for several groups of animals, is given for comparison.

Kerala forests are a subset of the Western Ghat forests, which is known to be a megabiodiversity center for plants. Since animal diversity is ultimately linked to plant diversity through the food chain, it can be expected to reflect the rich plant biodiversity. In fact, this is already evident from the presence of several endemic species of animals referred to later, but there is severe dearth of information for many groups of animals.

Table 3.6. Minimum number of genera/species of animals recorded from Kerala

Groups	No. of Genera	No. of Species	No. species World total[a]
Vertebrates (Animals with backbone) Pisces (fishes)		196	19,056
Amphibia (amphibians)		86	4,184
Reptilia (Reptiles)		142	6,300
Aves (birds)		475	9,040
Mammalia (mammals)		75	4,000
Invertebrates[b] (Animals without backbone)			
Protoza	63	-	30,800
Porifera (Sponges)	22	-	5,000
Coelenterata (jelly fish, corals)	90	-	9,000
Platyhelminthes (Flatworms)	117	-	12,200
Acanthocephala	16	27	-
Aschelminthes	265	121	-

Annelida (earth worms, leaches)	46	91	12,000
Chaetognatha	4	18	-
Mollusca (snails, oysters, etc.)	19	26	50,000
Echinodermata (starfish, sea cucumbers)	7	8	6.100
Insecta (insects)[c]	193	6000	751,000
Non-insect Arthropoda (crustaceams. Mites, spiders)	242		123,161

Source: [a]Wheeler (1990); [b]Radhakrishnan, ZSI (Pers. Comm..); [c]George Mathew, KFRI (Pers. Comm.)

Mammals

The mammals can be distinguished mainly by the presence of body hair and mammary glands. At least 75 species of mammals have been recorded from Kerala. Fourteen species, including the well known Lion-tailed macaque, the Nilgiri langur, Malabar civet and others mentioned below are known to occur only in the Western Ghats (endemic). The mammals can be broadly grouped, based on feeding habits into Carnivores and Herbivores. The Carnivores include the Cats, Civets, Dogs, Bears, Mustelids (otter and marten) and the herbivores include the monkeys, bats, elephant, deer, bovids, pigs, hare, rodents (squirrels, porcupine, rats and mouse) and omnivores (feeding both on animal and plant matter). They can also be grouped on the basis of size into large, medium and small mammals. However, the best means to comprehend the biodiversity of mammals is to group them according to the commonly understood groups as done below. However, to give a complete picture of the biodiversity of mammals occurring in Kerala, a list of numbers of orders, families and species is given in Table 3.10. The individual species are not listed.

Birds

Kerala is a paradise for bird watchers and birds are probably the best documented group of animals in the state. About 475 species of birds have been reported from the State, thanks to the pioneering work of Salim Ali (1986), Neelakantan (1958) and other naturalists. Even the list of families itself is long (Table 3.11). The bird fauna includes a number of endemic and migrants (Neelakantan et al, 1993). Ten species of birds which are endemic to Western Ghats are present in the State. Most Protected Areas in Kerala are rich in birds – 249 species are present in Periyar Tiger Reserve, 192 in Silent Valley, 185 in Parambikulam, 177 in Peechi and 160 in Chimmoni. The Order Passeriformes, consisting of Pitas, Larks, Swallows, Shrikes, Orioles, Drongos, Starlings, Mynas, Crows, Tree pipes, Cuckoo shrikes, Minivets, Fairy blue birds, Bullbuls, Joras, Babblers, Fly catchers, Warblers, Thrushes, Chats, Nuthatches, Pipits, Wagtails, Sunbirds, Flower peckers, Munias, Sparrows and Weaver birds constitute the major group accounting for 186 species. Hawks, Vultures and

Falcons contribute 40 species. Grebes, Boobies, Cormorants, Herons, Ducks and Geese are the major water birds.

The Great Indian Hornbill, the State bird is one of the magnificent species found in the evergreen forests. The Fairy blue bird, Malabar whistling thrush, Jerdon's Imperial Pigeon and Nilgiri laughing thrush are a few other species of evergreen forests.

The Marked body, Shag, Greater Flamingo, Barheaded goose, Pink tail, Desert wheatear, Avocet, Wryneck, Eastern Orphean Warbler and Masked Wagtail are a few of the migrants.

Reptiles

The reptiles include Crocodiles, Turtles, Lizards and Snakes, distributed in a variety of habitats. At least 449 species of reptiles are reported from India of which 142 species occur in Kerala which include two species of Crocodiles, nine species of turtles, 57 species of lizards and 87 species of snakes. Number of species of Reptiles recorded from Kerala is given in Table 3.11.

Amphibians

The amphibians include frogs, toads, newts, salamanders and caecilians (limbless amphibians). Eighty six of the 197 species of amphibians recorded from the Indian Sub-continent are present in Kerala (George and Alex, 1995) (Table 3.12). Ranids (frogs) with 31 species dominate the group. Toads are comparatively rare and are represented by nine species in the state with one viz., Ansonia rubuginosa known only from Silent Valley National park. Microhylids are represented by seven species and almost all are distributed in the Ghat area. Among these, Kaloula pulchra, the Ceylone Kaloula, the most beautiful from in the world is found in the state. Uperodon globulosum is an uncommon burrowing form recently recorded from Erumely in Kottayam district.

The limbless Caecilians are the least studied group among the Amphibians. They are snake like with poorly developed eyes and therefore referred to as Blind snake. They are small and often mistaken for earth worm. Eleven species are known from the State under three genera. Most of them are known only from their type locality and the knowledge on their distribution and status is poor. The amphibian fauna of Silent Valley was studied recently by Pillai (1986).

Fishes

The hill streams and rivers of Kerala have a rich fish fauna, comprising 194 species (Table 3.14). The carps and the related species like Hatchets, Labeos, Hill trouts, Flying barbs, Garra, Razor bellies and Mahseers dominate. Mahseers and Carnatic carp are game fishes – the former is endangered and the latter has become very rare.

The carps support the major fisheries in the State. The introduced species like, Gold fish (Cryprinus carpio communis), Catla (Catla catla), Rohita (Labeo rohita)

and Mrigala (Cirrhinus mrigala) thrive well in the natural ecosystems and man made lakes. However, they exert pressure on the native fishes threatening their survival.

The highly torrential forms like the Bhavania, Balitora, Travancoria and Noemachilus are well adapted to the mountain streams of Western Ghats. Among the fishes, Travancoria, Horaglanis and Horabagrus are some of the endemic genera of the State. Similarly there are about 25 endemic species under various genera represented in the State (Talwar and Jhingran, 1991; Jayaram, 1981). Many of the species including the endemics are either endangered, rare or threatened. The fishes like Wayanad barb (Puntius wynaadensis), Periyar trout (Lepidopygopsis typus), Travancore batasio (Mtasio travancoria) and Malabar puffer fish (Tetraodon travancoricus) are some of the endemic endangered fishes (Menon, 1993). "The recent outbreak of fish disease, unscientific method of fishing, over-exploitation and pollution from various sources lead to the decline of even common species (Easa and Basha, 1995).

The Invertebrates

The invertebrates are animals without backbones and they far outnumber the better known vertebrates in species number. On a global scale, the number of invertebrate species is about 23.4 times the number of vertebrate species (Table 3.14). If we use the same proportion to estimate the number of invertebrate species from the number of vertebrate species, we should have about 22,800 species of invertebrates in Kerala. This appears to be a reasonable estimate.

The most dominant among the invertebrates are the insects which account for nearly three fourth of the living organisms described so far, as indicated earlier. A recent attempt at the Kerala Forest Research Institute to list the insect species recorded from Kerala has brought up 6,000 species and the number in growing as we scan more publications. We estimate that this number will reach 10,000. The diversity, ecological functions and pest status of the forest insects of Kerala have been reviewed recently (Nair, 1997).

In general, the invertebrate animals of Kerala is very poorly known and the available literature is very widely scattered. Within the time available for preparing this paper, it was not possible to gather sufficient information. We, therefore think it best to reserve a discussion on various invertebrate groups although they are more numerous and diverse than the vertebrates. While we have not been able to assemble all the available information on invertebrates of Kerala here, as indicated earlier, it is evident that more investigations are needed to chronicle the invertebrate biodiversity of Kerala.

Conservation of Forest Resources

The State of Kerala has a relatively high percent (24 %) of the forest declared as protected areas by establishing Wildlife Sanctuaries and National Parks (Table 6). Recently, 7 medicinal plant conservation areas covering different vegetation types were also established mainly for the in-situ conservation of medicinal plants (Table 7). The floristic studies carried out in the protected areas have

brought out the plant wealth in sanctuaries. From Periyar Tiger Reserve, Thekkady which has an areas of just 777 km^2 including the Periyar lake has about 2000 species of flowering plants were recorded of which 150 species belong to the threatened categories including 16 species considered as possibly extinct. The recent studies carried out in the protected areas in Kerala have revealed that the Wildlife Sanctuaries and National Parks are rich in biodiversity, particularly of higher Organisms. We are yet to study the diversity among lower groups of plants and animals including microbes. Though our forests are rich in biodiversity, they are also very much threatened.

Table 6. Protected Areas in Kerala

Sl. No.	Name of the Sancturary	Area (km^2)	Date of Notification
1.	Neyyar Wildlife Sanctuary	128.00	06 Aug 1958
2.	Peechi-Vazhani Wildlife Sanctuary	125.00	06 Aug 1958
3.	Parambikulam Wildlife Sanctuary	295.00	12 Feb 1973
4.	Wynad Wildlife Sanctuary	344.46	30 May 1973
5.	Idukki Wildlife Sanctuary	70.00	29 Feb 1976
6.	Periyar Tiger Reserve	777.54	09 Aug 1977
7.	Eravikulam National Park	97.00	19 May 1978
8.	Peppara Wildlife Sanctuary	53.00	21 Dec 1983
9.	Chinnar Wildlife Sanctuary	90.44	04 Aug 1984
10.	Shenduruny Wildlife Sanctuary	100.32	25 Aug 1984
11.	Chimmoni Wildlife Sanctuary	76.00	25 Aug 1984
12.	Aralam Wildlife Sanctuary	55.00	15 Oct 1984
13.	Silent Valley Wildlife Sanctuary	89.52	15 Nov 1984
14.	Thattekkad Bird Sanctuary	25.16	27 Aug 1993

Table 7: Medicinal Plant Conservation Areas (MPCAs)

Name of MPCA	Location	Area (ha)
Agasthyamala	Trivandrum Wildlife Division	150
Triveni	Ranni Forest Division	130
Eravikulam	Eravikulam National Park	120
Peechi	Peechi Wildlife Division	150
Athirapally	Vazhachal Forest Division	135
Periya	North Wayanad Division	160
Silent Valley	Silent Valley National Park	200

Sustainable utilization

According to FAO (1993) sustainable forest management involves planning production of wood and non-wood forest products for commercial purposes as well as for meeting the local needs and it does include protection or setting aside areas to be managed as plant or wildlife reserves for recreational and environmental purposes. It also ensures that conversion of forestlands for agriculture or other uses is done in a planned or controlled manner emphasizes regeneration or re-vegetation of wastelands and degraded forests and also

establishment of forest plantations. In short, sustainable forest management is the specific and practical action for translating the concept of sustainability into reality. Forest management, which does not aim at sustainability, will be burdened with heavy social cost. Of course, sustainable forestry is not free from constraints. It includes institutional, technological, economic and social aspects.

One of the major challenges in forestry is the conservation and sustainable utilization of forest resources, particularly the NWFPs. Traditionally, tribals are the gathers of NWFPs and it is their major source of income. The depletion of NWFPs can leads to several ecological and socio-economic problems. Due to increase in population, shrinking resource base, increase in demand, the tribals quite often exploit the forest resource in an unsustainable manner. Species, which are in high demand, are over exploited while others not fully extracted, resulting in the changes of species composition, density, and availability that affects the biodiversity of the forests.

Many factors have been acting as constraints in the sustainable management of NWFPs in the State. No serious studies were carried out in the past to assess quantitatively the NWFP resource base. Only recently studies have been take up to prepare a quantitative inventory of NWFPs of Kerala jointly by KFRI and TBGRI, and the study is progressing. Other important aspect is the sustainable extraction. In order to maintain the resources sustainably, the collection should not exceed the rate of regeneration. Recent studies carried out by KFRI have revealed that regeneration capacity varies with species and to a greater extent linked with the reproductive efficiency of the species and the parts of the plant exploited. Further more, there should be active participation and co-operation from the gatherers. The motive of the collectors is to earn more income in the shortest time possible whether the collection method is sustainable or not. Joint forest management of NWFPs is more relevant in this context for sustainable utilization. The Government of Kerala has given the right for collection of NWFPs only to Scheduled Cast and Scheduled Tribes free of cost, which may be reviewed after sometime to evaluate benefits according to tribals.

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SOILS OF KERALA AND THEIR SUSTAINABLE MANAGEMENT PERSPECTIVE FOR AGRICULTURE

C.J. THAMPI

Farmers in ancient India (3250 B.C – 1200 A.D) were to a great extent conscious of **different types of soils and its suitability for crops.** They broadly divided soil into three classes 1. Jangala (Barren) 2. Anup (Moist) 3. Sadavama (Ordinary). Soil classification was broadly medieval and economic. Caraka and Susuruta had in view the **efficiency of drugs of plant origin depends on the nature of soils in which they grow** (quality concern and about productivity of different types of soils.

In the 'Arthasastra' it is found guidelines about classification of soil on the basis of differential assessment of the soils. This system has been undergoing change with time. In the area of gradation of land survey and measurement and classification, (Vide Manu VII 130; Gangopadhyaya 1932, P 27). Colour of the soil taste viz, sweet, sour, pungent etc. and stoney or soft. During medicinal period (1200-1800 A.D) witnessed management of soil fertility by application of organic manures cow dung and leaves of plants together with conservation and judicious use of water resource.

With the establishment of Imperial Institute of Agricultural Research in 1906 Dr. J.W. Leather the **'Father of Soil Science'** in India carried out extensive investigations on the problem of soils (Sodic Soil) of the country. He characterized the soils either on the basis of geological formation or on colour in four major groups or association viz. alluvial, black, red and laterite.

Francis Buchanan who undertook a survey of South India identified laterite in Malabar. Madam Scholasky in the year 1932 prepared the first soil map of India depicting physiographical and geographical features. This was followed by D.N. Wadia in 1935. Prof. J.N. Mukherjee and his associates at the Calcutta University made valuable contribution towards fundamental problems of soil chemistry.

The need for soil resource inventory information was felt as early as 1937 by the soils wing of the Board of Agriculture in India and decided soil survey to be carried out in the country. Initial collection and collection of available data were done in 1942 by the then Imperial Agricultural Research Institute, New Delhi, ICAR bulletin 1953. This was followed by the decision to generate a data base on soils of all states in the country under the leadership of Dr.S.P. Raychandhuri, the then Soil Survey Officer in the Indian Council of Agricultural Research (ICAR) in 1954. Perhaps this is the first generalized macro level information soils of India publication of the country (Dr.S.P. Ray Chaudhuri, et al. 1963).

Note: Dr.C.J. Thampi, Former Principal Scientist & Head, Eastern India, Regional Centre, NBSS & LUP, ICAR & Commissioner, Kerala State Land Use Board, Thiruvananthapuram.

In 2003 – Soil Science – Status

"As a scientific discipline soil science is young and about 200 years old. "Yet a sense of fatigue is being felt in several quarters and therefore it is dubbed as a SUNSET DISCIPLINE". C.G. Narayana Swamy (2003). The knowledge bank has not been harnessed by society at large for which it is intended. This mismatch between potential and actual usage because of our inability to raise the level of social awareness in this area".

In 2004 – Soil Science Status

N.N. Goswamy writes "it saddens me to observe that soil science is slowly but surely losing its identity as a separate entity and is under complete threat of amihilation in the strategy of "Natural Resource Management". Unfortunately, soil science at National Level has lost its status as a separate entity. Soil science has to be a good science and at the same time utilitarian so that its both identities are recognized. Goswamy N.N. (2004)".

SOIL IS AN INTEGRAL PART OF LAND AND ITS USES

I. ECOLOGICAL :

(1) Comprising biomass production, a source of food, fodder, renewable energy and raw materials vital for the very existence of biotic life system including humans.

(2) Functions as a filter (Mechanical process), Buffer (Adsorption and Precipitation on the surfaces of inorganic and organic soil components through physico-chemical process, transformation (Alteration and decomposition of organic compounds (Microbiological/bio chemical activity), between atmosphere, ground water and vegetative cover. Soil acts as a protective medium, preventing the uptake of harmful substances by plant roots or their leaching into the ground water and producing gases through bio-chemical processes.

(3) Biological habitat and gene reserve, variety of organisms lives in or above the surface of soil. Therefore, soil is directly linked with biodiversity. (Antibiotic penicillin was developed from the ubiquitous penicillium fungus present in the soil, genes from soil are increasingly used in bio-technology and bio-engineering

II. HUMAN ACTIVITIES

1. Technical 2. Industrial and 3. Socio economic

1. Soil as a base for technical, industrial and socio-economic structures and their development viz, industrial production, housing, transport, sports, recreation, dumping of refuse and others.

2. Soils serve as a source of geogenic energy, raw materials such as clay, sand, gravel and others and as a source of water.

3. Soils are geogenic and cultural heritage, forming part of the landscape and concealing palaeontological and archeological treasures of great value for understanding of the history of earth and mankind.

Agricultural use of land is only one of the uses perhaps most important depends on all other uses in a given area for its sustainability. Sustainability of the use of soil for Agriculture is determined by other socio, economic, cultural, government political decisions.

Soils of Kerala State

According to this, soil resource inventory of Kerala was initiated as early as 1949 in different locations at different levels and methodologies. Kerala State national endeavour to study soils having nine districts and was divided into three physiographic regions Low Land, Mid land and High land.

Geographic Setting

Kerala State lies between 8° 18' – 48' N and 74° 52' – 77°-22' E in the South Western part of India have geographical area of 38, 855 sq. km. (1.18 per cent of the area of the country. It is bounded by the Lakshadweep. Arabian sea on the West Karnataka on north and east, and Tamil Nadu on the South. The length is approximately 590 km, and width ranges from 15 to 120 km. Four major geological formations are (1) Crystalline rocks of Arabian age (Charmokites, Khondalite, Dharwars, granites, Dykes of dolorite) (2) Sedimentary rocks of tertiary age (Laterite, Sandy clays, Sandstone lands, Aluminium clays, lignite beds). (3) Laterite capping the crystalline and (4) Sedimentary rocks, recent and sub recent sediments.

Physiographically state is divided into three broad regions based on elevation differences low land <7.5 m above M.S.L (3979 sq. km, 10.24%), Mid land 7.5 – 75 m above MSL (16231.2 (41.76%), High land > 75 m above M.S.L (18653.5 (48.00).

Drainage system consists of three east flowing river and 41 west flowing rivers. Climate of the state is humid tropical with average annual rainfall of about 3000 m.m. Sixty per cent of the rain fall is received during south west monsoon (June to Sept.) North east monsoon is from October to December. Summer months January to April experience generally dry spell.

The state falls under humid tropical climate except the southern most area and eastern parts of Palghat, where climate is dry. Temperature and rainfall distribution is not uniform in many parts of the state.

The soil temperature regime

Soil temperature regime can broadly be considered as isohyperthermic (soil temp. at a depth of 50 cm is 22°C or more and difference between mean summer (June to August) and mean winter (December to February) temperature is less than 5°C.

Five soils were broadly identified viz 1) Alluvial soils comprising coastal alluvium and alluvial soils from rivers. The alluvial soils of Kuttanad (Ambalapuzha, parts of Changanacherry, Chertala and Kottayam are low lying and believed to be once part of sea and later filled up by the silt carried down by rivers. The coastal alluvium are sandy having a low water holding capacity and a low nutrient status. The alluvium on the banks of the main rivers are fertile.

Peaty Soils (Kari Soils)

There are submerged soils under water during monsoon season. After the monsoon season these soils are put under paddy cultivation. The soils are black and heavy textured and highly acidic pH as low as 3.9. They contain 10 to 40 percent of organic matter, 20 to 30 percent Fe_2O_3 and Al_2O_3 and 0.4 per cent K_2O. They are relatively poor in available P_2O_5. The low acidity is due to the decomposition of organic matter under anaerobic conditions and sometimes the soils are highly toxic to plant life as they contain ferrous and aluminium sulphates in considerable amounts. Accumulation of large quantities of water soluble alkali salts are observed. Area is approximately about 150 km^2.

Occurrence of these salts are likely to be due to differential topographical areas and salinity due to tidal action. Dissolved salts are held up by the soil which is extremely plastic and sticky. Besides the sub-soil water in these areas contain salts within a meter of the surface of the land and by capillary action rises upward. This process leads to high concentration of slats in the 'kari' soil which contains varying high degrees of organic matter.

Red soils form a good position of mild land region of the state. Major portion of these soils have been developed from the deposits from upper regions. These are very deep, uniform, well drained medium textured. In the lower elevations due to water accumulation deep lower horizons tend to become yellow in colour and sometimes light reddish and pH is 6 to 7, soils are highly productive.

Evaporation

Evapotranspiration is high between March and May, monthly ET being as high as 173 mm in April and May at Palakkad. Myladumpara has the lowest annual ET of 1314 m.m. and Kozhikode and Kannur have the highest of 1730 m.m. Palakkad also has a high annual ET of 1726 m.m.

Soil Water Balance

The study of soil water balance of nine locations in the state viz, Alappuzha, Kannur, Kochi, Kommam, Kozhikode, Myladumpara, Palakkad, Ponnani, Thiruvananthapuram are briefly described.

Alappuzha:The area has a fairly well distributed rainfall with moisture surplus from the middle of May to the end of November, and a period of utilization of surplus moisture in December. There is deficit of soil moisture from January to mid-April, as evapotranspiration is much higher than rainfall during that period.

Kannur : The area receives a very high total rainfall from June to August, but has severe deficit from around the 20th of December to the middle of May, when recharge starts. From June to October there is a moisture surplus, followed by utilization from November to mid December.

Kochi : The area has moisture surplus from the middle of May to the end of November, after which utilization of stored moisture takes place during the first half of December. The deficit which starts thereafter extends to the end of April. The period of recharge starts from the beginning of May, and by the middle of May again there is a moisture surplus.

Kollam : Kollam receives fairly well distributed rainfall, but since the evapotranspiration is higher than rainfall, there is deficit of moisture from the last week of December to the end of April. Recharge starts from May and there is surplus moisture from the end of May to the end of November.

Kozhikode : From May considerable rainfall is received, more than the evapotranspiration. During early May recharge takes place, and from the middle of May to the middle of November, there is a surplus. Utilization of stored moisture takes place during December. Moisture deficit is evident from the last week of December to the end of April.

Myladumpara : The area is representative of the high hills. Though rainfall is considerably less than in the plains, so is the evapotranspiration, because of the lower temperatures. The soil gets recharged during early June and a moisture surplus is noticed till the end of November. Stored moisture is utilized during December and the first half of January; moisture deficit extends from mid-January to the end of May.

Palakkad : The soil gets recharged during the first week of June and there is surplus of moisture in the soil till the end of October. Stored moisture is utilized during November and the first fortnight of December. The deficit which starts from the middle of December extends to the end of May. This area has the longest dry period in the state, followed by Kannur and Kasaragod areas.

Ponnani : The soil gets recharged during May, and a surplus occurs from the last week of May to the end of November. Stored moisture is utilized during the first three weeks of December; after this soil moisture deficit starts, and continues to the end of April.

Thiruvananthapuram : The soil gets recharged during May and from the end of May to the end of August, there is surplus moisture. Part of the stored moisture is utilized during September and surplus again occurs till the end of November; the stored moisture is utilized during December and the first week of January. January to April are deficit months.

Natural Vegetation

Forest vegetation comprises tropical wet evergreen and semi evergreen (50%) tropical moist deciduous (33%) and tropical dry deciduous (2%) grass land (2%) and forest plantation (13%).

Land Utilization and Cropping Pattern

Kerala State with population of 31,83,8619 is having population density per sq. km. 819. Per Capita geographic area of 0.134 in 1991; per capita cultivable area of 0.14 in 1961 has come down to 0.084 and per capita forest area of 0.06 ha. came down to 0.037 in 1991. Different land uses of Kerala are 27.8% under forest, 9.3 per cent not available for cultivation, 0.1 per cent permanent pasture or grassland, 1.3 per cent land under miscellaneous tree crops grows, 3.3 per cent cultivable waste, 0.7 per cent follow other than current follow, 1.1 current fallow, 56.4 net sown area. (KSLUB 1995) land Resources of Kerala State.

Socio Economic Factors

About 50 per cent of the population depends on agriculture. Farmers are by and large marginal (<1.0 ha 46%), Small (1.0-2.0 ha) 21.55%, semi medium (2 - 4 ha) 15%, Medium (4.0-10 ha) 7.41%, Large (>10 ha) 9.66 ha.

The low lands and coastal plains are dominantly under coconut and rice; the midlands are mainly cultivated to coconut, tapioca, rubber, arecanut, pepper and cashew. Hilly region is under forest with small areas being used for cardamom, pepper and other spices. Cardamom is restricted to Idukki, Palakkad and Wayanad districts. Lower portions of the hill ranges are under rubber and coconut and higher elevations are under tea and cardamom. Coffee is extensively grown in Wynad plateau.

Laterite and Lateritic Soils

These soils are found in the mid land and parts of high land region. Both high level and low level laterites are met with in these areas. Francis Buchanan identified Laterite in Malabar in 1801 A.D. These soils are rich in crop production. Laterite soils of the west coast generally grow coconut arecanut, plantation crops like tea, rubber are

grown on higher elevations and paddy in lower elevation . Soils are generally poor in NPK and organic matter. PH ranges between 4.5 to 6.0.

Forest soil

These soils are identified in the areas covered by tropical forest. Soils are grayish brown and grayish red in colour. these soils are rich in nutrients and low pH.

Kerala State Soil Survey Organization identified seven soil types viz, Forest soil, Laterite soil, Sandy soil, Alluvial soil, Peaty soil (Kari), Red soil and black soil (Koshy, MM and Thomas Varghese (1972) Soils of India, The Fertilizer Association of India). Besides the earlier information on additional soil type of black soil occurring in a very limited area was identified in Chittur Taluk in Palakkad district which is an extension of black soils of Coimbatore in Tamil Nadu.

S.P. Ghose et al (1991) identified ten soil types for the study of Agro-climatic zone specific research an India perspective under NARP (ICAR).

1 Red loam (Southern parts of Trivandrum) essentially Kaolinite in nature, acidic in reaction, highly porous and friable, low in organic matter and essential plant nutrients.

2. Laterite (65% of total area of the State). Soils are typical Kaolinitic weathering products of geneissic and granitic rocks developed under humid tropical conditions. Kerala laterites are poor in available NPK and low in the basal elements, poor water holding capacity, CEC and high 'P' fixing capacity with low organic matter content and pH (4.5 to 6.2).

3. Coastal alluvial-coastal tracts along west coast developed from marine deposits have loamy sand and sandy loam soils of low fertility levels, clay and organic matter contents are generally low.

4. Riverine alluvium – Banks of rivers and tributaries where horizon differentiation is not well expressed. Soils are deep with surface texture sandy loam to clay loam, medium in organic matter, N and K and poor in P and lime. Soil is acidic in reaction.

5. Onattukara alluvium – In certain parts of Quilon and Alleppey districts such soils are available. Soil coarse textured, low lying with high water table, highly permeable and extremely deficient in all the major plant nutrients.

6. Brown hydromorphic – (Valley bottoms and coastal strip) soil profile has occurred under impeded drainage, hydromorphic features like grey horizons, mottling streaks, hard pans, organic matter deposition, iron and manganese conception, drainage problem, moderate in organic matter, N + K and deficient in lime and P.

7. Saline hydromorphic – (Ernakulam, Trichur, Alleppey and Cannanore districts). The Pokkali and Kaipad soils come under this category. The network of backwaters and estuaries bordering the coast serve as inlet of tidal

waters causing salinity of soil. During rainy season salt is leached out leaving the area almost free of salt having EC of 0.1 to 2.0 mm/hos/cm^2. EC goes high from 10 to 15 mm/hos/cm^2 during March to April. The soils are dominantly brown, deep and imperfectly drained with wide variation in texture. In some areas undecomposed organic matter is observed in the lower layers causing problems of acidity.

8. Kuttanad alluvium – (875 Km^2 of Kuttanad area). During monsoon, the rivers and rivulets pour fresh water into the area. This area is faced with serious problems of hydrology, floods, acidity and salinity. This soil can be grouped under three categories Kayal soils, Karappadam soils and the Kari soils.

9. Black soils- (Chittor taluk of Palghat district). This is an extension of the black cotton soil in the adjacent Coimbatore of Tamilnadu. The soils are dark, low in organic matters, calcareous, pH 7.0 to 8.5 high in clay and CEC and cracks occur in dry period. It is known as Poonthalpadam soils in Kerala possessing a slushy layer to a depth of about 0.5 to 1.5 m. A bed of limestone is seen beneath the slushy layer.

10. Forest loam-(Eastern part of the State). These soils are the products of weathering of crystalline rock under forest cover with wide variation in soil depth. In divided areas, leaching the deposition of humus take place in the lower layer. These soils are acidic (pH 5.5 to 6.3) and rich in nitrogen, but poor in bases due to heavy leaching.

Soil resource inventory was conducted by NBSS & LUP (ICAR) and Kerala State Soil Survey Organisation (1994) based on 1:250,000 scale base map using remote sensing data and Survey of India toposheets on the basis of a uniform methodology. 38 soil associations were identified in five physiographic divisions viz soils of Low lands, soils of Midlands, soils of Central Sahyadri, soils of Nilgiris, Soils of South Sahyadri.

Soils of lowlands are very deep. Broad valleys and submerged lands have drainage problems and high water table. The soils are acidic and have low base saturation. The beaches and subdued sand dumes have aquic and typic ustipsanments as major soils. Some soils are sulfaquents. Sulfidic material with high organic matter content and salinity.

The estuaries and backwaters of coastal region salinity is a problem. The soils have loamy and clayey textures. The sulfaquents need special care to avoid submergence and keeping the soil moist throughout the year to prevent oxidation of sulfudic material. The reclaimed lands have loamy and clayey soils classified as fluventic dystropepts. In the coastal laterite, the clayey and gravelly clay soils have typic kandiustults. The gravelly loam soils fall under ustoxic dystropepets.

The midlands are gently sloping laterites with inseparable valleys, moderately steepling, sloping laterite mounds, laterites with out crops and valleys. Midland laterites have clayey, gravelly clay and loamy soils. These are deep to very deep and well

drained. The Kandiustults have low base saturation, CEC and organic matter. Soils are imperfect to moderately well drained.

Soils of Central Sahyadra

Central Sahyadri includes the hills, the Wayanad plateau and the Palghat.

Soils of Waynad plateau are of low base saturation, acidic, very deep and occassionaly, moderately shallow to deep, with rock out crops in some areas. High amounts of organic matter have accumulated because of the thick vegetation and soils have medium CEC. The soils identified have dominantly clayey, gravelly clay and loamy textures. The valleys of Wayanad plateau have loamy and clayey soils with fairly high base saturation.

Soils of Palaghat gap forms part of Nilgiri land form. High hills have loamy, clayey and gravely clay soils. With low base saturation and fairly high CEC. Medium hills have loamy and clayey soils. Soils are generally very deep. The foot hills and valleys and gently sloping uplands with valleys have dominantly loam soils, gravelly loam and gravelly clay soils with low base saturation. Soil depth ranges from moderately shallow to very deep.

Soils of South Sahyadri

This land form occurs in Palakkad, Thrissur, Ernakulam, Idukki, Kottayam, Pathanamthitta, Kollam and Thiruvananthapuram districts. The elevation range from 300 m to 2695 m at Anamudi peak. Erosion is severe. Rock out crops cover considerable area. Soils are deep to very deep, well drained and acidic, CEC medium, high organic matter levels, low base saturation. Soil texture loamy, clayey and gravelly clay. Narrow valleys represent imperfectly drained soils.

Important soil attributes recorded during the soil survey NBSS & LUP and Kerala State Soil Survey Organisation.

Soil depth

Four soil depth class associations were identified in Kerala. The depth ranges and extent of the classes are :

Moderately shallow (50-75 cm)	2 per cent
Moderately deep (75-100 cm)	2 per cent
Deep (100-150 cm)	25 per cent
Very deep (150 cm)	64 per cent

Nearly six per cent is covered by rock and laterite outcrops.

Surface soil texture

The texture of the surface layer of soils of Kerala covers a wide range, from sandy to clayey. The relative extent of the dominant surface textural classes are:

Sandy	4 per cent
Loamy	59 per cent
Clayey	30 per cent

Slope

The major part of Kerala being hilly, a wide range of slope classes are found. The relative distribution of the different slope classes in the state is :

0-1% slope	Level to nearly level	13 per cent
1% - 3% slope	Very gently sloping	24 per cent
3% - 5% slope	Gently sloping	13 per cent
5% - 10% slope	Moderately sloping	19 per cent
10% - 15% slope	Moderately steeply sloping	20 per cent
15% - 30% slope	Steeply sloping	2 per cent
> 30 slope	Very steeply sloping	8 per cent

Soil erosion

The erosion status and corresponding extent of dominant soils in Kerala are

None to slightly eroded	20 per cent
Moderately eroded	69 per cent
Severely eroded	4 per cent

Soil drainage

About 82 per cent of the area of Kerala has moderately well drained and well drained soils. The dominant drainage classes and their relative extent are

Very poorly drained; poorly drained, imperfectly drained	6 per cent
Moderately well drained	6 per cent
Well drained	76 per cent
Somewhat excessively drained	5 per cent

Surface gravelliness

Relative distribution of soils with different gravel content is give below :

15% gravel	73 per cent
15% - 40% gravel	19 per cent
40% - 70% gravel	1 per cent

Soil available water capacity (AWC)

The capacity of soils to hold water in reserve is a function of soil depth, and soil texture including gravel content in the soil column. About 35 per cent of the area of the state is dominated by soils with high AWC. Available water capacity is expressed in mm of water in 100 cm of the soil or in the entire soil column if the soil is shallower. The AWC classes and the relative extent of the dominant soils in Kerala are :

Very low	(500 mm)	6 per cent
Low	(50-100 mm)	38 per cent
Medium	(100-150 mm)	14 per cent
High	(150-200 mm)	35 per cent

LAND CAPABILITY CLASSES OF KERALA

Map Symbol	Land Capability subclass association	Soil mapping units (Soil Map NBSS & LUP & State Soil Survey Organization (1994)	Area	
			ha	%
1	IIIe – IIe	K18, K29, K37	254930	6.57
2	IIIw – IIIsw	K15	34560	0.88
3	IIIw – IIIes	K16, K17	123380	3.17
4	IIIsw – IIIs	K34	1840	0.04
5	IIIsw	K05, K08	118410	3.06
6	IIIes	K07, K10, K11, K12	1125630	29.00
7	IIIs – Ivw	K06	11480	0.30
8	IIIes – Ives	K22, K32	294990	7.59
9	IVes – IIIsw	K23	12010	0.30
10	IVsw - IIIsw	K03	44940	1.15
11	IVe	K31	136850	3.52
12	IVsw – IVs	K01, K02	174010	4.49
13	IVes	K09, K28, K35	329520	8.48
14	IVsw – VIsw	K04	43000	1.11
15	IVes – VIsw	K21	83160	2.14
16	IVes – VIII	K13, K14, K24, K25, K27, K33	275330	7.07
17	VIe – VIes	K20, K30, K36	458520	11.79
18	VIe – VIII	K19, K26, K38	333850	8.60
	Thiruvananthapuram urban area and water bodies		29140	0.74

KEY to land capability classes
Class II Good cultivable land
Class III Moderately good cultivable lands
Class IV Fairly good, cultivable lands
Class VI Well suited for forestry or grazing
Class VIII Lands suited only for wildlife and recreation

KEY to land capability subclass symbols
e – erosion and runoff; s – soil, w – wetness/drainage

Major problem soil of the state

Soils of Kuttanad is highly productive and problematic also.

Grain sanctuary in Kuttanad comprises an area of 875 km^2. Kuttanad soils are grouped into KARI, KARAPPADAM, AND KAYAL SOILS.

KARI SOILS

Soils of Kuttanad are grouped into 'Kari', 'Karappadaom' and 'Kayal soils'. These soils are formed either by submergence of a pre-historic forest caused by natural calamity by violent disturbance on this part of the land mass or due to the deposition of organic materials with soil by the rivers. Meenachil, Pampa, Achan Coil and Manimala from the western ghats before joining the sea. These lands are confined in isolated patches along the coastal plain of Kuttanad soils adjoining the backwaters in Alappuzha and Kottayam districts. Very often particularly decomposed plant residues are present in the sub soil containing less than 50 percent mineral matter. Texture of different horizons of soil profile varied from clayey to sandy loam. Soils are dark in colour, poorly drained. Organic matter content range between 10-30 per cent. Most of the kari soils registered pH below 4.5. EC varied from 2.3 to 3.3 dsm^{-1}. Kari soils was largely lingo protein complex consisting of large quantities of lignin organic matter in these soils do not contain hemicellulose and cellulose. CEC varied from 24.1 to 42.5 emol (p^+) kg-1. Hydrogen dominated and occupied about 75-80 per cent of the exchange complex. Low fertility of kari soil was due to low available plant nutrients. Soils contained different forms of sulphur and bacterial action releases sulphuric acid which causes extreme acidity. Copper and zinc deficiencies are observed in these soils. Available iron content is found in toxic levels. Kaolinate is the clay fraction that dominate the soils.

Adoption of efficient drainage system to avoid the adverse effect of sulphur. To avoid sulphur compounds coming to the surface deep ploughing is avoidable. Liming is effective but expensive process.

KARAPPADOM SOILS

Karappadam soils occurring along the inland waterways and rivers composed 1014 padasekharams in Alappuzha and Kottayam districts. These are 1-2 cm below MSL and are alluvial deposits. Soils are very deep, poorly drained, dark grey in colour with clay loam surface texture followed by silty clay sub soil. Presence of sandy layer in the sub surface is another feature. Organic carbon content varied from 0.79 to 4.09 per cent. Soil pH varied from 3.85 to 5.75 for west sample and dry sample 2.8 to 5.5. These soil recorded EC of 2.4 to 3.6. CEC ranges from 13.1 to 25.3 cml (p+) kg^{-1}. Hydrogen is the most dominant exchangeable cation. Base saturation percentage varied from 7.8 to 55.2 and aluminium saturation ranged from 6.7 to 34.1 percent. Lime requirement ranged from 3.0 to 18.8 tha^{-1}. These soils recorded a CN ratio of 11.9 to 24.6.

Organic sulphur was constituted more than 90 per cent of the total sulphur ranges from 3.8 per cent in the surface larger to 6.8 in the sub soil. Micronutrient Zn and Cu is found deficient in these soils.

Soil management must take care of nutrients. Soil amendments by the application of lime in some locations and water management.

KAYAL LANDS

Kayal lands comprising an area of 8000 ha of Kuttanad and found to occur in the reclaimed lands of Vembanad and Kayamkulam lake. Land is submerged 1.5 to 2.0 m below mean sea level for a period of 5 to 6 months in a year. Land is protected from saline water intrusion by perimeter lands. Soils colour gray with red and brown mottles. Soils are mostly silty loam or sandy clay loam in texture, fine sand being the dominant fraction of the soil. Soils are severely affected by salinity than other soils of Kuttanad. PH varied from 4.5 – 6.9 and the submerged soils ranged from 5.05 to 7.10. The electrical conductance ranged from 2.6 to 3.9 dsm-1 at 25°. Organic carbon content ranged from 0.58 to 3.30 per cent. CEC ranged from 11.6 to 17.2 cmol $(p)^{+}$ kg. Base saturation varied from 22 to 98 per cent. Soil was low in available nitrogen and phosphorus but was comparatively richer in potassium. Distribution of different forms of sulphur showed water soluble as well as total sulphate sulphur increased with depth in some areas. Kayal profiles are uniformly deficient in cu, zinc.

Pokkali, Kaipad and Orumundakam lands

Twenty west flowing rivers draining into the adjoining backwaters which in turn connected to Arabian sea. Deltaic areas by and large at sea level or 1.0 to 1.5 m below MSL. Impact of tidal effect is seen in the rivers through the presence of saline water. Based on location intensity and extent of salinity three types of saline soils are recognized viz. Pokkali lands, Orumudakam and Kaipad lands. These soils are cropped with paddy once in a year during monsoon season from June-July to October-November when the salinity level is below critical level. These soils are formed from low lying marshes near rivers and other waterways, water logged and ill drained and subjected to tidal waves. Pokkali soils were at sea level whereas Orumundakam soils are slightly above MSL and karipad lands below MSL. Kappali and orumundakam soils are dark gray in the surface layers whereas karipad soils are dark yellowish brown. Pokkali soils are clayey while orumundakam and Kaipad soils are dominated by texture. PH of Pokkali and orumundakam are uniformly low ranging from 3.1 to 3.3. Kaipad soils have pH ranging from 5.1 in the surface soil and decreasing with depth. Management of these soils must take care of location specific needs of nutrients, soil amendments and water management (Padmaja P. et. Al (1994). A glimpse to problem soils of Kerala, Kerala Agriculture University.

Four 'Bench Mark Soil Series' identified in Kerala, for Red and laterite soil region (3 numbers) and coastal and castaic region (1 number) established by NBSS &

LUP (ICAR), ICAR, State Soil Survey Organisation are briefly furnished: (NBSS & LUP/ (ICAR), KAU, State Soil Survey Organisation (1982), Bench Mark Soils of India.

Thekkadi series are developed on gneiss and occur on moderately sloping hills in an Idukki district. They are deep, clayey, well drained and medium to strongly acid. CEC ranges from 6 to 16 meq. Per 100 g soil. AWC is medium to high soils are under natural forest.

Trivandrum Series – Oxic distropept

Trivandrum soils occur on laterite mounds in Trivandrum District. They are moderately deep to deep, clayey skeletal, well drained and strongly to very strongly acid. The CEC ranges from 4 to 7 m.e. per 100 g. of soil. The AWC is medium to high. These are cultivated to cashew, coconut, root crops, etc.

Kunnamangalam Series – Typic Haplorthox

Kunnamangalam soils occur on gently sloping dissected laterite plateaus in Calicut district of Kerala. They are deep, clayey skeletal, well drained and medium to strongly acid. The CEC ranges from 3 to 5 m.eq.per 100g. soil. The AWC is medium to high. These soils are under rubber, cashew and coconut plantations.

SOILS OF THE COASTAL AND DELTAIC REGION

Ambalapuzha Series : Acid Sulphate Soils

Ambalapuzha soils occur in level basis 2 to 3 m. below sea level in Alapuzha and Ernakulam districts of Kerala. They are moderately deep fine textured, poorly drained, extremely acid mineral soils lying over undecomposed organic material. These soils are subjected to inundation by the sea. They are cultivated to rice and yield is poor due to poor drainage and high acidity.

KOLE LANDS

Kole lands comprising an area of 13, 632 ha. are spread over districts of Thrissur and Malappuram extending from the northern bank of Chalakkudy river in the South to the Southern bank of Bharathapuzha river in the north. Physiographically the area is derived from the fluvial deposited from Kechery and Karuvannur rivers of alluvium followed land development and cultivation hymen. The land is a saucer shaped basin 0.5 to 1m. below the mean sea level and surrounded by laterite hills. Some portion of Kole area exhibits lacustrine environment and contains black carbonatious clay. The major portion of the area is level topography and remains submerged for about six months in a year. A network of canal system connects this tract to rivers. Excess water in the fields are drained by pumping the water to the canal system. This being a flood plain water level increases upto 5.5 m during peak south west monsoon season.

Soils of the flood plain are dark grey, very deep, imperfectly drained fine textured alluvial deposits. Soils of the outer fringes formed from colluvial deposits are very dark grayish brown, loamy alluvial soils overlying loamy sub soils with decrease in clay content. Soils are well drained and moderately drained. Soil structure is massive and on air drying the soils become very hard because of high content of clay and sesquioxides.

The organic matter content in the surface layer varied from 2.07% to 4.16 per cent. While in the sub surface layer it was 1.37 to 9.7 per cent. Wherever peat deposits are observed organic matter content range from 28.91 to 69.91 per cent. Soils are acidic with pH ranging from 2.6 to 6.3. The total nutrient content are high in kole soils. The CEC of the surface soils varied from 12.6 to 48.6 mc/100 gm. Soils are medium or high in available phosphorus and low in available potash. Proper water management is crucial to the area for successful cropping. The aluminium, iron and manganese toxicity is observed in the area. Application of lime and water management are needed.

Soil and water management are key to the success of the production strategy of this grain sanctuary of Thrissur district.

Clay minerals of the soils of Kerala State are dominantly kaolinitic and mixed type. This has it own importance in the soil behaviour and crop productivity for sustainable management. Ferugenous soil clays are enriched with kaolinite and mica with occasional presence of other 1.4 mm minerals in traces to moderate amounts. The formation of clay minerals in highly weathered soils results from hydrolytic decomposition of primary alumino silicates and the rate of hydrolytic decomposition processes are strongly affected by the rate of water movement through the coarse grained metamorphic rocks by leaching. Rainfall and temperature are related to leaching rates and clay mineral composition.

The predominance of kaolinite followed by illite keeps the nutrient holding capacity of ferruginous soils. These soils contain sufficient biotite mica that escaped the advanced stage of tropical weathering and are releasing K to plants. [DK Pal et. al 2000 (2000)].

DEGRADATION OF SOILS/LAND

Land degradation assessment by Govt. of India, Ministry of Agriculture reveal about 12.28 lakh is already under severe degradation in the area of soil erosion (9.52), Sodic/Saline 0.01 lakh hec., water logged 0.76, degraded forest 1.98 (Soil & Water Cons. Div., Ministry of Agri. 1994).

Barren and other uncultivable soil/land resources of Kerala is reported 48434 ha. Cultivable waste land 3984 ha. KSLUB 1997). Report of cultural wasteland – its magnitude and degradation is recorded in the coastline of Kerala having 590 km length having 34 lagoons or 'kayals', 41 rivers of the state draining into the sea through the kayals/coast line. Major coastal land forms are beaches, beach cliff, shore platforms, spits and bars, beach and ridges, lagoons and mud flats. Soil include sand, subdued sand

dumes, narrow valleys, submerged lands, reclaimed lands and coastal laterites. There are nine broad association units.

Some of the dominant soils are :

Very deep moderately shallow water table on very gently sloping subdued sand dumes, with high erosion, to very deep poorly drained clayey soil with shallow water table on sub merged lands, swams and marshes associated with poorly drained sulphide rich, saline clayey soils with very shallow water table; very deep well drained gravely clay soil on gently sloping coastal laterites associated with gravelly clay with surface gravelliness. Deep well drained, gravelly clay soils with moderate surface gravelliness and iron stone layer at 100 to 150 cm. On gently sloping midland laterites associated with laterite out crops.

Wave activity is intrinsically related to the process of coastal erosion. The erosion/accretion scenario along Kerala state reveal that the beach in South Trivandrum and Alleppy records erosional trend except for a small patch north of Kayamkulam kayal outlet. Beach South of Kochi also shows erosional trend. Immediately north of Baypore River outlet there is an accretionary patch of 10 km. This is followed by an eroding beach of 110 km and thereafter upto Mansfeswar the trend is accretionary. The total accretionary beach volume is 625.70 m^3 as compared to 1275.98 m^3/m erosional change. It is estimated on an average approx, 2 mt of good soil/resource is lost annually due to sea erosion. (KSLUB, 1996, Coastal ecosystem – an overview).

Land slide

The soil system in the state is fragile and susptable to varying degrees of degradation. About five decades before landslide was prevalent in only one district ie Thodupuzha in the then Kottayam district. Today, out of 14 districts 12 districts experience landslides in the high and mid zone. The study on the magnitude and extent of landslide areas and zonation categories reveal : High risk zone – 2077 sq. km., moderate risk zone – 1596 sq. km. Low risk zone – 9290 sq. km. (Very low risk zone 2247 sq. km. (KSLUB, 1996), Land slides – Kerala State.

Process of Soil Degradation

Soil degradation is a complex process, involving interactive effects of physical, chemical and biological processes leading to adverse effects on soil's capacity to produce economic goods and services and perform ecological regulatory functions. Degradation of soil physical properties is set in motion by the decline in soil structure leading to clay dispersion and transport in surface and subsurface flow, and water imbalance. Chemical degradation is related to nutrient depletion and imbalance, and loss of bases and acidification. Just as decline in soil structure leads to physical degradation, decrease in soil organic matter and cation exchange capacity sets in chemical degradation. Soil contamination by waste disposal and industrial pollution is an important aspect of chemical (and biological) degradation especially in the vicinity of industrial installations.

Biological degradation refers to the loss of soil total and biomass carbon, decrease in activity and species diversity of soil fauna, and buildup in population soil pathogens.

Rapid decline in quality and quantity of soil organic matter and decrease in biomass carbon and soil biomass carbon and soil biodiversity have adverse effects on soil structure in terms of macro-aggregation, per cent aggregation and aggregate stability and strength. Decline in structural attributes leads to dispersion, crusting and compaction, low infiltration, excessive runoff, and rill and inter-rill erosion. Simultaneously decline in quality and quantity of soil organic matter content and elimination and loss of clay fraction lead to a decrease in cation exchange capacity, leaching of bases and biomass production. The rate of chemical degradation can be accentuated by soil contamination through disposal of industrial bye-products and urban wastes. Decline in quality and quantity of soil organic matter and of soil biodiversity are indices of biological degradation. The latter is also aggravated by low biomass production related to soil physical and chemical degradation. Once degradative processes are set in motion, they have a snow-ball effect and are accentuated by declining trends in one another. All three processes of soil degradation are severe problems in tropical ecoregions.

Conversion of Semi Aquatic Rice Soils

Precious semi aquatic/aquatic paddy soils which are largely responsible not only for food supply but also areas for conservation of water resource and environmental stability at micro level on sustainable basis.

12.07 lakh ha. of paddy field in 1994-95 has been reduced to 7,45, 250 ha. ie. within a short span of 8 years 4,62,646 ha were converted to unsuitable crops and non-agricultural purposes. Remaining paddy fields now available is hardly 5.5 lakh ha. While our requirement of rice is 46.65 lakh tonne. Our rice production today is only 6.93,, which is about 15 per cent of our requirement. Without any consideration for the future basic needs of food, environmental stability and water resource selfish MAN with the concurrence of wrong political decisions irrepairable loss is being caused to the present and posterity to come. Good paddy soils are rapidly getting degraded.

Laterite Soils and Management

Red and laterite soils occupy about 60 per cent of the geographical area of the state. Laterites derived from the tertiary sediments of Kerala relatively show weak degree of laterisation.

Red and laterite soils are present varying effective soil depth intervals even in the same landscape. They are well drained, low in essential plant nutrients, organic matter. Moisture regime depending on texture, structure in the surface sub surface and sub soil varies widely. These call for careful water management. Variable soil moisture in different situations in a catena, viz, excess moisture during monsoon, severe drought condition in summer, flooding of the valley bottom. Weathered laterite profiles with gravelly texture in surface and sub surface with increase in the clay content (dominantly

kaoline) with depth show high infiltration rate, variable permeability. Gravelly texture increase the soil temperature and causes rapid drying of soil. Soil surface flow caused by variable permeable layers and low moisture retention capacity reflects moisture stress on the crops viz. coconut, banana, root crops etc. Soils are highly susceptible to erosion and needs comprehensive location specific conservation practices.

Management suggestions must be micro level panchayat (Cadastral scale) soil/land resources information for each agro-climatic region to be generated, awareness among planners and land users at grass root level. Location specific studies essential on physico chemical properties are required. Application of secondary nutrients, especially Ca, Mg, P together with organic matter need to be considered liming of red and lateritic soil as per lime requirement is essential. Integrated nuteint and moisture regime management is necessary. Surface crusting is a common phenomenon in red and lateritic soils and breaking it by ploughing is considered. Land evaluation based on land suitability need to be followed. Appropriate location specific water harvesting structures are required depending on soil suitability for construction. All these soils need to be covered with suitable vegetative cover. Land use planning must be done keeping in view Scientific/Technical soundness, economic viability, social acceptance and environmental stability at micro level.

FUTURE STRATEGIES FOR SUSTAINABLE DEVELOPMENT OF SOIL/LAND RESOURCES

Soil/Land Evaluation Systems for Location Specific Micro Level Land Use Planning

Two Land Evaluation Systems are in dominantly in vogue universally viz, land capability classification (USDA) and land suitability classification (FAO).

Land Capability Classification

Land capability classification (USDA) system was evolved by Klingabiel & Montagomery 1961 and has been in use in India since the inception of soil survey and soil and water conservation in India as early as 1957. It has served its purpose world over to evaluate the land depending on its physical limitations characteristics for crop growth viz, e (Erosion), w (Excess water), s (Root zone limitation), C (Climic limitations). Capability classes are groups of capability sub classes that have similar limitation hazard. It just provides general recommendation for agricultural use. It cannot provide the user location specific crop specific information to the actual grass root level user of land. Capability classes are broadly divided into VIII classes of which I to IV are agricultural uses and V to VI non agricultural users including forestry, wild life. Land capability classes (I) are divided into sub classes indicating major limitation (c). This is further divided in capability unit [Ie (i)] indicating the specific limiting problem.

Land Suitability Classification (FAO)

The inadequacy of land capability classification system for location specific and crop specific needs was felt by agriculturists world over during last three decades. Today for an economically viable, sustainable, environmentally sound agriculture with optimum production need comprehensive interpretative information in appropriate sectors for agricultural use of land.

In order to improve the technology for evaluating the suitability of land. FAO on the basis of International dialogue and extensive consultations brought out guidelines on Land Suitability Classification (FAO 1976, 1977, 1979). These are intended to provide universally acceptable methods, which can be used at any scale and with great deal of precision.

Land suitability classes can be assessed by using technique highly complex ones and also by simple technique to produce satisfactory results depending on the purpose, degree of accuracy needed and the time frame available.

Suitability of individual soil/land qualities are described by five factor rettings and by degrees of limitations. S1 highly suitable, S2 Moderately suitable, S3 Marginally suitable, N1 currently not suitable, N2 not suitable. Each factor rating may be assessed in terms of the reduction in the yields of crop in a particular location/agro-ecological situation.

Guidelines for definition of classes for factor rating :

Factor rating class	*Definition in terms of yields:* Expected crop yields, as a percentage of yields under optimal conditions, in the absence of inputs specific to the land quality considered 1/	*Definition in terms of inputs:* Inputs or management practices, specific to the land quality considered, necessary to achieve yields of 80 % of those under optimal conditions
S_1 Highly suitable	More than 80 %	None
S_2 Moderately suitable	40-80%	Inputs needed, which are likely to be both practicable and economic
S_3 Marginally suitable	20-40%	Inputs needed, which are practicable but only economic under favourable circumstances
N Not suitable	20%	Limitation can rarely or never be overcome by inputs or management practices

1/ Yield percentages are given as an example, and vary according to economic conditions; thus a yield reduction to 40% of optimum might be acceptable to a subsistence farmer but not to a competitive commercial enterprise.

The structure of Land Suitability Classification has four categories: land suitability order, class, sub-class and unit. Suitability order indicate whether land is suitable or not suitable. Suitability classes indicate degrees of suitability. Suitability sub-classes reflect kinds of limitation and shown by small letter suffix and land suitability. Units are sub divisions of sub classes for detailed applications structure of land suitability classification

Order	Class	Subclass	Unit
S Suitable	S1		
	S2	S2m	
	S3	S2e	S2e-1
	etc.	S2me	S2e-2
		etc.	etc.
phase : Sc, conditionally suitable			
N Not Suitable	N1	N1m	
	N2	N1e	
		etc.	

Land Suitability Classification for coconut in Kerala (Tentative)

Suitability parameters of individual cultivar crops are to be assessed for each agro-ecological situation and these are to be matched with land resources inventory data of the specific location. Crop parameters (tentative) as per C. Says (1985, 1991) the crop coconut is furnished. Since factual data for each agro ecological region is yet to be generated for Kerala's five agro-ecological region this data base is used for "first approximation" study at State level

COCONUT : Climatic requirements

Climatic characteristics	Climatic class, degree of limitation and rating scale					
	S1		S2	S3	N1	N2
	0	1	2	3	4	
Annual rainfall (mm)	>2,000	1,700-2,000	1,450-1,700	1,250-1,45	-	<1,250
Length of dry season (months)	<1	1-2	2-3	3-4	-	>4
Mean annual temperature (°C)	26-32	24-26 32 +	22-24	20-22	-	<20

COCONUT : Key for determination of climatic classes

Climatic Characteristics	Climatic classes				
	S1	S2	S3	N1	N2
Annual rainfall (mm)	>1,700	>1,450	>1,250	-	Any
length of dry season	<2	<3	<4	-	Any
Mean annual temperature (°C)	>24	>22	>20	-	Any
Relative humidity, mean annual (°C)	>60	>50	any		

COCONUT : Crop suitability parameters for three suitability classes

Land characteristics	Land class degree of limitation and rating scale					
	S1		S2	S3	N1	N2
	0	1	2	3		4
TOPOGRAPHY (t) slope (%)	0-4	4-8	8-16	16-30		>50
WETNESS (w) Flooding Drainage	Fo Good	moderate	imperfect fluctuating watertable	F1 Imperfect Almostalways high watertable		F2+ Very poor not drainable
PHYSICAL SOIL CHARACTERISTICS (s) Texture/structure	C-60s,Sic, Co, SiCL,	C+60s, L, SCL, SL, LfS, LS	LcS, fS	S, cS		Cm
Coarse fragments (Vol. %)	CL Si, SiL, SC	3-15	15-35	35-55		>55
Soil depth (cm)	<3	> 75	50-75			<25
CaCO3 (%)				25-50		
Cypsum (%)	>100					
FERTILITY CHARACTERISTICS (t) Apparent CEC (meq/100g clay)		20-35	<20			
Base saturation		08.1.5	<0.8			

(%). Organic matter (%C,-15cm)	Any. >35 >1.5				20-25	
SALINITY AND ALKALINITY (n) EC, mmhos/cm ESP	<8	8-12	12-16	16-20		>25

Calculation of soil parameters over 150 cm

COCONUT : Key for determination of landclasses

Land characteristics	Land classes				
	S1	S2	S3	N1	N2
TOPOGRAPHY (t) Slope (%)	<8	< 16	< 30		Any
WETNESS (w) Flooding					
Drainage	F0 Moderate or better	F0 Imperfect fluctuating watertable or better	F1 Imperfect almost permanent high watertable or better		Any
PHYSICAL SOIL-CHARACTERISTICS (s)					
Texture/structure	C _ 60s to LS	C+60s to fS			Cm to cS
Coarse fragnebts (Vol. %)	< 15 >75	<35 >50	C+60s to cS		Any Any
Soil depth (cm)			<55 >25		
CaCo3 (%)					
Gypsum (%)					
FERTILITY CHARACTERISTICS (t)					
Apparent CEC (meq/100g clay)	Any				
Base saturation (%)	>20	Any			
Organic matter (% C, 0-15 cm)	>0.8	Any			
SALINITY and ALKALINITY (n)					
EC, mmhos/cm	<12	<16			Any
ESP			<20		

Calculation of soil parameters over 150 cm – Based on land evaluation C Sys

Land suitability evaluation was initiated by Kerala State Land Use Board (Thampi et.al.1997) for use of State level perspective plan on the basis of Soil Survey information by NBSS & LUP (ICAR) (1993) and other available data base. This has been a first level of study and brought out a first approximation document for perspective planning based on Land Resources.

Results obtained for coconut crop for suitability classes S1, S2, S3 are as follows

Name of Crop	Highly suitable (S1)	Percentage	Moderately Suitable (S2)	Percentage	Marginally Suitable (S3)	Percentage
Coconut	368230	38	572230	59	28075	3

Agro-Climatic/Ecologic regions for sustainable Agriculture – Macro and Micro Level

Location specific research and development of agriculture for sustainable development of productive Agriculture is an accepted National Agricultural Policy 2000 para 18 based land resources – Soil, Water, Plant, Animals including humans. This will enable resources based planning for agriculture and allied sectors with explicit recognition of local resource endowments, constraints needs.

The present account on decentralized planning particularly with the strengthening of Panchayat Raj System after the enactment of 73rd Constitutional Amendment and Panchayat Raj Act stipulating "Land Utilization" as the mandatory power of Gram Panchayat, generation of micro level resource information and land use plan for action programme is very much needed.

For want of micro level resource based land use plan for each agro-climatic/ecological region no comprehensive development at panchayat level could take place through Panchayat Raj decentralized Planning while is in operation in Kerala for more than four years. generation of essentially required data base and it simplified interpretation for applications must be provided.

In the present land evaluation system of 'land capability classification' is continued even today without considering suitability classification and agro ecological factors. Success of decentralized planning can only be a dream if the policy makers and scientists face the realites. With this in view ICAR as a part of National Agricultural Research Project (NARP) delineated five agro-climatic regions in Kerala and established Five Regional Research Stations to identify problems and potentials of each region and provide guidance for the development of the region. (Ghosh S.P. (1991) Agro-climatic Zone Specific Research (ICAR). Soil information generated by NBSS & LUP at 1: 250, 000 was super imposed on the Agro-climatic region and attempt was made to evaluate the status of some of the crops based on the FAO suitability classification.

This being a macro level reconnaissance evaluation can only be an indicative result throwing light into the merit of the FAO system of classification.

	Highly suitable	Moderately suitable	Marginally suitable
Name of crops	S1	S2	S3
Coconut	368230	501856.50	28075.50
Banana	46798.50	2417	125
Cassava	121676.50	113512	9457.50
Pepper	118542.50	140158	8696.50
Clove	810	1317.65	555
Tea	52160	25430	8120
Rubber	322960	105053	55905
Arecanut	56463	28586	11109.10

NBSS & LUP conducted land suitability assessment of Rubber crop in Kerala and Tamil Nadu (1:50,000) at the instance of Rubber Board. (NBSS & LUP (1999) Report on Soil Survey Land Suitability classification and management of rubber). Land suitability assessment showed 30 land suitability sub-class associations in the rubber growing areas of Kerala and Tamil Nadu. Dominantly highly suitable lands without any limitation for rubber cover (S1) 2,52, 019 ha. or about 25.7 per cent of the surveyed area, moderately suitable (S2) land under rubber cover 5,25,960 ha. (56.8% of surveyed area). Marginally suitable lands (S3) cover 1,50,210 ha (15.3 per cent). Currently not suitable land (N1) is recorded 14,003 (1.43%) and land not suitable for rubber (N2) covers 7016 ha. 0.72 per cent the surveyed area.

Soil and climatic parameters for each dominent crop in the area with alternatives may be generated for five suitability classes (S1, S2, S3, N1 & N2) for each Agro-ecological region. This will enable the land user by matching the land resource and climatic parameters at micro level location with the crop parameters established for the region. For deciding upon the land use/crop cultivar for a specific location, crop parameters may be matched with the micro level resource and other socio economic factors.

Attempts have been made to prepare agro-climatic maps based on physiography and climatic and agro-ecological maps incorporating growing periods based on soils and rain fall. (1:250, 000 scale). But these have the limitation of small scale maps for application which can only have the usefulness at National level planning and not for the benefit of grass root level farmer or land user for decentralized planning system.

Regional Research Stations established by ICAR and is now functioning under Kerala Agricultural University need to be strengthened with full complement to identify the potentials and problems of each zone are to provide guidance from time to time for sustainable development at panchayat level for the benefit of individual land owner in the

Five Agro-climatic zones viz, Pilicode, Patambi, Ambalavayil, Kumarakom and Thiruvananthapuram.

Each Regional Research Station to be fully reestablished and must be linked with gram panchayats within each Agro-ecological regions. According to the magnitude and extent of the potential and problems if required, sub-centres could be established in due course.

Soil based Agro-Technology Transfer

Rapidly increasing need of the population coupled with limited time and resources for research has created an urgent need for soil based Agro-technology transfer by a process of diffusion of information. Transfer of technology from one site to another similar site is crucial for successful sustainable agriculture. Soil and soil environment information plays a vital role in this activity which is a key to the success of Agricultural Extension Programme. This must take care of

1. Scientific transferability of agro-production technology within the purview of soil and soil environment.
2. Intensive production of crops for vertical expansion of area of production due to inadequate land availability of land for horizontal expansion.
3. This will demonstrate the basic values of soil and soil environment for sustainable crop production and other management systems.

International Benchmark sites network for Agro-technology transfer (ISBNAT) was initiated by Soil Management of support services of (SMS) of USDA.

Bench Mark Soil Study will facilitate scientists to perform quality experiments, to generate substantial information on soil and climatic crop (cultivar) parameters for extrapolation of agricultural experience from the research stations in the state and country to elsewhere in the similar soil and soil environment.

Upon this handful of soil our survival depends. Husband it and it will grow our food, our fuel and our shelter and surround us with beauty. Abuse it and the soil will collapse and die taking man with it.

Translation in Sanskrit - 1500 B.C

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INLAND FISHERY RESOURCE MANAGEMENT IN KERALA - CHALLENGES AND OPPORTUNITIES

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Background

Inland fish production provides significant contribution to animal protein supplies in rural areas throughout the world. As most inland fish produced is consumed locally and marketed domestically, freshwater fish forms an irreplaceable source of high quality animal protein for marginally food secure communities. Despite the fact that a high percentage (77%)of population in Kerala consume fish, Kent(1987) observed that over 10% of the population are protein deficient. This study reveals that the protein intake levels in Kerala is lower than the national average despite very high level of fish consumption, implying that fish in requisite quantities is beyond the reach of the poor.

Although, among the maritime states of India, Kerala occupies foremost position in marine fish production, accounting for over 25% of the total landings in the country, contribution to inland fish production is only negligible, 0.75 lakh tons as against 5.94 lakh tons from the marine sector and this is primarily due to the inadequate attention received by this sector during the early stages of the states planned development. This in part also owes to the marked bias of Keralites in favor of marine fish. However, in the context of the crisis situation in marine capture fisheries and growing uncertainties concerning its sustainability in recent years, people are turning towards the inland fish and the state has now recognized the importance of inland fisheries and freshwater aquaculture.

The scientific management of inland fishery resources essentially need to consider the community ownership of the resource. Owing to the degraded nature of the aquatic environments, the thrust of the management strategy should be on conservation of stocks and biodiversity. While in the lacustrine system, the focus should be on optimization of production by various bio-manipulation practices, in the open water fisheries, the focus may be on enhancement strategies such as ranching and habitat restoration.

The inland water resources of Kerala consists of 2,42600 ha of brackish waters; 30000 ha of reservoirs; 3300 ha of freshwater ponds and tanks and 85000 ha of rivers and streams. Coupled with the marine water spread,36000 sq.km, coming under the Exclusive Economic Zone , the aquatic resource of the state constitute almost double the cultivated land area of the state.

Kerala rivers – 'hotspots' of biodiversity

With almost one fifth of the geoghraphical area covered by wetlands, Kerala is said to be the wettest state. Located in the tropics and endowed with a warm climate and high rainfall of over 3000 mm, the Western Ghat locatioins in Kerala is manifested in rich biodiversity. A combination of distinguishable altitudinal variations ranging from 2-3m below mean sea level situations in the coastal wetlands to heights of over 2500m in the Western Ghats, the undulating topography and the multitude of micro and macro environments have all been conducive for sustenance of a variety of plant and animal life. The 44 rivers together with the wetland systems and the drainage basins are physiographically divided into three parallel north-south zones viz. the highland (75m above msl) mid land(7.5 to 75m above msl) and low land (below 7.5m msl). The Western Ghat regions of Kerala covers over 56% of the total geographic area and constitute a little over 42.5 %of the entire Ghat region . This region make up unique biological regions of the world and is one of the 18 global biological hotspots. The numerous west flowing rivers have richest expression of diversity of freshwater fish fauna.

Endemic species

Out of the 670 freshwater fish species reported in India, 210 are found in the inland waters of Kerala, of which over 25% ie, 53 are exclusively endemic to the region. These endemic forms include several rare fish species such as *Lepidopygopsis typus Horaglanis krishnai* (blind catfish) *P.ophiocephalus*(Eettilakandai), *Crossochilus periyarensis*(Karimpachi). Cultivable food fishes native to Kerala waters include *Gonoproktopterus curmuca* (kooral), *Labeo dussumieri* (Tooli), *Horabagrus brachysoma* (Yellow catfish), *Neolissocheilus wynadensis, Tor khudree malabaricus* (kuyil) , *T.musallah* (Katti), *Channa micropeltes* (manal waaha), *C.leucopunctatus*(puliwaaha), *Barbodes carnaticus* (Pachialavetty), *Silurus wynadensis* (Wynad mushi) and *Clarias dussumieri dussumieri*(Naadan mushi). Streams and rivers of Kerala are also the 'gold mines' of several ornamental fish species such as P*untius.denisosnii, P.arulius, P.jerdoni, Barilius bakeri, Tetrodon travencoricus, Mesonemachielus triangularis, M. guentheri, Oreonectes keralenis,* and *Pristolepis marginata.*

Yellow catfish endemic to Kerala

Threat to biodiversity

However, the biodiversity of these river systems is alarmingly declining due to a variety of reasons viz., obstruction of river courses, regulation and diversification of water flow, damming, sand mining & habitat destruction, loss of riparian canopy cover, deforestation leading to soil erosion, indiscriminate capture of the spawners during spawning season popularly known as *oothapidutham* and unethical fishing practices such as poisoning, dynamiting and electrical fishing. The river habitat is also subject to man made interventions such as barriers and check dams that impair the natural movement of

fishes. Reduced summer flow leading to drying up of rivers and pollution hazards from agro-chemicals, pesticides and sewage also lead to occasional mass mortality of fishes. The major obstacles to conservation of biodiversity are under valuation of these natural resources

Aquatic resources – issues and conflicts

Unscientific construction of check dams without provisions for fish ladder apparently affect migration and proliferation of fish species in these river systems. The large-scale removal of boulders and cobbles, from the riverine reaches, lead to rapid landslides and deprive the natural habitats for several high land fish species. With the enormous publicity given to the ornamental value of several of the river fish species in international ornamental fish trade, the endemic fish species are being removed unscrupulously from these river systems for export. This pose a serious threat to several native species, as even the last fish is being picked up from the river pools during summer. Export of such species for which captive breeding technique is not available should be forbidden and a certification and eco-labeling insisted. Bio-piracy is another problem wherein many ornamental species are traded internationally with no compensation for the country of origin, which calls for imposing responsible practices and equitable benefit sharing

Estuaries / Backwaters

The backwaters or estuarine systems of Kerala is formed of a chain of coastal, brackish, myxohaline wetlands including lakes, lagoons mudflats, tidal marshes and mangrove swamps. These backwater systems that lie parallel to the coastline exert profound influence on the coastal fisheries, as they are the nursery and breeding grounds of coastal fish and shellfish species. These estuarine systems are also net exporters of organic matter that enhance and sustain coastal productivity. The high productivity of the coastal seas of Kerala is undoubtedly linked to the chain of coastal backwater systems that lie parallel to the coastline, and open to the coastal seas through *azhis* and *pozhis*. This backwater system occupies over 2,42,000 ha.. Owing to rapid urbanization of the coastal zone, fish fauna in these coastal wetlands are exposed to consistent pressures. The estuarine system not only renders habitats for a unique assemblage of living organisms and waterfowls but also buffer flood damages, prevent salinity incursion and aid to recharge of groundwater.

The most serious anthropogenic alterations taking place in the backwaters of Kerala in the living memory is their alarming rate of reduction to 73% of its original area (Surendran, 1992). The classic example is the Vembanad wetlands, which has been subjected to physical shrinkage by reclamation for agriculture, harbor development, urbanization and industrialization. The vertical shrinkage of the backwater system by siltation and progressive shallowing of the lake to 35% of its original depth by deforestation in the high lands has also been widely documented (Gopalan et al, 1983).

Table 1 **Estuaries / Backwaters of Kerala**

Sl. No.	Name	District	Sl. No.	Name	District
1.	Karingote estuary	Kasargode	17.	Purathur / Ponnani estuary	Malappuram
2.	Nileswar backwater	Kasargode	18.	Chettuva backwater	Thrissur
3.	Kavvai backwater	Kannur	19.	Azheekode estuary	Thrissur
4.	Dharmapatanam backwater	Kannur	20.	Kodungalloor backwater	Thrissur
5.	Mannaycd estuary	Kannur	21.	Akathumuri lake	Thrissur
6.	Mahe estuary	Kannur	22.	Cochin estuary	Ernakulam
7.	Kattampally	Kannur	23.	Vembanad backwater	Kottayam & Alappuzha
8.	Kotta backwater	Kozhikode	24.	Kayamkulam backwater	Alappuzha
9.	Korapuzha estuary	Kozhikode	25.	Ashtamudi estuary	Kollam
10.	Payyoli backwater	Kozhikode	26.	Paravoor backwater	Kollam
11.	Elathur backwater	Kozhikode	27.	Edava Nadayara backwater	Trivandrum
12.	Kallayi backwater	Kozhikode	28.	Anchuthengu backwater	Trivandrum
13.	Beypore estuary	Kozhikode	29.	Kadinamkulam backwater	Trivandrum
14.	Kadalundi estuary	Kozhikode	30.	Veli lake	Trivandrum
15.	Conolly Canal	Kozhikode	31.	Poonthura backwater	Trivandrum
16.	Puraparamba backwater	Malappuram	32.	Poovar backwater	Trivandrum

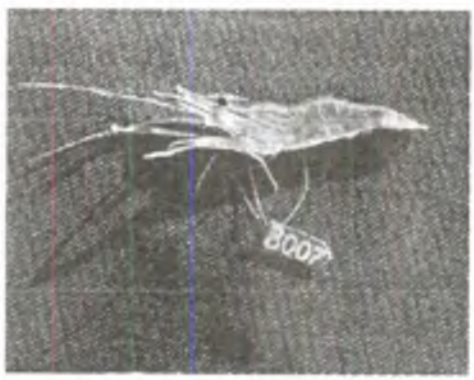
Vembanad – ecological backlashes

The Vembanad estuarine system, the largest wetland system in Kerala has also been a classical example for human interferences and ill effects. Being in confluence of the coastal seas, this vast estuarine expanse has been the favored nursery areas of the coastal fisheries, and fisheries has been the most important attribute of this wetland. However, during the last century, a series of human interventions, to facilitate intensification of rice cultivation has brought about appalling changes in the ecology of this wetland. The major rice centric intervention, ie., construction of a barrage across the lake to exclude salinity has been most catastrophic to the estuarine fisheries. The virtual division of the estuarine system and adoption of high input rice cultivation practices by indiscriminate use of pesticides and chemical fertilizers led to near elimination and endangerment of its rich fishery resources. The disruption of the physical and biological

continuity of the lake with the coastal waters fuelled the decline of fish production to almost one tenth, upstream i.e, 507 to 584 tons per annum. The chronic imbalances in the species spectrum of the lake and impoverishment from 150 species (Kurup and Samuel,1987) to 36 species upstream the barrage has also been documented (Padmakumar et al, 2002).

The mutually reinforcing contribution of this estuarine system to the coastal seas and the appearance of the unique phenomenon of *mud bank* or *chakara* along the coast by sustaining an hydrostatic regime is well documented The recurrence of such quiescent areas from year to year, enabling an abundant fishery in the coastal seas consequent to flooding of the backwater indicates the direct linkage of the riverine system on the coastal zone processes. The discharge of loose mud from the riverine side towards the seas and the subsequent calming of the monsoon swells through the thixotropic properties of the mud cones by the kinotomatic viscosity of the medium promotes the mud bank phenomenon (Rao et al.,1980).

The physical obstruction by the barrage and its effect on the fishery of the endemic freshwater prawn, *Macrobrachium rosenbergii* has also been highlighted. The annual recruitment of this species was totally disrupted in its home ground. The annual catch of these species during the pre-barrage days was as high as 429 tones which dwindled to less than 40 tones in the late eighties and further down to 27 tones on the southern stretches after a brief spell of recovery during the late 90's.



Ranching in home ground

Another major ecological consequence of these interventions has been the near extinction of the estuarine mangroves that fringe the shores of these backwater system and provide breeding grounds for a variety of estuarine fish species.

Reservoir resources

Constructed mainly for hydel power generation or irrigation, the fishery potential of reservoirs is much higher than reservoirs. Unlike the neighboring state, Tamil Nadu, Kerala doest not have a history of ancient irrigation reservoirs, as traditionally rice farming has been practiced in the rainfed wetlands. Storage of rainwater for irrigation and power generation has been relatively a modern concept in Kerala and most of the dams were constructed after independence. There are 35 reservoirs in the state, spread over 30000 ha , 21 of them are below 1000 ha and among the rest, Idukki reservoir is the largest with area over 6168 ha. Owing to

manageable size, all these reservoirs are logistically suitable for fish production. Despite the existence of many such small and medium reservoirs in the state, no serious effort has been made to develop them on scientific lines for fish production. No reliable data is available on the total fish production from these reservoirs although 17 reservoirs are under regular stocking However, fish production figures are available only in respect of 9 reservoirs, the per hectare yield being Peechi(4.5kg/ha), Vazhani(27.4 kg/ha), Malampuzha (5 kg/ha), Mangalam(44.5kg/ha), Meenkara(68.6 kg/ha), Chulliar(316.6 kg/ha), Pothundi(!(.4 kg/ha), Valayar(18 kg/ha) and Kanjirampuzha(26.2kg/ha). Although the average yield in the managed reservoirs is 23.38kg/ha, the average per ha yield of the total reservoir area in the state is only 5kg/ha. The hydel reservoirs built in high land locations have deep basins portraying oligotrophic tendencies as compared to that on the plains which are in transient phase of eutrophication. Khatri (1985) observed the physico- chemical profile of Idukki reservoir and observed that being a deep basin reservoir, a substantial part of the storage is always held up as dead storage and nutrients such as phosphate is totally absent and nitrate and silicates also being very low. Standing crop of plankton being extremely poor, fish production tend to be low in such systems. Only 17 species of fishes including two exotics, *Cyprinus carpio* and *Oreochromis mosambicus* were observed in the reservoir. Nair(1988) inferred that Idukki is passing through a trophic depression as evidenced by low rate of colonization by biotic communities and the retarded growth rate for *Oreochromis mosambicus* is attributed to this phenomenon. The irrigation reservoirs in midland locations in the state being shallow and spread over rich alluvial soils with and high nutrient loading from allachthonous sources, its high primary productivity may be conducive for fish production.

A three-pronged strategy for reservoir fisheries comprising production of seeds of appropriate species, stocking and creation of breeding and rearing facilities at the reservoir sites were initiated since early fifties. The Indo-German Reservoir Fisheries Project, the advisory mission has made comprehensive fish stock assessment of Malampuzha reservoir (Taege *et al* , 1993) and has suggested organizational alternatives for production of stocking materials using low cost and easy to manage systems. Studies conducted by these authors have revealed that indigenous species and tilapia form bulk of the fish population in Malampuzha reservoir, the first reservoir in the State stocked with major carps since 1951.

Table 2 Freshwater Lakes of Kerala

Sl.No.	Name of the lake	District
1.	Pookot	Wayanad
2.	Muriyad	Thrissur
3.	Kattakambal	Thrissur
4.	Enammakkal	Thrissur
5.	Manakkodi	Idukki
6.	Sasthamkotta	Kollam
7.	Vellayani	Trivandrum

Competing demands

The low productivity of most of the reservoirs in Kerala is attributed to undesirable species mix. lack of scientific database, inadequate stocking, wrong selection of species and multiple ownership. The State Electricity Board has control over the reservoirs under hydro-electric project and those in the reserve forest are under the forest department. Fisheries department has access only to the irrigation reservoirs. This multiple ownership comes in the way of scientific management of reservoirs. Introduction of fast growing species to colonize unutilized niches is considered a pre-requisite for fisheries development in reservoirs. Stocking of exotic fish in such pristine waters is a subject of controversy due to its deleterious effects on indigenous species and stocking of endemic species with proven track records has not made any head way.

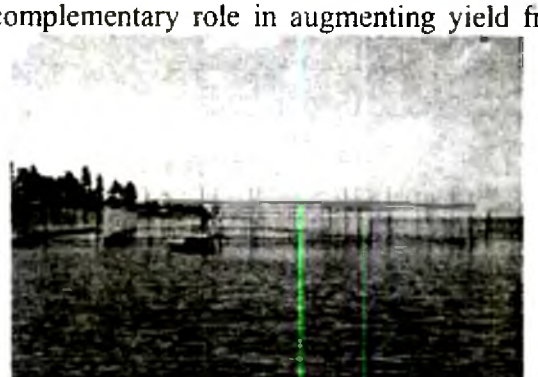
Despite abundant and varied resources, the inland fisheries production in the state is only at a subsistence level. The main challenges in enhancing production are tackling issues such as 1).Degradation of aquatic environment 2).Increasing competition for resources and 3) Inadequate institutional system

Mastering the challenges

Integrated approaches

Integrated management of resources shared by fisheries and other users is essential to facilitate sustainable inland fish production. In order to enhance fish production, there is a dire need for integration of inland fisheries, aquaculture and agriculture. This can add value to the shared resources. Integrated fish farming techniques and farming system models tested and developed during the past decades can be utilised at the farm and community level. This can help recycling of nutrients and utilization of byproducts and waste for production of crop- livestock-fish systems . Intensified stocking of natural and manmade water bodies and additional measures for fertilization , predator control, habitat improvement and cage culture are some of the other identified strategies.

Observations on open water fish culture in cages and pens, taken up in Vembanad lake, Kerala has shown that enclosure fish culture can play a significant complementary role in augmenting yield from capture fishery. The advantage of this captive aquaculture is high production owing to dense stocking and intensive feeding. Cage fish culture has great potential in large water bodies such as lakes and reservoirs. The endemic fish *E.suratensis* has been demonstrated to grow upto 230g in 6-7 months when reared under a feeding regime using commercial pellets. Since open water bodies are used for diverse activities involving wide range of



Openwater fish culture

stake holders, such intensive farming strategies should take into consideration the carrying capacity of the water body .

In the context of shrinking land bases and water resources, time tested technologies of integrated farming involving aquaculture has great relevance to Kerala. The rice-fish farming model developed and popularized by Kerala Agricultural University in Kuttanad is such a widely acclaimed farming model as rice and fish are staples in the diet of the people in these places. Operated in a structured manner, this could not only enhance income base of the farmer and sustain rice cultivation but also help to protect water resources. It has been demonstrated that rotational farming of rice and fish could help to convert low land rice polders temporarily into water storage and harvesting structures. Introduction of herbivorous and macrophagous fish species in rice fields can help to control weeds and bring about significant savings on fertilizer cost making rice cultivation more organic.

Weed utilisation

Waste water fed production systems

Inland fish farming can also help to utilise waste waters and agro-based industrial effluents. This will add a new dimension to inland aquaculture rendering it eco-restoring, environment compatible and economic. By 2020, it is estimated that over 50% of our population will be urban whereby, human food chain and nutrient cycles are going to become unstable as waste and byproducts are not going to be returned to soil leading to ecological problems of eutrophication on water bodies. Utilization of sewage and urban wastewater for aqua-farming is one of the suggested methods for treatment of such effluents. Such waste water reuse system that promote waste water fed huge crop-fish- livestock production units near our urban centers is one strategy to alleviate environmental problems of eutrophication

In the context that fishery decline in natural waters is due to environmental degradation of aquatic habitats and poor fisheries management, conventional fisheries management measures such as regulation of mesh size , closed areas, or closed seasons can not be the right option for enhancement. Ranching and open water fish culture are considered options in such a context. The phenomenal rate of growth of the lake fishery in China has been attributed to such effective management programme involving setting up of fish protection zones and promotion of artificial stocking.

Openwater sanctuaries

Investigations on the above lines carried out in the open Vembanad lake revealed that by

providing simulated breeding habitats, fishery recruitment can be enhanced. A variety of artificial nest and substrates deposited on the lake floor in the engineered fish sanctuary has been found to provide nesting surfaces for Karimeen, *Etroplus suratensis* the commercial fish species of the lake. Fish population studies in the engineered fish sanctuary indicate that fishes utilize sanctuary habitats and the deposited substrate materials for breeding While developing this engineered habitat, co-operation of the local fisher communities were sought and their participation ensured. These experiences highlight that successful resource management undoubtedly depends on the increased participation of stake holders groups and communities. Such an effective partnership and linkage by close involvement of the local interests will go a long way to ensure protection of the resources and environment.

Table 3 Reservoirs of Kerala

Sl.No	Name of Reservoir	Name of River Basin	Location-District	Area (ha
1	Pazhassi	Valapattanam	Kannur	648
2	Kuttiyadi	Kuttiyadi	Kozhikode	1052
3.	Malampuzha	Bharathapuzha	Palakkad	2313
4.	Mangalam	Bharathapuzha	Palakkad	393
5.	Meenkara	Bharathapuzha	Palakkad	259
6.	Chulliyar	Bharathapuzha	Palakkad	159
7.	Pothundi	Bharathapuzha	Palakkad	363
8.	Walayar	Bharathapuzha	Palakkad	259
9.	Parambikulam	Bharathapuzha	Palakkad	2092
10.	Thunakadavu	Bharathapuzha	Palakkad	283
11.	Kanjirapuzha	Bharathapuzha	Palakkad	512
12.	Peechi	Karuvannur	Thrissur	1263
13.	Vazhani	Kecheri	Thrissur	255
14.	Sholayar	Chalakkudi	Thrissur	870
15.	Peringalkuthu	Chalakkudi	Thrissur	263
16.	Chimmony	Karuvannur	Thrissur	1010
17.	Pamba	Pamba	Idukki	570
18.	Kakki	Pamba	Idukki	1800
19.	Idukki	Periyar	Idukki	6160
20.	Anayirankal	Periyar	Idukki	433
21.	Kundala	Periyar	Idukki	230
22.	Mattupetti	Periyar	Idukki	324
23.	Sengulam	Periyar	Idukki	33
24.	Periyar lake	Periyar	Idukki	2890
25.	Pooyamkutty	Periyar	Idukki	
26.	Azhutha	Pamba	Idukki	
27.	Eravikulam	Periyar	Idukki	
28.	Neriyamangalam	Periyar	Ernakulam	413
29.	Bhoothathankettu	Periyar	Ernakulam	608
30.	Malankara	Muvattupuzha	Ernakulam	566
31.	Kallada	Kallada	Kollam	2590
32.	Neyyar	Neyyar	Thiruvananthapuram	1500
33.	Peppara	Vamunapuram	Thiruvananthapuram	582
34.	Aruvikkara	Karamana	Thiruvananthapuram	258
35.	Ponmudi	Karamana	Thiruvananthapuram	260