Draft Final Report

Carrying Capacity Based Developmental Planning for Greater Kochi region

(Volume III)

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Chapter V

Environmental Hotspots and Limiting Resources and Short/ Long Term Management Plans

5.0 ENVIRONMENTAL HOTSPOTS AND LIMITING RESOURCES AND SHORT/LONG TERM MANAGEMENT PLANS

5.1 Environmental Hotspots, Concerns/Conflicts and Management Plans

Environmental concerns/hotspots are identified and technological/ management interventions necessary to minimize the environmental degradation are suggested in the following sections for each of the environmental components.

5.1.1 Air Environment

5.1.1.1 Present Status

The existing ambient air quality within the study area was established through secondary data analysis and actual monitoring at 58 locations spread all over the study area during 1999-2000. Further, ground level concentration of major criteria pollutants, SPM, SO_2 and NO_x were predicted under different meteorological/emission scenarios using appropriate air quality models for all the identified emission sources.

Analysis of long term secondary data (1990-98) on ambient air quality for Kochi city indicates that air quality indices for different seasons and activity zones fall under excellent to good category. Another study carried out in Ernakulam and Kottayam during 1993-99 indicated fair to dangerous category of AQI, due to higher levels of SPM. SO_2 and NO_2 were in general well within the stipulated limit of 80 $\mu g/m^3$. AQI estimated from the primary data collected in all the districts of GKR indicated excellent to fair category of AQI in different activity zones. Ambient air quality status in GKR is in general satisfactory except in few pockets like Kalamassery, Eloor and Udyogmandalam industrial area in Kochi, heavy traffic movement in city area, particularly in Ernakulam, Irumpanam. High levels of NH_3 are also observed in Udyogmandalam industrial area.

Hotspots/concerns for air environment and the suggested technological and management interventions are summarized in **Table 5.1.1.1** and are discussed here in detail.

5.1.1.2 Management Plans

Safeguards to improve the status of air environment, at all the receptors within GKR, have been delineated adopting three stage mitigation scheme:

- at the pollution generation stage (at source),
- during pollution propagation between source and receptor, and
- at receptor exposure sites.

5.1.1.2.1 Technology Options : Control at the Source

Point Sources

The objective is to first estimate the quantum of the likely emissions of the major pollutants; SO_2, NO_2 and SPM, which are emitted due to the combustion of fuels used at different sources, and then make recommendations on technological interventions for air pollution control to reduce these emissions. Emissions from each industry vary from one another greatly with respect to characteristics and quantity in relation to production capacity of the plant, type of fuel used, type and complexity of the processes employed, air pollution control measures in use and degree of maintenance in force and therefore, each industry needs particular/specific attention towards air pollution control management. Technological means for air pollution control from point sources is numerous, varied and can be tailored as per the requirements of an industrial unit. The air environment management plan recommended for the industries include :

- Cleaner technology options
- Cleaner fuel options
- End-of-pipe/flue gas treatment
- Dispersion through tall stacks
- Changes in operational schedule to utilize air assimilative capacity

Major air polluting industries are located in Kalamassery, Udyogmandal, Aluva, Cherthala and Kottayam area, which significantly influence the air quality in the study region.

The air pollution prevention strategies for all the industries in general would include :

- Reduction in fugitive particulate matter emissions by proper storage & loading & unloading, providing proper covers over conveyor belts & bucket elevators, and carrying out batch operations in enclosed sheds
- Significant reduction in specific fuel consumption with better combustion and use of cleaner fuels to reduce emissions
- Different types of control systems such as multicyclones, fabric filter & wet scrubber can be used for reducing SPM, SO_2 & emissions of other gases

All the large and medium scale industries in GKR should follow the CPCB guideline of providing a minimum of 30 m stack height and complying with emission standards set for SPM/SO_2/NOx etc. Any industry, which is unable to meet the emission standards, should go for the recommended options to keep the emissions under permissible levels.

Area Sources

Emissions from area sources originate mainly from domestic fuel consumption where a broad range of fuels is used. The area emissions vary in relation to the status of population and availability of the fuels. These include; bio-fuels, viz. wood, dung cakes and other combustible agricultural wastes and fossil fuels viz. coal, kerosene and LPG. Emission inventory on domestic fuels combustion indicates that wood is the major fuel in the rural areas of GKR, resulting in high SPM, HC and CO emissions. Though individually each house may not contribute noticeable air pollution, but collectively the total activity certainly contributes significantly and therefore, needs attention.

Various control options recommended for area source emissions are as follows:

Cleaner Technology Options

Fuel-efficient chulhas alongwith chimney for efficient heat utilisation is recommended for rural areas, while increase in use of LPG is recommended for urban areas.

Use of Clean Fuel

Switching over to cleaner fuels is essential so as to minimize the pollution from area sources and also because the conventional fuels are scarce. Further to conserve the conventional fuels, the use of non-conventional energy resources viz. solar energy and biogas should be increased.

Solar Energy : The first option in the ranking of cleaner fuels is the use of solar energy.' However, this needs technology innovations, social awareness and general acceptance breaking the traditional norms of bio-fuels usage. Kerala is having the highest literacy rate in India should not have any problem relating to awareness promotion. In fact solar cookers are quite popular in Kerala and need to be further promoted.

Biogas : More usage of biogas in rural areas should be promoted. Increased use of LPG would further reduce emissions.

Line Sources

Vehicles contribute a whole range of HCs besides SO_2, NOx, CO, SPM and lead. Diesel vehicles mainly emit smoke and NOx whereas gasoline vehicles emit more CO and HC. The quantity of pollutants emitted by the vehicles is directly proportional to the number of vehicles plying on the road. The intensity of pollution potential depends on several factors such as geographical locations, unplanned development of central business areas, inadequate and ill maintained roads as well as vehicles, unplanned traffic management, meteorological and climatic conditions and non-availability of adequate emissions control technology and therefore, require proper traffic management.

Auto exhaust emission standards were introduced in the year 1989 as per the Central Motor Vehicle Rules 1989 and amended from time to time, whereas the mass emission standards were introduced since April 2000 for petrol and diesel driven vehicles, as presented in **Tables 5.1.1.2** and **5.1.1.3** respectively. The following measures are recommended to control mobile source emissions and improve the ambient air quality in major cities / towns of GKR.

- Compulsory servicing of public and private vehicles to minimize air pollution emissions
- Reorganization of traffic movement in most crowded areas of the city
- Increase in open green spaces
- Supply of lead free gasoline
- Battery operated/CNG based vehicles adoption may be explored within the city, particularly in Ernakulam

Exhaust Emissions Control

The endeavors for development of exhaust emission control technologies are based on :

- Operation norms alterations
- Engine design modifications
- Fuel modifications
- Exhaust gas treatment

Indian automobiles have distinct differences viz. average life (>15 years), low compression ratio engines, low fuel efficiency and vast number of two stroke vehicles on urban roads. With the standards currently applicable, CO (idling) reduction through carburetor tuning can achieve 30% reduction for passenger cars and 20% for 2 and 3 wheelers. Engine design modifications such as reduced compression ratio, improved combustion chamber design, stratified charged engines; help greatly in the total exhaust emissions reduction. Further, fuel modifications including the use of gaseous fuels like LPG and CNG in place of gasoline can extensively reduce CO and HC emissions. There are, however, some important problems to be solved on engine side as well as on the storage and safety problems associated with such gaseous fuels.

Major shift in existing engine technology as well as fuel use pattern is not envisaged in near future and, therefore, the exhaust gas treatment is the only option to meet the emission control limits for all the important pollutants. The most prominent methods to mitigate pollution through tail gas treatment include :

- Exhaust manifold reactors
- Direct flame afterburners and
- Catalytic converters

Among these options, exhaust manifold reactors require high temperature resistant materials, which are very costly. Some undesirable metal oxides are also formed inside the reactors at high temperatures and they come out with the treated exhaust. Whereas, the second option (direct flame afterburners) needs supply of additional air and triggering device for initiating combustion, which makes the unit. complicated. These options, however, do not appear to be viable in near future.

Catalytic Converter Technology (CCT)

This technology works on the principle of chemical conversion of pollutants to harmless gases; needs no triggering device and operates at moderate temperatures obviating the need of a specific high temperature resistant material.

Today CCT is identified as the best practicable technology for control of automobile exhaust emissions and can meet world's most stringent emission standards. For Indian application of CCT, the catalyst configuration should be free from lead and sulphur poisoning. Otherwise, it will be necessary to incorporate essential changes in petrol as well as lubricant refining in India.

NOx formation in case of diesel engines can be minimized either by restricting the air availability using Exhaust Gas Circulation (EGC) or by lowering the peak cycle temperature by retarding injection timing.

The major problem in the deployment of three ways CCT including NOx control besides CO and HC, is the blocking of catalyst pores by soot and particulates which should be removed prior to the converter. A particulate trap (ceramic honeycombs, wire mesh or cyclone traps), which collects the particulates, can be used before the converter. This will also help in meeting the future standards for particulates.

5.1.1.2.2 Air Pollution Mitigation on Source-Receptor Pathway: Green Belt Development

The GB for abatement in identified and likely hot spots can be designed adopting two stage approach :

- Control near the source - to attenuate the concentration of pollutants near the source
- Control near the receptor - to mitigate the pollution exposure of sensitive receptors

Thus, location specific GB development plans and plantation schemes in GKR are to be evolved to encircle the sensitive receptors and on both the sides along the heavy traffic avenues as well as major industry/industrial estates.

The prevailing air pollution conditions should be assessed. In order to select the plant species suitable for pollution abatement through GB development, the appropriate selection is guided by their performance/response to pollution and also upon their economic/aesthetic value. Furthermore, the selected plant species should preferably be indigenous, fast growing, requiring minimal maintenance and self-rejuvenating. The afforestation should also be based on mixed type of plantation to support bio-diversity perpetuating local ecosystem. Based on the findings, suitable plants shall be recommended for effective pollution abatement in region.

Line Sources

NO_2 pollution build-up in identified hot spots, particularly in urban centers, can be attributed to the automobile activity in the corridors. Thus, the plantation of avenue trees as one of the measures for auto exhaust pollution mitigation becomes imperative.

Industrial Sources

Fugitive emissions from various industrial sources in the region, during various unit operations include SPM, SO_2, NOx, HC etc. The mitigation efficacy of GB depends mainly on the width of GB, distance from the source and tree height. Thus the GB around industrial sources lowers the impact levels of fugitive emissions on the surroundings. The plantation pattern in a hot spot may be undertaken with site-specific changes.

Air environment management strategy through green belt development along with pollution reduction potential is depicted in **Fig. 5.1.1.1.**

Table 5.1.1.1

Environmental Concerns / Hotspots, Technological and Management Interventions: Air Environment

Concern	Sector/ Pollutants	Critical Zone	Technological and Management Intervention
Ambient air quality	High levels of NO_2 and NH_3	Commercial & Industrial areas of Ernakulam, district. All the stations monitored in Pathanmthitta & Thrissur district	• Reduction in Industrial and vehicular emissions • Organized/controlled refuse burning wherever applicable • Plantation wherever possible
Emission load	Industrial Sector	Kalamassery, Udyogmandal, Aluva, Kottayam, Cherthala	• Emissions reduction from various processes either by modifications in the process or by installing additional/ efficient pollution control devices • Strict adherence to stack emission standards • Green belt development around the industrial emission sources
	Transportation Sector	Along all major transportation corridors in the study area, particularly in urban centers	• Strict adherence to vehicular emission standards • Use of good quality fuel and proper traffic management • Plantation along the roads
	Domestic Sector	Commercial/Rural zones	• Use of good quality fuel and promoting usage of cleaner fuels like LPG • Optimum utilization of fuels • Organized/controlled refuse burning wherever applicable • Plantation wherever possible

Table 5.1.1.2

Mass Emission Standards : Petrol Vehicles (1.4.2000)

Vehicle Category	Mass Emission Standard (g/km)	
	CO	HC + NOx
Passenger cars (all categories)	2.72	0.97
Two Wheelers (all categories)	2.0	1.5*
Three Wheelers (all categories)	2.0	1.5*

* HC Only

Note: The test should be as per Indian driving cycle with cold start.

Source : Mass Emission Standards for Petrol and Diesel Vehicles, CPCB, 1990

Table 5.1.1.3

Mass Emission Standards : Diesel Vehicles (1.4.2000)

I Approval Tests

Vehicle Category	Mass Emission Standards (g/kwH)				
	HC*	CO*	NOx	SPM*	Smoke
Medium & Heavy (over 3.5 Ton/GVW)	1.1	4.5	8.0	0.36	***
Light (upto 3.5 Ton/GVW)	1.1	4.5	8.0	0.61	***
OR (g/km)					
	CO**	HC + NOx**	SPM**		
	2.72	0.97	0.14		

Note:

* The test should be as per 13 mode cycle

** The test should be as per Indian driving cycle with cold start

*** The emission of visible pollutants (smoke) shall not exceed the limit values of smoke density, when expressed as light absorption coefficient.

II Conformity of Production Tests

A relaxation of 10% for the values of Type Approval Test given above would be permitted for Conformity of Production Test for all vehicles.

Source : Mass Emission Standards for Petrol and Diesel Vehicles, CPCB, 1990

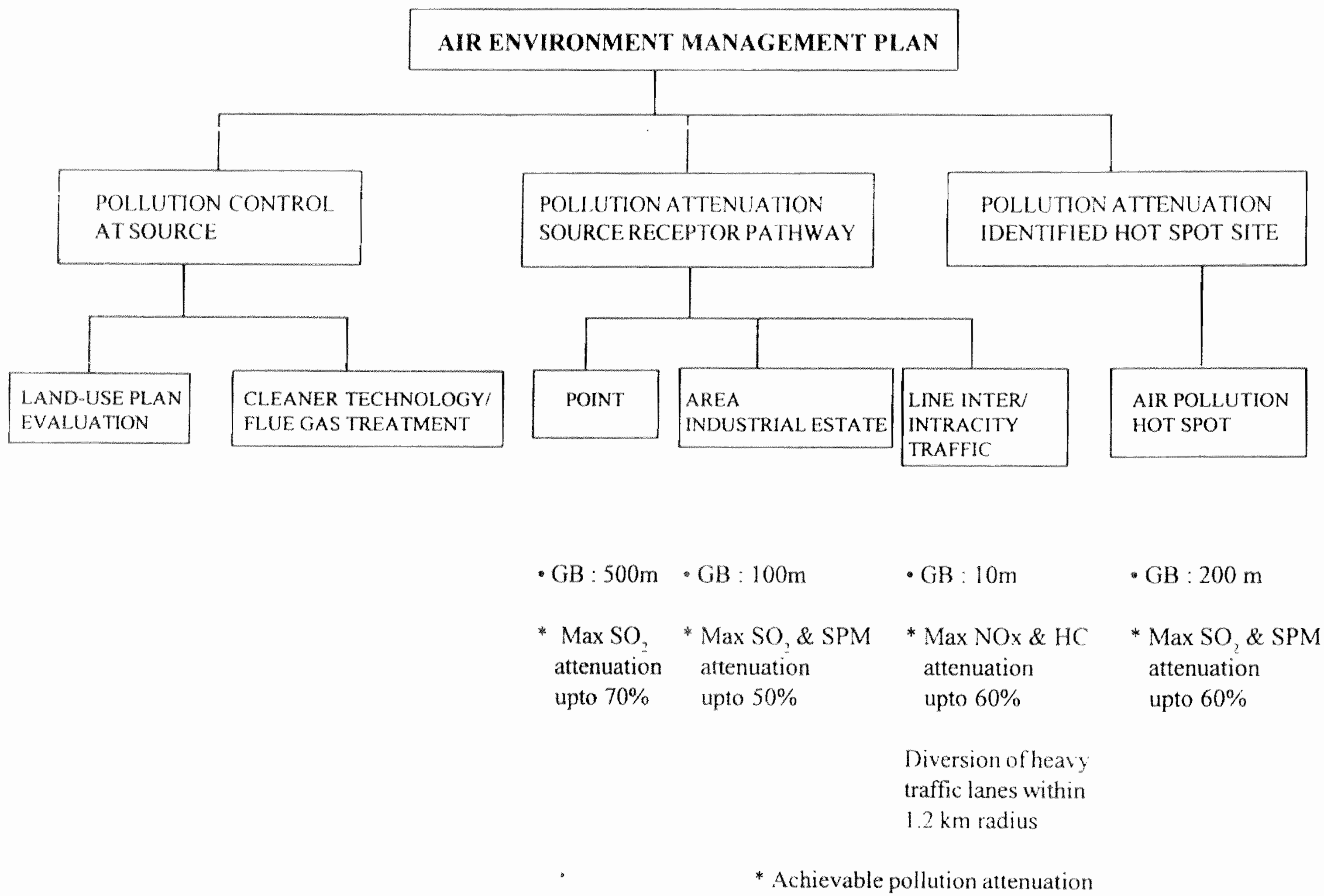

Fig. 5.1.1.1 : Air Environment Management Strategies through Green Belt Development

5.1.2 Noise Environment

5.1.2.1 Present Status and Management Plans

Noise in the region is generated by multiple sources such as medium and heavy industries, urban activities in the commercial and residential areas and movement of traffic. Accordingly, the ambient noise levels were measured in residential, commercial, industrial and silence areas of Jamshedpur region, as per the CPCB guidelines.

In general, the in-plant noise levels were found to be high. Further, the residential areas near traffic corridors also recorded high noise levels. Ambient Noise levels recorded in the study region were more or less within the exposure limits, however, occasionally high levels were observed due to surface as well as water transportation activities in Ernakulam/Kochi, Kottayam, Aluva and Alappuzha. As a result, aquatic avi fauna and resident population along the transport corridors were found to be affected. To minimize/control the ambient noise levels, appropriate management options are suggested in **Table 5.1.2.1** and discussed in detail here.

The noise environment consists of three interrelated elements; the source, the receiver and the transmission path between the source and the receiver. By examining each of these elements and the ways in which each can be modified, an approach to environment management plan for noise is evolved.

5.1.2.1.1 Point Sources

The technological means for noise pollution control from point sources is numerous, varied and can be tailored as per the requirement of an industrial unit. Management options for noise control in an industry are :

- Reduction of noise at the source
- Changing to quieter method of work
- Preventing or reducing propagation

Recommendations for noise control at the point sources are :

(i) Reduction of noise from major machinery and equipments by :

- Choosing power sources and transmission which give quiet speed regulation e.g. step less electrical motors
- Isolating vibration sources within the machine
- Ensuring that cover panels and inspection hatches on machines are stiff and well damped
- Providing machines with adequate fins which reduce the need for air flows and, therefore, fans
- Providing air exhausts from pneumatic valves with silencers

- Changing the pump type in hydraulic systems

(ii) Noise during material handling is mitigated by :

- Minimising the fall heights for material collected in boxes and containers
- Choosing conveyer belts in place of rollers. Roller transporters are liable to rattle
- Controlling the speed of conveyer belt transports to match the amount of material to be transported. This avoids the stops and starts which cause noise from vibrations and impact of transported material

(ii) Reduction of noise at the source by providing an enclosure such as :

- Sealed material in panels of metal or plasterboard for the outer surfaces
- Lining of inner surface with mineral wool, glass wool, foam rubber or polyurethane material. Sealed enclosures of such type can reduce noise by 15-20 dB(A)

5.1.2.1.2 Area Sources

Noise emissions from the area sources originate due to commercial activities, construction work and the traffic movement in the region. The mitigation measures to be adopted for the environmental noise control are as under:

Residential Areas

The baseline noise status in the residential areas in Kochi indicates noise equivalent levels in the range of 40-70 dB(A). It is recommended to regulate the movement of heavy and medium vehicular traffic in the residential area. The use of horns and loudspeakers during night hours should be banned.

Silence Zone Areas

A number of educational institutions, hospitals and courts are considered as sensitive receptors and are classified under Silence Zone category. The Leq measured at these locations in Kochi are 38-60 dB(A) thus exceed the standard limit of 50 dB(A) and 40 dB(A) for day and night time respectively. The recommended measures for noise control in silence zone areas are:

- Operational restrictions on the movement of heavy vehicles in the silence zone areas
- Reduction in volume of traffic by diversion to other roads
- Banning the use of pressure horns
- Building of acoustical wall around the hospitals and educational institutions situated near the main roads

Commercial Areas

The ambient noise levels in commercial areas of Ernakulam ranged between 46 & 77 dB(A) during daytime. In Alappuzha, Kottayam and Pathanamthitta noise levels ranged between 46 & 70, 60 & 72 and 51 & 65 dB(A) respectively.

Industrial Area

The ambient noise levels in the industrial areas recorded in general, were high. This indicates that for mitigating noise levels from various industries in the industrial area, the inplant noise has to be kept within the operational limits so that the noise levels in the surrounding areas do not exceed the permissible limits.

5.1.2.1.3 Line Sources

Kochi is the nodal centre of trade, commercial and industrial activities in the region. Besides the inner and the outer roads, there National Highways No. 17, 47, 49 pass through Kochi. A considerable increase in the volume of activities, presence of work force and population along these corridors leads to an increase in noise level. The vehicular population in Ernakulam district was 284455 in 1999 out of which nearly 62% of the vehicles were two wheelers. In other districts also, two wheelers are around 50%.

The noise equivalent levels measured at major traffic junctions indicate noise levels ranging between 50 - 84 dB(A). The peak hour traffic volume presents the grim traffic scenario at these locations. The noise levels are not dependent only upon the number of vehicles but also upon other factors like locations of the surrounding buildings and their distances from the road, duration of signal cycles, composition of traffic flows, average speed of the vehicles and the total area at intersections. It was observed that at certain traffic junctions, the area of intersections is less and a higher congestion period prevails due to slow moving vehicles leading to high noise levels.

Acoustic barriers in the form of walls and beams located between the line source and the receiver assist in noise attenuation. The noise level reductions due to various wall heights and distances from the source as per IS : 4954 are illustrated in **Fig. 5.1.2.1.**

Table 5.1.2.1

Environmental Concerns / Hotspots, Technological and Management Interventions: Noise Environment

Concern	Sector/ Pollutants	Critical Zone	Technological and Management Intervention
Source	Industrial operations	All major industries	• Selection of less noise generating machinery and equipment • Use of noise absorbers / barriers near the machinery and equipment • Use of noise protecting devices like ear plugs/ ear muffs by the inplant workers • Acoustically insulated operators cabin / control room • Rotation of workers duty in high noise zones • Green belt development for noise attenuation • Buffer zone between industries & residential areas.
	Traffic movement	All major traffic corridors	• Usage of less noise generating systems / retrofitting of silencers • Better traffic management • Plantation along the transportation corridors
Receptors	Residential, commercial and sensitive areas	Residential / sensitive areas along the major traffic corridors	• Restriction on use of horns in sensitive areas • Restriction on use of pressure horns • Restriction on use of public address system during night hours • Provision of acoustic walls or barriers near the sensitive receptors like hospitals, schools etc. • Plantation wherever possible

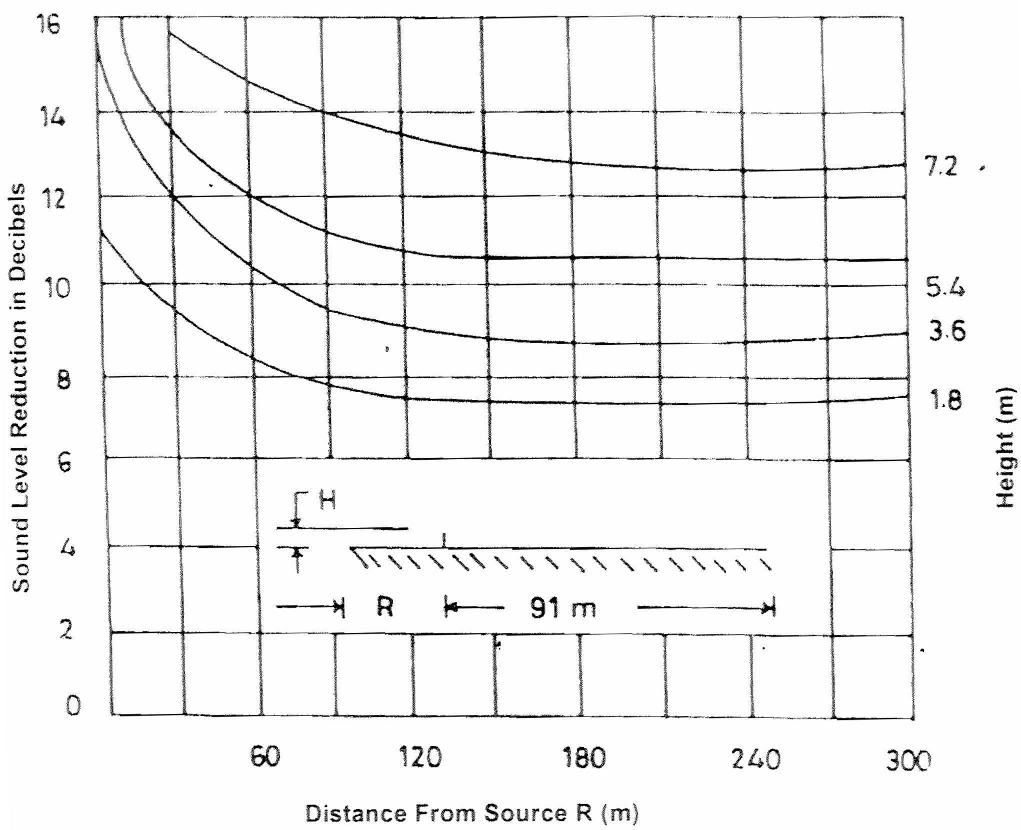

Fig. 5.1.2.1 : Sound Level Reduction at various Wall Heights and Distance from Source (Ref : IS-4954)

5.1.3 Water Environment

5.1.3.1 Surface Water Quality

Chithrapuzha, one of the tributaries of Periyar is found to be highly polluted, as it receives a variety of effluents from fertilizer, refinery and other industries located in the Udyogmandal area. The effluents contain ammonia, ammonium sulfate, phosphate, calcium, sulphate, nitrate, and heavy metals. The total effluent discharge into Chitrapuzha River is about 33,600 m^3/day.

Water quality of seven rivers (Chalakuddy, Periyar, Muvattupuzha, Meenachil, Manimala, Pamba, & Achencoils) flowing through the region was, in general, satisfactory falling under 'B' category of CPCB classification. Total coliforms were found much higher than the permissible limits indicating unsuitability of river water without disinfection. The details of the study carried out are reported earlier in Section 3.3.1.8. FACT and other industries are advised to adopt appropriate measures before discharging their treated wastewaters into the river.

5.1.3.2 Ground Water Quality

5.1.3.2.1 Fluoride Concentration

Drinking water sources of Kerala are influenced by the peculiar physiographic and hydrologic conditions of the state. Even though small amounts of fluoride are good for the teeth of growing children, excessive amounts can cause the disease, dental fluorosis and a crippling bone disease called skeletal fluorosis. The factors influencing the onset of fluorosis include nutritional deficiencies, low calcium and high alkalinity of drinking water, duration of exposure, age of individual etc. It is important that preventive measures should be taken immediately to protect people from intake of high concentration of fluoride through drinking water.

CWRDM had undertaken a study during 1995-96 to determine the quality of tube wells, which is the main source of drinking water in Alappuzha and Cherthala areas. A simple and extremely reliable index for identifying the endemicity of fluoride in Alappuzha and Cherthala regions was adopted, where in the areas were identified through a survey conducted among lower and upper primary school children. A profile data sheet was prepared for assessing dental fluorosis among school children. The teeth of the school children were examined for the following factors:

- Loss of luster and shine of the enamel of teeth
- Discoloration of the teeth-yellow, brown and black streaks or spots
- Pitting and chipping of teeth
- Loss of teeth

Based on the survey, the contaminated areas were identified and water samples were collected from these areas. Fifteen schools in Alappuzha and Cherthala regions were selected for carrying out a survey work to examine fluorosis prevalent among children. 750 children were examined for the dental fluorosis, and it was found that the children affected were the residents of the areas; Punnapra, Kadanthuruthi, Varanad, Kalavoor and Alappuzha town. About 10% of the children studying in school in Punnapra were found to be affected by fluorosis. Water samples were collected from different parts of Alappuzha region during post monsoon and summer period. The samples were analyzed for the parameters like pH, electrical conductivity, chloride, fluoride, bicarbonate, calcium and magnesium as per the standard procedure. The results are given in **Table 5.1.3.1**, perusal of which indicates that concentration of fluoride is greater than the permissible limit of 1 mg/L in 9 tube wells of Kerala Water Authority in various parts of Alappuzha region. Fluoride concentration was found more in the samples collected during summer **(Table 5.1.3.2).**

It was also found that high fluoride content in natural water is associated with a high alkalinity and low calcium and magnesium content which may be attributed to the following physical factors:

- The size of distribution of fluorspar and fluorapatite and other fluoride bearing minerals in rocks
- The ability of ground water to come into contact and time of contact of ground water with those minerals.

The aquifers in Alappuzha region have different composition. The fresh water of Ambalapuzha-Thakazhi zone has the composition Ca-Mg-HCO_3. The chemical composition of water changes to Na-HCO_3 up to Alappuzha area and further north (Alapuzha-Cherthala zone) Ca-Mg-Cl type is noted. The calcium rich water moving northward releases sodium by ion exchange from clay minerals, which had become sodium rich. This results in Na-HCO_3, which also explains the higher fluoride content. The alkaline waters can release fluoride from the minerals like fluorapatite since hydroxide and fluoride have same charge and near equal ionic radii.

Prevention and Control of Fluorosis

The following fluoride removal technologies are available:

- Absorption on activated carbon, activated bauxite or activated alumina
- Fluoride exchangers – Tri calcium phosphate or bone charcoal
- Precipitation using lime or calcium chloride. Further reduction by passing through a packed bed of alumina
- Nalgonda technique – Use aluminium salts for removal, followed by precipitation, settling and filtration
- Precipitation by lime, sodium carbonate or alum solution

Preventive Measures for Excess Fluoride Intake / Consumption

- If the water has fluoride concentration more than 1 mg/L, do not use for cooking or drinking
- If any of the symptoms of fluorosis is detected, avoid major sources of fluoride content
- Intake of Vitamin C in large amounts is advisable. Vitamin C helps in the production of collagen protein, which is important for the calcification of bone and teeth
- Diet should have adequate calcium. Calcium interacts with fluoride to form calcium fluoride which will be excreted being a large molecule

Based on the report of CWRDM, a committee consisting of Executive Engineer, Kerala Water Authority, District Medical Officer, Engineer, Kerala State Pollution Control Board, Professors from Medical College Alappuzha, Secretary, Alappuzha Municipality etc. was constituted. The committee was assigned the responsibility or finding out alternate sources of water, commissioning a defluoridation plant and to study its performance, to undertake fluorosis survey and water quality surveillance in the entire district of Alappuzha with the technical advice of CWRDM.

5.1.3.2.2 Groundwater Pollution due to Heavy Metals

Aluva -Eloor and Ambalamedu areas have been identified as hotspots due to groundwater quality problems with reference to heavy metals, nitrate and fluoride as detailed in Section 4.3.11. The solution to this problem is supply of surface water to this area.

5.1.3.3 Cochin Backwater System : Hotspots

- The primary data collected for one year on the various physical, chemical and the biological parameters show that the area in and around Marine Sciences jetty (1 km^2), Fisheries harbor, backwater adjoining the islands of Bolghatty, Vallarpadam and Vypeen, backwater system in the northern limb receiving effluents from the industrial belt involving water spread area in Vaduthala, Varapuzha and Eloor regions can be considered as hot spots in the backwater system.
- The assessment was done based on the recorded values of suspended solids, dissolved oxygen, pH, nitrite, phosphate, silicate, Cu, Zn, Mn, Pb, Cd, faecal coliforms and species diversity of zooplankton and benthos.
- In the case of trace metals and petroleum hydrocarbons in sediments, hot spots were identified based on previous reports as no standards are available for comparison and values higher than the reported normal range were considered.

- In the case of Cochin backwater system, it is better to think in terms of rejuvenating the existing backwater system rather than restoration, with the available technical know-how.
- Expansion activities should be relocated from the coastal regions of Cochin city
- Land stability of the immediate hinterlands of the backwater be given due importance
- The embankments of the backwaters require protection and periodic maintenance
- Flood control measures should be practiced for the area adjoining the backwaters as there is a total neglect of this aspect at present
- To prevent unscientific dumping of wastes, the backwaters should be notified as protected zone
- For the other physico-chemical parameters, KSPCB standards and guidelines for the best designated usage was taken as the baseline for identification of hot spots
- The present data on productivity is higher than previous reports and places the estuary above the global average of 0.7 $gC/m^2/day$ during post and pre monsoon seasons
- The complete absence of euryhaline as well as stenohaline marine species was noticed in the area beyond Thannirmukkom bund (southern sector) even in the pre-monsoon season. This is only due to the closure of the Thannirmukkom bund during the pre-monsoon periods, which not only prevents the salt water penetration but also the ingress of migratory marine fishes into the southern sector of the Vembanad Lake

5.1.3.4 Coastal water

5.1.3.4.1. Physico-Chemical Water Quality

Water quality of the coastal waters was found to be within the threshold values prescribed by the CPCB for the five designated usages of waters. Hence, no "hot spot" was identified in the coastal waters of the study area (based on the primary and secondary data on water quality **(Fig. 5.1.3.1)**). However, near shore waters in Kochi barmouth area appear to be a potential hot spot area, due to slight build up of nutrients over the years and higher concentration of trace metals as compared to other places.

Management Plans

- The problems that could arise from the shipping activities are accidental oil spill, ballast washing and discharging, and dumping of solid waste from ships
- A contingency plan and preparedness should be put in place to combat the oil spill if it occurs
- Water quality standards need to be made more stringent by incorporating more parameters

Water Environment (Coastal waters) : Long Term Management Plan

- Dumping of any waste into the sea should be allowed after specific EIA study on case-to-case basis. Even if the EIA study clears disposal of waste, post-operational monitoring should be carried out frequently to understand the changes that will take place in the water quality and to take corrective measures
- Only treated waste as per standards prescribed by the statutory authorities may be permitted to be disposed in the coastal waters
- Existing legal interventions are adequate to control the above said activities and to ensure preservation of the water quality, if implemented strictly
- If the existing National and International legal interventions such as Merchant Shipping Act, Indian Port Act, Coast Guard Act, International Convention for the prevention of pollution from ships (MARPOL convention), International Maritime Organization (IMO) guidelines, etc. are strictly adhered to, pollution of coastal waters from the shipping activities can be minimized or avoided
- A contingency plan and preparedness should be put in place at the Kochi Port Trust to combat the oil pollution, if it occurs
- Recycling of industrial and municipal wastewater through proper treatment (technology) and its reuse in agriculture and aquaculture depending on its characteristics can be considered as an alternative for wastewater disposal
- Water quality data for the coastal waters indicates that various parameters are within the limits prescribed by the CPCB for coastal waters. Hence, it is assumed that the assimilative capacity of the region is adequate to take care of the pollutants reaching the coastal waters at present
- As such no effluent, either of industrial or municipal origin is discharged directly into the sea. The industries are mainly situated on the banks of the backwaters and are discharging effluents directly into the backwaters. Municipal wastewater is also discharged into the backwaters. Although a part of it is expected to reach the coastal waters after undergoing dilution processes in the backwaters (estuaries) through the two openings at Kochi as well as Munambam (Azhikode), no information is available about

pathways and changes occurring along the pathways of the pollutants from the discharge point to the coastal waters. However, it appears that there are a few hotspots in the backwater system indicating that the backwaters or the estuary is not able to assimilate the pollution load or flush it out to the sea fully. The assimilative capacity of the backwaters is yet to be estimated

- In the light of the above, alternative options could include disposal of wastes in the sea. It is suggested that at least some of the major effluent discharging industries should plan to dispose off the treated effluents somewhere in the open sea after making specific studies for finding out proper locations. This could be achieved in two ways: one option is to discharge through a marine outfall at a location selected through proper studies. Another option is to carry the effluents through barges and dispose them at suitable locations in the open sea
- The effluents should be treated and the quality of effluents should conform to the standards specified by the statutory authorities. If the industries find it economical, the effluents from different industries could be brought together to a common plant and then discharged through submarine pipeline and diffusers into the open sea after conducting specific studies needed
- Water quality standards for various designated uses need to be revised to make them more stringent and by incorporating more relevant parameters.

5.1.3.4.2 Land (Mining, Erosion, Waste Disposal and Salinization)

Status / Concerns

Analysis of secondary and primary water quality data reveals that the entire study area is not a hot spot with respect to water environment **(Fig. 5.1.3.1)** but is a biological environment hot spot **(Fig. 5.1.3. 2)**. The activities which affect the environment of coastal waters of GKR are effluent discharges into the backwaters, dredging, dumping of dredge spoil, removal of sand from beaches, shore protection works (methods), over fishing etc.

In the Coastal Zone physical environment, erosion is a major problem in some areas. Geologically, the coastline is of recent origin comprising of recent sediments and it has not reached an equilibrium state. Hence, shoreline changes do take place always along the coast, which may shift from place to place. The sediment transport along the coast changes seasonally in its direction. The net annual drift appears to be towards south along the coast. Formation of mud banks during southwest monsoon period along the coast is a major factor affecting the stability of the coast in such a way that erosion takes place in the down drift area and accretion on the up drift area. Some of the areas found stable or undergoing accretion are because of the mud bank formation in those areas.

The coastal structures such as breakwaters also affect the shoreline stability similar to that of mud bank formation. This is evident at Munambam and Azhikode where breakwaters are constructed for the development of fishery harbour. Accretion is noticed on the Azhikode side (northern side of the north breakwater) and erosion on the Munambam side (south of the south breakwater). Sea level rise and decrease in the sediment input to the coast due to the damming of rivers, bunding and siltation in inland water bodies also contribute to the erosion of the coast. The dredging of the navigational channel at Kochi Port and dumping of the spoil in the coastal waters also have some impact on the shoreline. Removal of sand from the beaches is also noticed along the coast especially at Andhakaranazhi.

Erosion occurs in the area south of Kochi bar mouth for a considerable distance whereas accretion takes place in the north Puduvypu area. Dredging and land filling for reclamation in the backwaters also may affect the input of sediments to the coast through the backwaters, since the rivers directly discharge into the backwaters. Seawalls have been constructed along most of the coastline except at a stretch near Mararikulam indicating occurrence of erosion along the coast at one stage or another. In many areas, beach has been developed in front of the seawall and as a consequence the sea walls are seen much interior. This indicates that sea wall construction may be effective in some areas whereas it is not very effective in other places. The stretch from Fort Kochi to Arthungal has no beachfront at all. In many places the sea walls collapse and no timely repair is undertaken leading to further erosion.

Management Plans

In the light of these observations, the following management measures are suggested:

- Sand mining from the beaches to be stopped.
- At present the dredged sediment from the Kochi Port area is dumped offshore. About 10 million m^3 of sediment is dredged annually. This quantity of sediment is lost every year from the near shore environment, which may be causing sediment starvation and, can be considered as one of the reasons for erosion of the coast. Therefore, the dredged material from the Kochi port area if used to nourish the eroding sector on the southern side of the Kochi bar mouth (Fort Kochi to Kannamaly), erosion can be controlled to a certain extent. If dumped away in the offshore area, the sediment supply to the coast gets reduced.
- Avoid construction of any structure across the coast (beach) which causes impediment to the littoral drift
- Minimize the activity that arrests the sediment input to the coast from the inland water bodies though it may cause siltation in the harbour channels
- Timely repair or reinforcement /reformation of damaged seawalls should be undertaken to avoid further erosion, and to save the land and the cost of construction of seawalls
- Several drainage canal openings to the coast (pozhis) are closed by the formation of sandbars at the mouth or blocked by bunds in the canals at various places constructed for preventing saline water intrusion for agriculture purpose or other purposes. Prevention of water flow through

these drainage canals leads to submergence of land in floodwater during monsoon period and accumulation of pollutants in the canals. These openings are cut open at some places during flood times for flood relief. If these drainage canals are kept open throughout the year, accumulation of pollutants in the inland water bodies can be avoided to a great extent. But it may affect agriculture due to saline water intrusion

- Dumping of any solid waste on the beaches should be avoided especially in places like Mararikulam-Arthungal sector in Alappuzha District and Edavanakad area in Ernakulam District, where tourism potential exists.
- Sanitation facilities should be provided in the coastal villages so that the beaches are not used for defecation
- No major industrial development is possible in the coastal zone since the land availability is meager due to the high density of population. Only the Puduvypu area, which is getting accreted, could be used for industrial development. However, the environmental impact of each industry should be studied before setting up the industry as practiced now
- Any major industry coming up on the coast should have a desalination plant to avoid pressure on the fresh water supply in the coastal belt which even now faces shortage of drinking water
- Tourism development projects should create proper amenities for sanitation and proper waste disposal so that the beaches are left unpolluted
- Plantation of Casuarina plants in the backshore area along the seacoast can be promoted which could arrest the erosion to a certain extent and provide firewood for the local population. Present practice is to plant coconut trees wherever possible for economic reasons.

Table 5.1.3.1

Chemical Characteristics of Well Water of Alappuzha District

Sr. No.	Location	pH	EC	Cl	F	HCO_3	Ca	Mg	TH
1	Eramallur	7.1	153	14	ND	58	20	1.9	58
2	Kadamthuruthi	7.5	2754	620	0.38	328	39	14.6	158
3	Thuravoor	7.7	270	22	ND	106	39	5.8	112
4	Pattanakkad	6.3	184	22	ND	68	22	2.9	66
5	Cherthala	6.4	306	54	ND	48	18	1.9	52
6	Cherthala (Govt. H.S.)	6.4	122	12	ND	54	22	1.5	60
7	Thaneermukkom	6.9	291	20	0.03	110	40	5.8	124
8	Kokkamangalam	6.6	122	12	ND	52	18	2.4	54
9	Valiyanad	7.4	418	46	0.1	122	40	4.9	120
10	Cherthala (Govt. U.P.S.)	7.0	189	28	ND	64	21	4.4	70
11	Kokkothamangalam	5.0	21	8	ND	8	1	1.4	8
12	Varanad	6.6	250	34	0.07	54	24	ND	60
13	S.L. Puram	6.1	500	98	ND	82	30	14.1	134
14	Kalavoor	6.2	291	48	0.09	60	10	0.5	26
15	Pathirapally	6.4	122	16	0.07	38	32	3.9	56
16	KWA Convent PH	6.8	908	132	1.0	216	29	17.5	144
17	KWA Vellakinar PH	6.8	857	118	1.01	14	17	19.0	120
18	KWA Alisery PH	7.5	581	32	1.09	218	20	7.8	82
19	KWA Chudukad PH	7.2	571	38	1.13	208	10	9.2	64
20	KWA Chudukad PH 2nd bore well	7.3	510	18	1.14	202	10	7.8	56
21	KWA Thookalam PH	7.0	602	62	1.02	188	17	10.7	86
22	KWA pazhavangadi PH	7.1	826	98	1.08	452	25	15.5	126
23	KWA vazhicherry	7.4	730	76	1.09	236	20	13.1	104
24	Kalarkode	6.8	337	36	0.61	112	20	1.9	58
25	Chambakkulam	6.2	352	50	0.15	58	16	11.7	86
26	Ramankary	6.4	337	36	0.09	80	33	6.3	108
27	Mankombe	6.5	714	132	0.27	154	50	9.2	164
28	Nedumudi	6.1	765	120	0.41	176	30	16.5	144
29	Karumadi	7.4	908	102	0.38	162	62	13.6	210
30	Thakazhi	7.0	530	36	0.44	194	30	17.9	150
31	Thottappally	7.8	306	30	0.21	98	42	2.4	144
32	Harippad	7.1	1020	120	0.24	270	84	6.3	236
33	Kayamkulam	5.7	173	20	0.33	42	14	3.9	52
34	Kurvnthruli	5.1	51	10	ND	14	2	1.0	8
35	Punnapra Near Milk Plant	7.2	380	14	1.3	210	14	10.5	66
36	KWA Chandanakavu PH	7.2	1275	240	1.15	58	24	12.2	110
37	KWA Chathanad PH	7.3	887	116	ND	228	20	14.6	110

All parameters are expressed in mg/l except pH and EC. EC is expressed in µmhos/cm.
EC- Electric Conductivity; Cl - Chloride; F - Fluoride; HCO_3 - bicarbonate; Ca - Calcium; Mg - Magnesium; TH - Total Hardness; ND : Not Detected; PH - Pump House

Source : Primary data collected by CWRDM

Table 5.1.3.2

Seasonal Variation in Fluoride Concentrations

Name of Sampling Station	Fluoride Concentration, (mg/L)	
	July 1995	March 1996
Alappuzha – Convent	1.00	1.20
Alappuzha – Vellakinar	1.01	1.40
Alappuzha – Alisserry	1.09	1.50
Alappuzha – Chudukad-I	1.13	1.90
Alappuzha – Chudukad-II	1.14	1.90
Alappuzha – Chudukad-III	-	1.80
Alappuzha – Thookkalam	1.02	1.90
Alappuzha – Pazhavangadi	1.08	1.40
Alappuzha – Vazhicherry	1.14	1.30
Alappuzha – Chandanakavu	1.15	2.60

Source : Secondary data collected by CWRDM

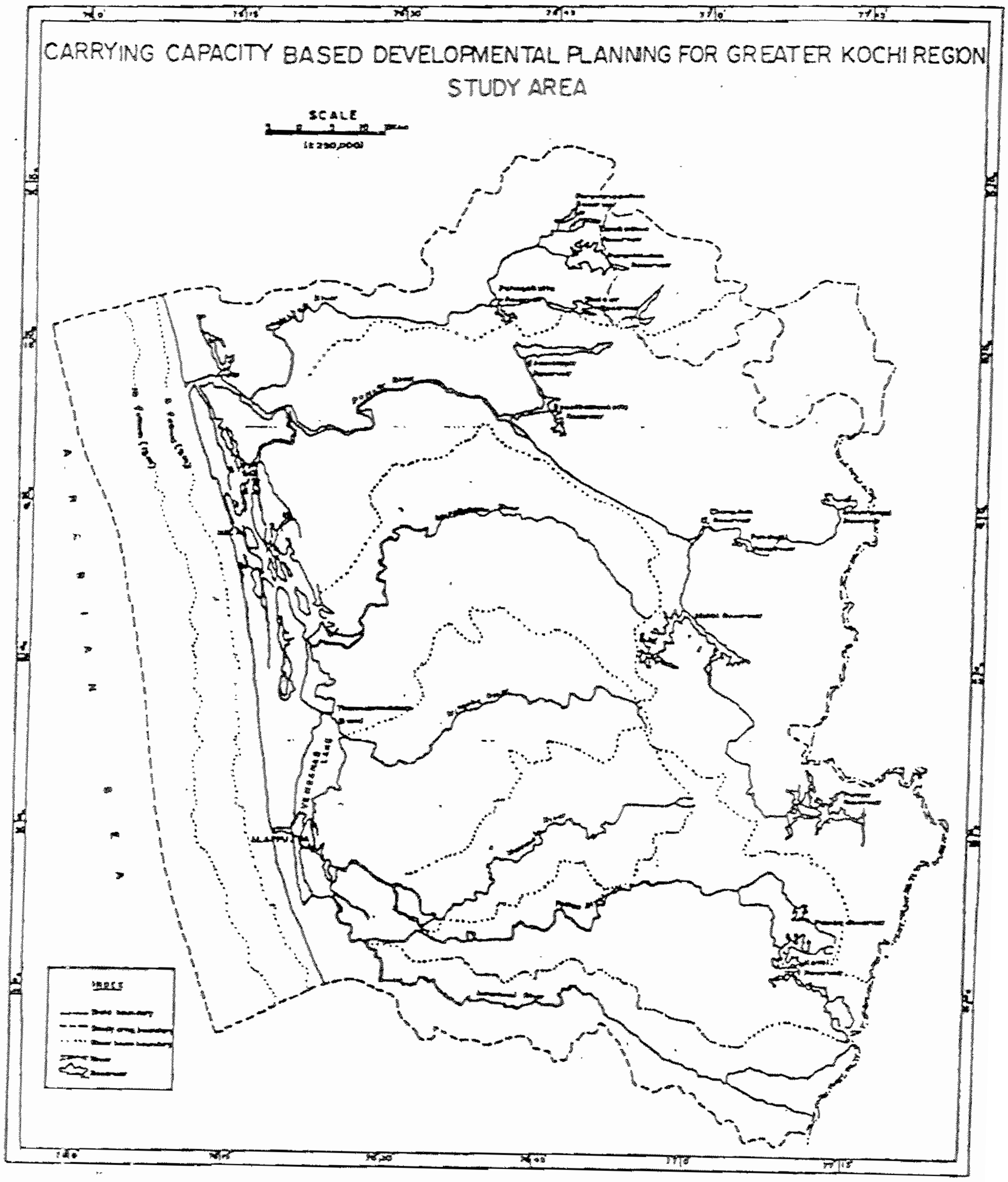

Fig. 5.1.3.1: Water Quality of Coastal Waters – No Hot Spots

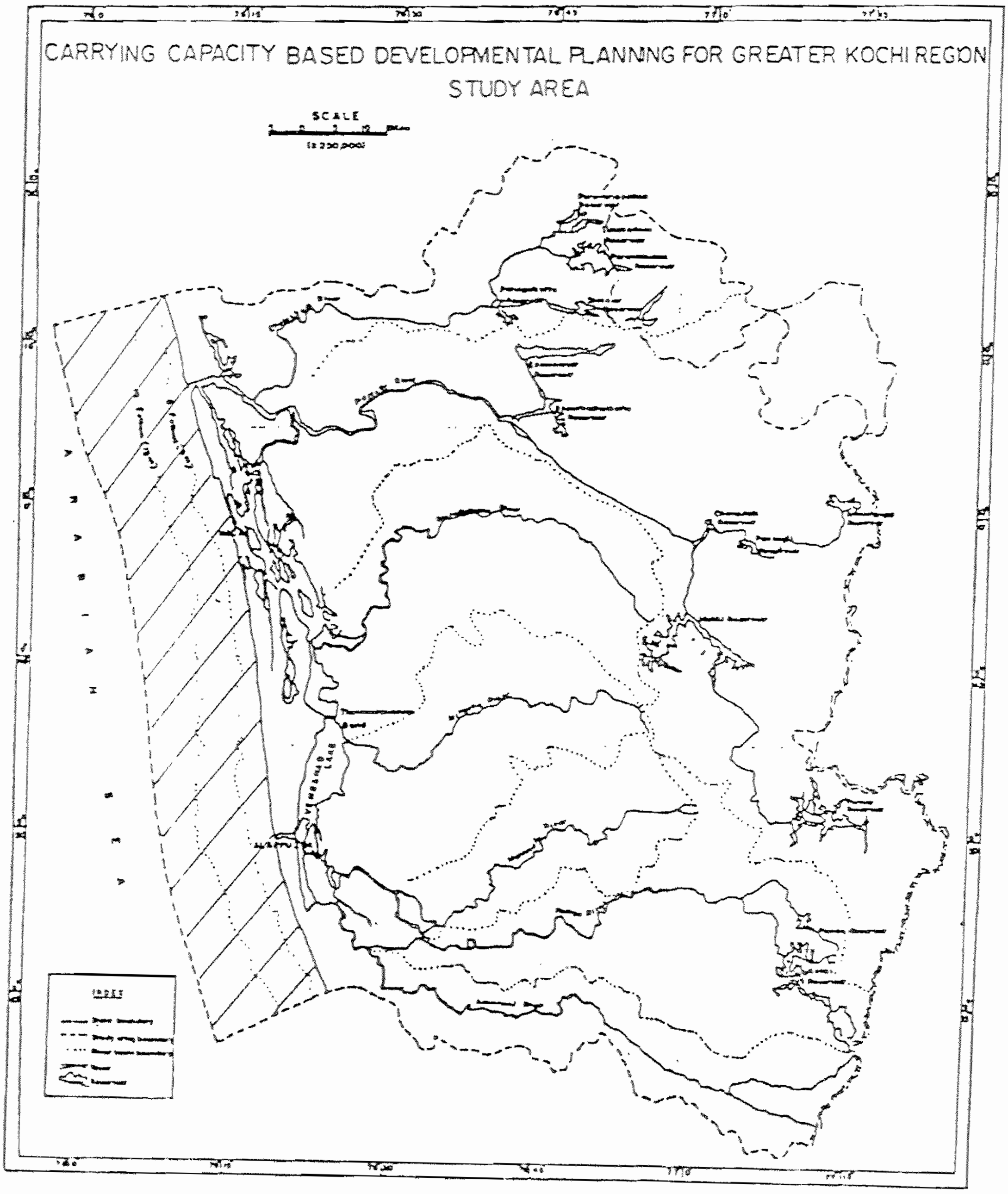

Fig. 5.1.3.2 : Biological Environment of Coastal Waters-Hot Spots

5.1.4 Land Environment

5.1.4.1. Mining : Hotspots & Concerns

The mining operations leave behind unsightly scars of unusable land by excavation and dumping of wastes with no attempt to reclaim and rehabilitate the land As far as the study area is concerned, all the mining areas for extraction of minerals such as shell limestone, tile and brick clays, silica sands and river sand are environmental hotspots.

Shell limestone Mining

Dredging for white shell is most likely to adversely affect the ecology of the lake, at least locally, because of various physico-chemical changes that are taking place as a result of mining operation. The important environmental parameters include, dissolved oxygen, total suspended matter, bottom topography, primary productivity, etc. in the water body.

Tile and Brick Clays

Indiscriminate mining of flood plain clays from Chalakkudy, Periyar, Muvattupuzha, Meenachil and Pamba basins for meeting the raw materials of the numerous brick kilns and tile factories is posing severe socio-economic and environmental problems in GKR. The excessive removal of clays either creates vast areas of fallow lands, unsuitable for any agricultural activity due to the loss of soil cover or extensive waterlogged areas.

Brick industry in GKR is mostly in the unorganized sector except a few factories making wire cut bricks. Most of the requirements of building industry are met from country bricks, which in turn have no quality control either of the raw material, or of the products. Mining of clays several meters below the prescribed levels, pumping out of water from the pits for further mining etc. induce lowering of water table and water shortage problems near the mining areas. The revenue from clay mining is meager, at the same time; the additional expenditure incurred to meet the fresh water requirements of the people living in areas adjacent to mining sites is increasing every year. Illicit clay mining and related socio-environmental problems are the major critical issues. Over 7000 laborers are engaged in the mining sector. Numerous tile and brick-manufacturing units are under private sector in areas, generally closer to the mining sites.

Silica sands

Silica sand mining is one of the easiest being practiced. The sand occurs as sand dunes, rising to a height of 3 to 8 m above the ground level. These loose sands are directly loaded into vehicles without much effort. Because of urbanization, increased settlements and raising of coconut gardens, paddy cultivation, etc., these dunes have become obliterated at many places, leaving the options of mining limited to certain places only. Because of the type of mining and occurrence of silica sands, hardly any environmental problems are noticed, which warrant any management plan. In fact, local people prefer removal of sands because of its infertility. It's removal, on the other hand, makes the underlying clay/sandy clay horizons exposed, which respond easily to agricultural practices, if properly treated.

River sand

Major problems and environmental concerns identified due to sand mining are:

- Excessive sand mining beyond sustainable yield
- Lowering of water table on either side of river channels
- Lowering of river beds
- River bank slumping due to indiscriminate mining
- River water pollution
- Change in river ecosystem characteristics

There are conflicting demands and interests at play in river sand mining working at cross purposes such as:

Demand for the Resource : With the ever increasing construction activities, the demand for the resource has been steadily increasing in Kerala as well as in neighboring states.

Environmental Issues : The environmental issues involved in the exploitation of river sands are many. However, implementation of stringent measures to control the same for environmental management, will lead to serious resource crunch.

Social Factors : On an average, a sizeable number (over 10,000) of laborers are directly or indirectly involved in river sand mining in GKR. The recommended figure of extraction (for the period 1999 - 2000) from these river basins is roughly 50% less than the existing mining rate, which would mean loss of employment opportunities under this sector by half or even more. This will create a serious socio-political problem.

Revenue from Sand Mining : Presently, sand mining is solely under the jurisdiction of the Village Panchayat, who lease out sand mining locations - known as *Kadavus* (in local vernacular) by auctioning. Many panchayats earn sizeable income through sand auctioning every year, even to the tune of Rs. one crore (in Koovappady Panchayat, adjoining the Periyar river). The bordering panchayats of these river basins, therefore, are/will be hard hit, economically leading to the conflicts of interests and demands.

5.1.4.2. Erosion

Two types of erosions, coastal and soil erosion occur in the area.

Coastal Erosion

About 2/3 of the shoreline of the GKR with a total length of 146 km form part of a very narrow strip of land (having an average width of 3 km), lying between the Vembanad estuary, on the east, and the Lakshadweep Sea on the west. Besides, it is one of the most densely populated coastal tracts of Kerala with an average density of population of 2642 per km^2.

An assessment of the erosional and accretional trends in the GKR coast indicates that the erosion/accretion in coast has been restricted to certain pockets. High eroding coast has been identified at Perinjanam, Mathilakam and Kulamattom, which are protected, with sea walls. The locations where moderate erosion is observed are at Kadappuram, Thrikkunnappuzha & Alappuzha. The nature of the coast and its geographical location in the GKR is given in **Table 5.1.4.1**.

Because of high density of population and narrow physiographic settings between the estuary and the sea, it became inevitable to have the main segments of the shore protected against erosion. The construction of seawalls in Kerala, started as an emergency measure to protect the thickly populated areas and highways, however, in due course of time it has been extended to all possible areas. As of today, about 68% of the total of 146 km, of the GKR coastal stretch is protected by sea walls (**Fig. 5.1.4.1**).

The longest stretch of seawall is between Munambam and Kadapuram (54 km) with intermittent gaps (average width of 150 m), at Kochi, Pallippuram, Nayarambalam, Elamkunnapuzha, Kumbalangi, and Chellanam, serving as boat/fish landing centres. The sea bordering Alappuzha Municipality is protected by a 3 km sea wall and further in south direction, a continuous stretch of 20 km of sea wall is seen extending from Ambalapuzha to Kallikkadthura. The stretch of beach near north of Alappuzha is unprotected, experiencing moderate erosion (**Fig. 5.1.4.2**).

Management Plans

During the eighth five-year plan period a budgetary provision was made under the head 'Anti Sea Erosion' for the construction and reformation of sea walls. Out of the above, till the end of 1996 about 347 km of new sea wall has been reportedly constructed. The ninth five-year plan document has envisaged a totally different coastal protection strategy, for Integrating, Engineering, Eco-restoration, Regulatory and management measures. Under the aegis of coastal zone management, an outlay of 50 crores has been provided under the CZM programme, for the protection of seacoast of Kerala. No separate allocation has been made for the GKR coast.

The task force on Forest and Wild Life constituted by the state Planning board in its report 1997 has recommended mangrove afforestation in Kerala's Coastline for protection from sea erosion. However, it may not be possible to grow mangroves along the Kerala coast where the beach material is predominantly constitutes uni-model sand grains. Mangroves can be grown only in place where the substratum is sandy/silty clay. Therefore, the following short and long term strategy for the sea erosion problem of GKR is recommended:

- The beaches along the Perinjanam, Mathilakam and Kulamattom are high eroding and are protected by the sea walls. This being vulnerable zones from the erosion point of view, immediate maintenance of the existing sea walls is called for.
- A 4 km coastal stretch north of Alappuzha is considered as a 'hot spot'. Since the same is not protected by sea wall and at the same time moderately eroding on account of the 'end effect' of the sea walls on either side, this stretch needs to be protected immediately by ~~cons~~tructing a sea wall.

Soil Erosion

The midland and highland regions of GKR together constitute 85.9 % of the total area. Considering the highly undulating nature of the terrain, this region is highly prone to erosion. It is estimated that about 3,285.3 km^2 area of GKR is prone to erosion. Out of these, the areas adjoining the fault scarp zone are subjected to critical erosion, which comes to about 2500 ha. The vulnerability to erosion gets increased as a result of mono-cultural practice in agriculture. The critically erosion prone areas are shown in **Fig. 5.1.4.3**, alongwith the land suitability, which indicates that even the land suitable for forestry, grazing and wildlife are beset with the problem of severe erosion, accounting to about 33% area of GKR. For this, immediate soil conservation measures have to be provided in such areas, which will include:

- Gully plugging
- Terracing of steep sided slopes
- Stopping tilling/ploughing practice in the steep slopes
- Planting tree crops along the steep slopes and
- Construction of small check dams across the streams

5.1.4.3 Land Slides

In general, people and the Government are aware of landslide hazard prone zones through past incidences and experiences. However, more often than not, landslides strike a place all of a sudden, during monsoon and this unpredictable nature makes the incidence catastrophic.

It is well known that the management of landslides largely lies in landuse measures to be adopted, management of surface and ground water drainage, public awareness and a host of other factors. Complexity and inter-relationship of these make it too complex to comprehend to make a meaningful and workable management package. In order to overcome the problems due to landslides, following management measures are suggested:

- Total avoidance of settlement in the hazard zone should be made mandatory.
- In highly unstable zones, it is preferable to avoid permanent settlement of any kind. However, construction of houses, if necessary, should be restricted to such locations identified as safe through a proper and very detailed terrain evaluation so that such spots are away from the path of possible slides.
- Site selection for settlements should be made with caution even in moderately safe zones especially in plateau edge regions. If an unstable zone prevails in the upper slopes, it may induce a slide with its impact felt even at the lower valley portions, which are categorised as stable.
- Diversion of stream channels (first, second and third order) in upper slopes, especially above settlements, is to be strictly disallowed.
- Areas covered by degraded natural vegetation in upper slopes shows maximum incidence of slides. In many instances, these areas form the source points or head region of slides. Such areas are to be afforested with suitable species. Stringent protection measures to prevent further forest degradation are to be initiated besides engineering afforestation.
- In high slope areas ($>16^0$), it is better to avoid seasonal cultivation involving intense tilling practices.
- Seasonal cultivation within coffee plantations is to be adopted only in stable locations because such cultivation in high slope areas make them vulnerable for initiation of slides within plantations.
- The existing patches of natural vegetation (forest and natural grassland) in good condition should be meticulously preserved. Care should be taken not to allow fragmentation of such pockets by way of encroachments, plantations, roads etc.
- Any developmental activity initiated in the region should be taken up only after carrying out detailed terrain evaluation with adequate plans for slope protection.
- Socio-economic survey indicates that in the most severely affected upper catchments of Meenachil and Manimala rivers, the local settlers possess only about 30% of the land while the balance is possessed by large estate owners and the Government (Revenue and Forest land). A concerted effort from the Government and large-scale estate owners can improve the situation considerably without much financial burden on the settlers.
- Wherever possible, lateral horizontal subsurface drains filled with gravel or sand may be provided between bunds / terraces to drain out water from the soil in order to eliminate building up of pore pressure within the overburden. In steep slopes, instead of cutting and erecting contour bunds, establishment of grass barriers (like Votive grass) may be an alternative and a cheap method of controlling soil erosion.
- The unstable zone often falls in the upper slopes occupied by highly degraded vegetation. These areas warrant immediate afforestation with suitable plant species. The first step is to identify the ownership of these

lands so that proper responsibility could be assigned for their development. Most of the slides in the area have source points on the upper slopes with degraded natural vegetation. The afforestation programme is to be properly planned so that little slope modification is done in the process. Bunding of any sort using boulders is to be avoided. The afforestation programme involves selection of suitable plant species, which can withstand the existing stress conditions.

- In general, the chief mitigatory measures to be adopted for the area are: (i) drainage correction (ii) proper landuse measures (iii) reforestation of areas occupied by degraded vegetation.

5.1.4.4 Solid Waste disposal

Population growth and pace of urbanization pose additional environmental challenges to Urban Local Bodies (ULBs) in our country. A major chunk of the solid waste generated remains unattended causing health hazards and /or nuisance to inhabitants. The uncontrolled fermentation and decay of garbage offer habitat for prolific growth of harmful bacteria. Insects and rodents multiply at alarming rates and often act as passive vectors of infectious diseases.
The major concerns are:

- Foul odor
- Rodents and insect menaces
- Contamination of surface and ground water
- Incidences of water borne and vector borne diseases
- Skin diseases to sweepers and other laborers engaged in cleaning.

Solid Waste Management (SWM) is one of the major obligatory functions of ULBs. The service is far short of desired levels in all the municipal towns and the Kochi Corporation area of GKR. Lack of designated waste disposal sites, inadequate collection and disposal systems etc. cause problems to health, sanitation and environmental degradation. Lack of financial resources, institutional weaknesses, improper choice of technologies and public apathy towards SWM has made this service far from satisfactory. In majority of cases, uncontrolled dumping of wastes at the nearest available low-lying sites is being practiced, resulting in nuisance and health risks to residents. This also has potential for surface and ground water pollution through leachates.

Analysis of the secondary data collected from various municipalities / corporation offices as well as the primary data collected from field surveys reveal that the existing solid waste management practices of GKR are quite inadequate. Insanitary conditions prevail in Kayamkulam, Mavelikkara, Pathanamthitta, Chengannur, Thiruvalla, Alappuzha, Cherthala, Angamali, Muvattupuzha, Perumbavur, Thripunithura, Aluva municipalities and Kochi Corporation and hence are identified as hot spots (**Fig. 5.1.4.4**). The problem is quite dismal in the Kochi Corporation area.

Management Plans

In view of the above, the following **short term** management plans are suggested for all municipalities / corporations of GKR:

- Acquire suitable, additional waste disposal sites within economic haul distance
- Upgrade the infrastructural facilities of collection, transportation and disposal of solid wastes
- Necessary steps are to be taken to minimize solid waste production of the area
- The designated solid waste disposal sites should be suitably engineered and lined using impervious stratum to prevent pollution of ground and surface waters due to leachates.

Further, following solid waste management plans are suggested for **long term** application :

Waste Minimization at Source through Separation and Recycle

- The solid wastes generated should be separated at source and the inert materials / residues left after separation should be disposed off as landfill.
- The recyclable components should be separated and recycled.

Upgradation of Collection, Transportation and Processing Facilities

- Adequate number of properly designated community bins and sweeping equipments should be provided in all the municipalities and other waste generating centres of GKR.
- Adequate number of vehicles should be provided to enhance the transportation capacity to the required level.
- Processing should be done to reduce pollution threats from municipal solid wastes.

Pollution Attenuation at Disposal Site

- The existing waste disposal methods such as open dumps and land fills are to be avoided.
- Sanitary land fill is also not suitable in GKR because of the following reasons :

  – lack of sufficient land for sanitary land fill

  – High density of population, open wells, settlements etc.

  – Many of the municipalities/corporation areas are located on low land region where the water table is very close to land surface. The water table level comes above the surface especially during monsoon season, which may contaminate the ground and surface water regimes of the area.

Recommended Waste disposal method of GKR

The high moisture content, low calorific value and substantially high contents of N, P and K of solid waste samples indicate that the wastes are suitable for composting to organic manure. Therefore, mechanical or semi-mechanical composting of vegetative factions, after separating recyclable fractions, is suggested for GKR. The inert, non-biodegradable residues and left after composting can be used as land fills. Creation of awareness among farmers / concerned authorities to use organic manure for agriculture plantations, or even in forestry is equally important for getting better results of this recommended measure.

5.1.4.5. Salinization

Hydromorphic Saline

Continuously and partially submerged soils found in the coastal tracts of Ernakulam, Alappuzha and Thrissur districts under the influence of tidal action and seawater inundation are included in this category. The network of backwaters and estuaries bordering the coast serve as inlets for tidal flow. Wide variations in salinity are observed. The soil is acidic and salinity is due to intrusion of seawater. During the monsoon season, the fields are flooded with rainwater and the salt is leached out. The electrical conductivity of saline soil ranges from 0.1-2.0 mmhos/cm during this saline period. Accumulation of toxic salts occurs in summer months when electrical conductivity goes as high as 10-15 mmhos/cm. The soil texture varies from loamy to clayey. The soils are imperfectly drained. Rice (salt resistant varieties) is the main crop.

As such, one way of preventing the tidal excursion to construct bunds at critical places such that major agricultural areas are protected from getting inundated by salinity, or else, flush the soil with fresh water during summer season at regular intervals such that the salt is leached out.

Acid saline

Acid saline soils comprise of the Kuttanad region, which is a unique agricultural area in the world. The low-lying areas in the vicinity of Vembanad Lake, the estuaries of the rivers-Pamba, Manimala, Meenachil and Muvattupuzha are also included in this group. These lands are subjected to ingress of seawater during summer months resulting in serious problems of floods, salinity and acidity to the local people.

Kari soils are deep black in colour due to high organic matter content and hence the name. They are heavy textured, poorly drained soils distributed in flat areas lying 1-2 m below sea level. The soils are very acidic (pH 3-4) under dry conditions but acidity decreases with continuous submergence. During June-

November for about six months, the soils are continuously submerged in rainwater. The soil acidity is mainly due to the oxidation of sulphur compounds derived from organic sources and also marine deposits.

During summer months, the water table is 1.0-1.5 m below ground level. Rice is the main crop but crop failure due to the peculiar hydrological situation and acidity are common. Coconut is grown on bunds around paddy lands.

The *Karapadom* soils occur in the upper Kuttanad region. They are found along the inland waterways and rivers of the area. This covers 1014 padasekharoms in Alappuzha and Kottayam districts. They have mostly river-borne alluvial soils. Soils are vey deep, poorly drained, dark gray in colour with clay loam surface texture followed by silty-clay subsoil. The subsoil shows the presence of abundant, predominant red and yellow mottles, grey horizons, streaks and concretions. Presence of sand pockets in the subsurface horizon is an important feature. High acidity, high salt content and fair amount of organic matter characterize soils. They are generally poor in available nutrients, particularly in P and K. They are highly deficient in lime and trace elements like Zn and Cu.

The entire area is planted with the rice during the *Punja* season. In some areas, an additional crop of paddy is taken during April-September. Garden lands seen as patches in between are used for raising coconut and various annual and seasonal crops like banana and vegetables.

The *Kayal* lands are the reclaimed beds of Vembanad and Kayamkulam Lakes in Kottayam and Alappuzha districts. It covers 8000 ha area and constitutes about 14% of the Kuttanand area. In this region soils are very deep, poorly drained and have dark brown alluvial deposits having silty loam to silty clay loam surface texture. The sub soils show the presence of lime shells. The clay content generally decreases with depth. These soils are slightly acidic to neutral, medium in organic matter and poor in total and available nutrients, but fairly rich in Ca. The fields are submerged 1.5-2 m below sea level for 5-6 months in a year. These soils are more severely affected by salinity than other Kuttanad soil types. Crop failure is common. Seawater intrusion has been prevented to a certain extent by the construction of a permanent bund between vechoor in Vaikom and Thanneermukkam in Cherthalai taluks, and consequently two crops are being raised in many places. Rice is the main crop, but coconut is also widely grown on bunds.

Reclamation and management of acid sulphate soil in pokkali fields are highly essential by lime addition and repetitive flushing.

5.1.4.6 Urbanization

Even though, the process of urbanization has been increasing throughout the coastal and midland regions of GKR, its impact has been most strongly felt in and around Kochi Corporation urban centre. The more important concerns over the development in land environment have been the following:

- Habitat destruction
- Extensive areas of wetlands, including Vembanad estuary (part), mangrove ecosystem, paddy fields, etc have been either totally destroyed or drastically modified
- Solid waste disposal
- Increase in built-up area (Kochi-Aluva stretch, being a highly industrialized belt, is one of the most fastly growing industrial belts of the country and is becoming most crowded city in Kerala)
- Blockage of drainage (the built-up features have already blocked the natural drainage at many places of Kochi, creating flash floods and pools of highly polluted water, which are breeding grounds of mosquitoes and therefore of health hazards)

Management Plans

- Complete restoration of the habitats lost as a result of urbanization is not possible. Many of the changes that had happened are irreversible. However, a partial restoration of mangrove eco-system is possible around Vembanad estuary north of Thanneermukkam Bund. For this, suitable areas have already been identified for afforestation, which may be taken up by the State Department of Forest on priority

In order to improve the natural drainage conditions, at least some of the old canals, which have been closed as a result of built-up area expansion, should be opened and properly maintained. This will equally apply even for letting out the floodwater from the Vembanad estuary which otherwise would inundate the low-lying coastal stretch west of Vemabanad lake and adjoining areas.

5.1.4.7 Flood proneness due to reclamation

The Thanneermukkam Regulator divided the Vembanad estuary (lake) into an almost fresh water tract on the southern side and a saline tract at its north. This has drastically changed the ecology of the pre-Thanneermukkam Regulator part of the Vembanad Lake. Flood prone areas in GKR are shown in **Fig. 5.1.4.5**.

Most of the important studies made on environmental concerns, development potentials and problems have already been cited before. Out of these, undoubtedly, the most important study is the one made by the Indo-Dutch Mission (1989). Some of the most important management perspectives and alternatives put forward by the Mission for the overall development and environmental management of Kuttanad are briefly described below:

Firstly, it suggested that opening of Thanneermukkam regulator for a limited period of time, from December to March, as insisted upon during the construction stage of the regulator. This would improve the quality of water in the southern tract of the regulator of Vembanad Lake and the adjoining region. This would control waterweeds as well to a certain extent.

Secondly, another option was to keep the regulator closed and increases the flow of fresh water by diverting water from Muvattupuzha River, which receives the tailrace water from Idukki dam. This would improve the quality of water and solve, to some extent, the drinking water problem. However, it might not solve the problem of waterweeds, estuarine productivity, etc.

Thirdly, option is to open the regulator permanently. At the same time, construction of a dyke parallel to the eastern bank of the lake from Muvattupuzha to Kuttanad and diversion of the fresh water from Muvattupuzha to Kuttanad is recommended. It was pointed out that this would improve the agriculture and fisheries sectors, considerably. Besides, it would also improve the quality of water in and around Kuttanad. The increased draining of water would allow flushing of pollutants from the stagnated water bodies. Other attendant benefits have also been highlighted.

5.1.4.8 Degraded Forest

About 746 km^2 of degraded forest exists in GKR in the districts of Kollam, Pathanamthitta, Kottayam, Idukki, Ernakulam, Thrissur and Palakkad. Area-wise details of each district are given in **Table 5.1.4.2**.

The National forest policy states that one third of the country should be under forest cover. Although GKR as a whole satisfies the same, Kottayam and Ernakulam districts have only very low coverage of forests. In the circumstances, to start with, the degraded forest areas of these two districts should immediately be brought under reforestation/afforestation followed by the degraded forest areas of other districts.

5.1.4.9 Seismic Activities

The earthquakes in Kerala, are, probably, spatially related to certain major shear/fault zones and lineaments. While some of them are studied, many of them remain to be explored and examined. Such studies will help, in the long run, to generate a map of faults in the State, and as more data is gathered these faults can be classified in terms of their potential to generate earthquakes. Although such studies will not facilitate short-term predictions, they will be useful in the long-term planning of earthquake management.

It has been noted that earthquakes, although moderate, have caused some damages to modern, RCC structures. Since Kerala falls in Zone III of the seismic zone map, where earthquake intensities up to VII can be expected, it is necessary to use appropriate building codes, which are developed by the Indian Standards Institution for all types of buildings, structures, roads, power lines, canals, etc. The Government may take necessary steps to enforce these codes strictly as a precautionary measure.

The portable stations available in the State (with CESS and others) have to be kept always in working condition in order to do follow up studies whenever micro-tremors occur in the State. The broadband unit established at Peechi and operated by CESS is to be maintained on a long-term basis.

5.1.4.10 General Recommendations in Hazard Management Awareness

This is a key element for launching disaster reduction measures at local and State levels, which will depend not only on the nature and degree of natural hazards and the vulnerability of the communities at risk, but also on the cost-benefit ratio of pre-disaster interventions as compared with post-disaster measures. In order to achieve the above, all relevant information pertaining to disaster intervention and post-disaster relief measures on reported occurrences are to be inventoried and made available to the planners and policy makers. The effective understanding of the benefits of intervention can definitely prompt formulation of proper policy framework for the implementation of various functions needed for disaster mitigation.

One of the problems most commonly encountered in this is the inadequacy or even absence of communication between scientists/engineers, on the one hand, and planners and civil authorities, on the other. Very few scientists/engineers take the trouble to understand the nature of problems faced by planners and administrators or venture to take decisions they are obliged to. Scientists normally express hazards and their vulnerably in terms of probabilities, which are difficult to be translated into 'Yes' or 'No' decision by public authorities. There are various technical problems here, and there is an urgent need for a dialogue among professionals in this matter. A constant interaction among professionals is important in awareness creation. This aspect has to be taken into account by the management institutions in the State, who are organizing training programs for various personnel.

Education, awareness creation and dissemination of information

In the past, natural hazards were considered as an expression of nature's anger, accepted with fatalism and reaction expressed only in the form of relief, help and rehabilitation. However, with the advancement of science and technology, it is now accepted that even though it is not possible to totally check some of the hazards, it is certainly possible to minimize the impact of a disaster. Now natural disaster management is not conceived as an effort to mitigate some hypothetical, localized and infrequent events but as a long term planning process to sustain economic development and to improve the living standards of people affected. In this context, it is the community, which responds first before any other agency. The accumulated experience of a community and the resistance built by it are the valuable assets in the effective management of a disastrous situation. Local community will have to be exposed to public awareness programs to develop adequate skills to combat a hazard. The education/awareness will also clear their misapprehensions and myths regarding a hazard.

The essence of a successful disaster management is in developing a plan that can be implemented by an informed and alert populace. Even in the policy formulation, those who face the risk must have a role in its evolution. Inclusion of the needs of vulnerable sections, like fisher folds in erosion prone areas should be made mandatory. It is high time that disaster preparedness is included in the academic curricula, too.

Local self-governments and NGOs are appropriate agencies who can reach out to grassroots level and mobilize community efforts. The regional technical guidance for such awareness programs could be availed from academic/scientific institutions. As a governmental agency, Department of Rural Development, with its field level functionaries spread out in all gram panchayats, have a tradition of working with community and can play a meaningful role in awareness building and community mobilization. The possibilities opened by the Information Technology application have to be fully utilized for the purpose. Electronic media, in addition to the print media, can effectively spread the message to the population. The awareness programme should be able to impart education to the public on causes, vulnerable zones, impacts, preparedness, possible early inventions procedures, long-term planning requirements, latest technologies available etc. to the community.

Media has an important role to play not only at times of disaster, but also before and after their occurrence. The first duty is objective reporting and public education.

Over emphasizing, dramatizing and high sensitizing in reporting will spread panic among people, which shall be avoided. In essence, a multi-sectoral approach involving government, local bodies, people's science movements, academicians, media and affected communities is perhaps what is needed.

Transfer of appropriate technology to implanting agencies

The responsibility of developing appropriate technology for mitigation resis with academic/scientific/engineering institutions. These tools are to be made available to various agencies actually involved in the implementation of mitigative measures. An appropriate state level-coordinating agency should develop a centralized facility for the diffusion of information and technologies gathered/developed by various agencies. In this respect, information technology can play a vital role. The information available from scientific / academic / engineering agencies should be pooled together at the proposed central facility, which should be accessible through IT network to any implementing agency on all new developments and technologies available at national and international levels. The Department of Science and Technology in collaboration with the IT Department of Government of Kerala can initiate action for such a facility in Kerala.

Research and Development on New Technologies and Policies

This includes the process of developing new knowledge base by original research and binding new applications. The ongoing process of original research on the subject must continue. But, a great deal remains to be done. Remote sensing and GIS applications have enormous potential in hazard management. It is essential that the implementing agencies set apart provision for research and development in these areas.

Table 5.1.4.1

Intensity of Sea Erosion and Coastal Protection

Sr. No.	Location	Latitude/Longitude	Status	Protection Measures
1	Thrikkunnappuzha	9°17'05" N 76°23'45" E	Moderate erosion	Sea wall extends upto 2 km
2	Ambalappuzha	09°22'22" N 76°21'20" E	Moderate erosion	Seawall upto 20 km
3	Alappuzha	9°29'58" N 76°09'00" E	Moderate erosion	Seawall extends to 3 km.
4	Kadappuram	09°43'28" N 76°17'14" E	Moderate erosion	Seawall
5	Puthuvaippu	09°59'23" N 76°13'10" E	High accretion	Two sets of seawalls
6	Nayarambalam	10°03'58" N 76°11'35" E	Moderate accretion	No seawall
7	Munambam	10°10'25" N 76°10'12" E	Moderate accretion	Protected by seawall
8	Mathilakam	10°11'59" N 76°08'08" E	High erosion	Protected by seawall
9	Kulamattom	10°13'34" N 76°08'56" E	High erosion	Protected by seawall
10	Perinjanam	10°19'01" N 76°07'32" E	High erosion	Protected by seawall

Table 5.1.4.2

District Wise Landuse/ Land-cover Sub-Category Area for the Period 1968-1972

Sr. No.	Landuse/Land-cover	Palakkad		Thrissur		Ernakulam		Idukki	
		Area	% of Area	Area	% of Area	Area	% of Area	Area	% of Area
1.0	**Agricultural land**								
1.1	Paddy	9.78	2.03	218.96	22.98	505.03	20.98	53.80	1.29
1.2	Coconut	0.00	0.00	0.56	0.06	0.00	0.00	0.00	0.00
1.3	Mixed crops/trees	3.98	0.83	258.33	27.12	1058.68	43.97	256.89	6.17
2.0	**Agricultural plantation**								
2.1	Rubber	16.28	3.38	2.14	0.22	295.88	12.29	30.44	0.73
2.3	Tea	0.11	0.02	0.00	0.00	60.29	2.50	199.27	4.79
2.4	Coffee	8.77	1.82	0.35	0.04	0.00	0.00	0.62	0.01
2.4	Cardamom	36.28	7.53	0.00	0.00	0.00	0.00	421.91	10.14
3.0	**Forest land**								
3.1	Dense/mixed/open jungle	287.43	59.64	345.71	36.29	181.10	7.52	1900.67	45.68
3.2	Forest plantations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.2.1	Eucalyptus	0.00	0.00	13.01	1.37	24.78	1.03	135.48	3.26
3.2.2	Teak (Forest Department)	92.20	19.13	64.59	6.78	52.95	2.20	32.55	0.78
3.2.3	Teak (Private)	0.00	0.00	0.00	0.00	0.24	0.01	0.00	0.00
3.2.4	Pine	0.00	0.00	0.00	0.00	0.00	0.00	4.36	0.10
3.2.5	Bamboo	0.00	0.00	0.00	0.00	0.00	0.00	13.64	0.33
3.2.6	Others	0.00	0.00	0.00	0.00	1.20	0.05	1.53	0.04
4.0	**Grass land**		0.00	5.96	0.63	5.49	0.23	310.96	7.47

Contd...

Table 5.1.4.2 Contd...

Sr. No.	Landuse/Land-cover	Palakkad		Thrissur		Ernakulam		Idukki	
		Area	**% of Area**	**Area**	**% of Area**	**Area**	**% of Area**	**Area**	**% of Area**
5.0	**Barren land**								
5.1	Beach	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.2	Open Scrub	0.00	0.00	10.57	1.11	52.54	2.18	11.75	0.28
5.3	Rock outcrops	0.00	0.00	0.00	0.00	0.00	0.00	673.06	16.18
6.0	**Built-up area**								
6.1	Dense	0.62	0.13	1.04	0.11	18.83	0.78	2.03	0.05
6.2	Moderate	0.00	0.00	0.00	0.00	0.00	0.00	5.40	0.13
6.3	Sparse	0.00	0.00	0.14	0.01	0.00	0.00	0.00	0.00
7.0	**Water bodies**								
7.1	River/ Stream	5.29	1.10	22.89	2.40	94.20	3.91	34.36	0.83
7.2	Reservoir/Tank/Lake/ Pond	21.19	4.40	8.45	0.89	0.87	0.04	71.81	1.73
7.3	Back water/Kayal	0.00	0.00	0.00	0.00	53.14	2.21	0.00	0.00
8.0	**Marsh/Swampy land**		0.00			2.48	0.10		

Area in km^2

Source : Secondary data collected by CESS

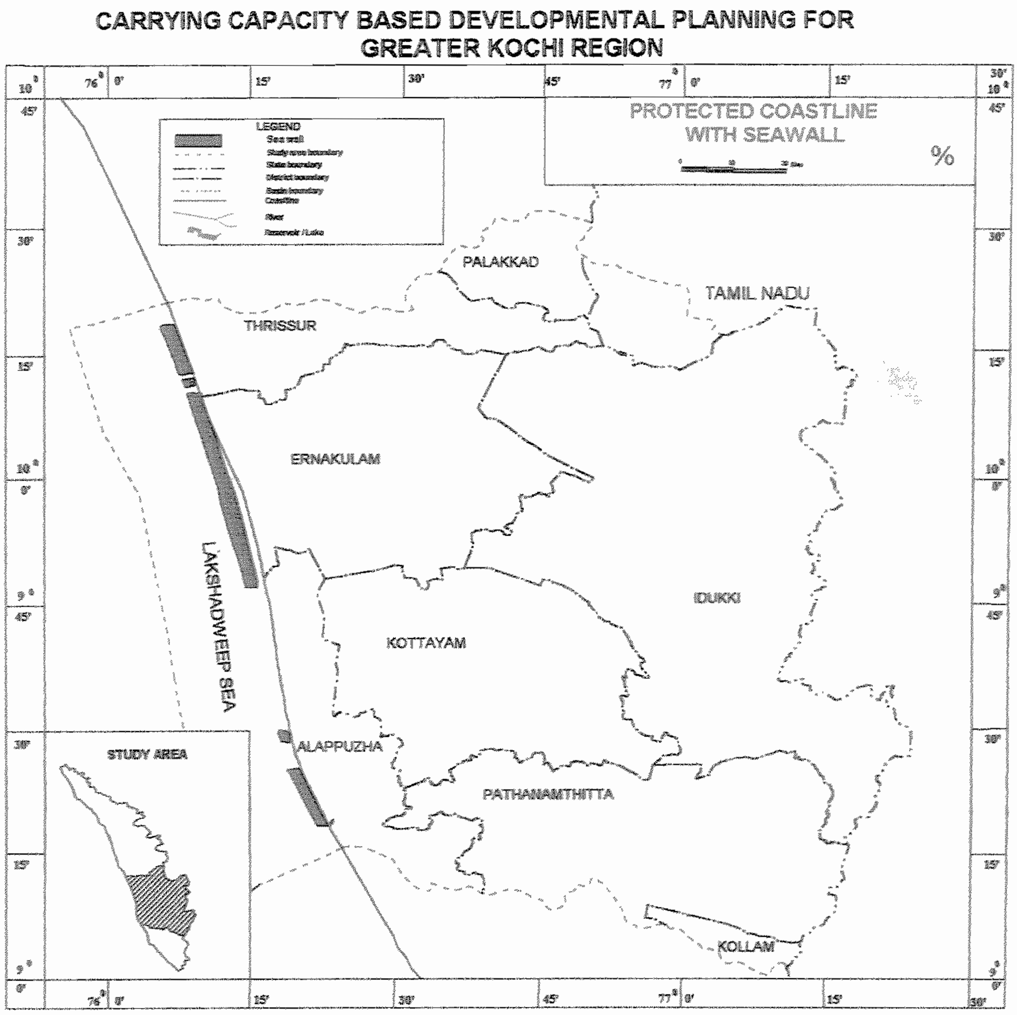

Fig. 5.1.4.1 : Protected Coastline with Seawall in GKR

CARRYING CAPACITY BASED DEVELOPMENTAL PLANNING FOR GREATER KOCHI REGION

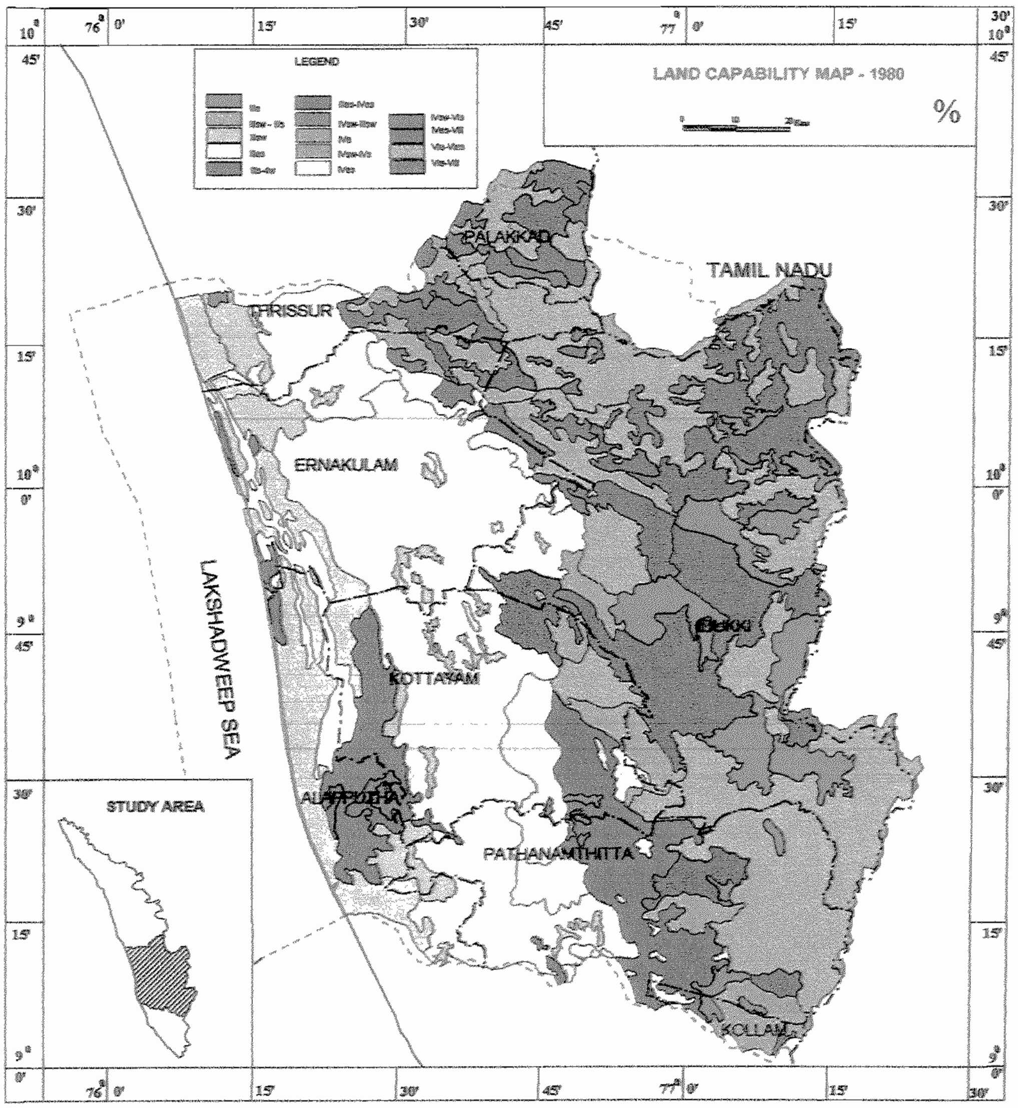

Fig. 5.1.4.3 : Critically Erosion Prone Areas with Land Capability Map of GKR

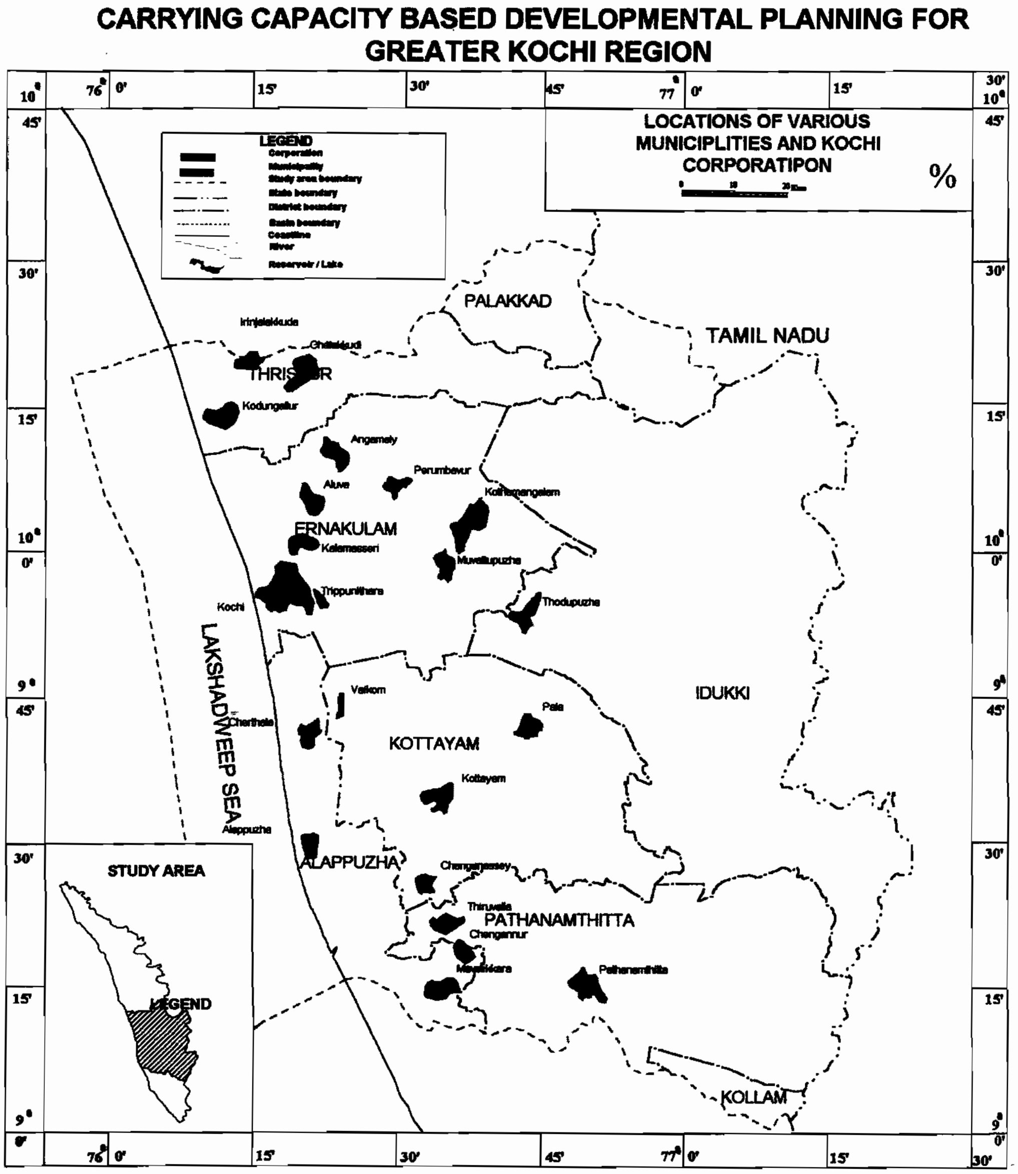

Fig. 5.1.4.4 : Locations of Various Municipalities and Kochi Corporation in GKR

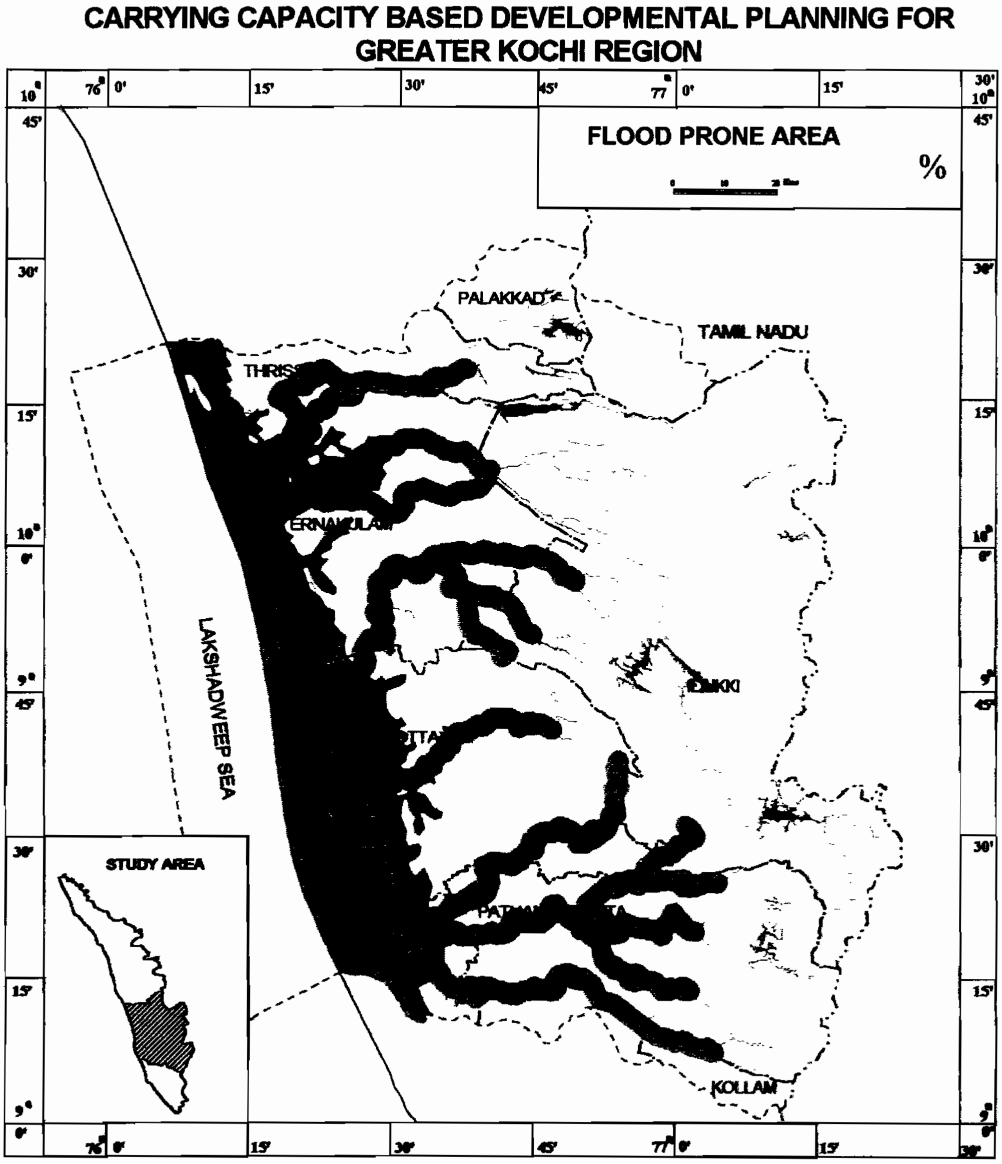

Fig. 5.1.4.5 : Flood Prone Areas in GKR

Fig.2.Hot spots

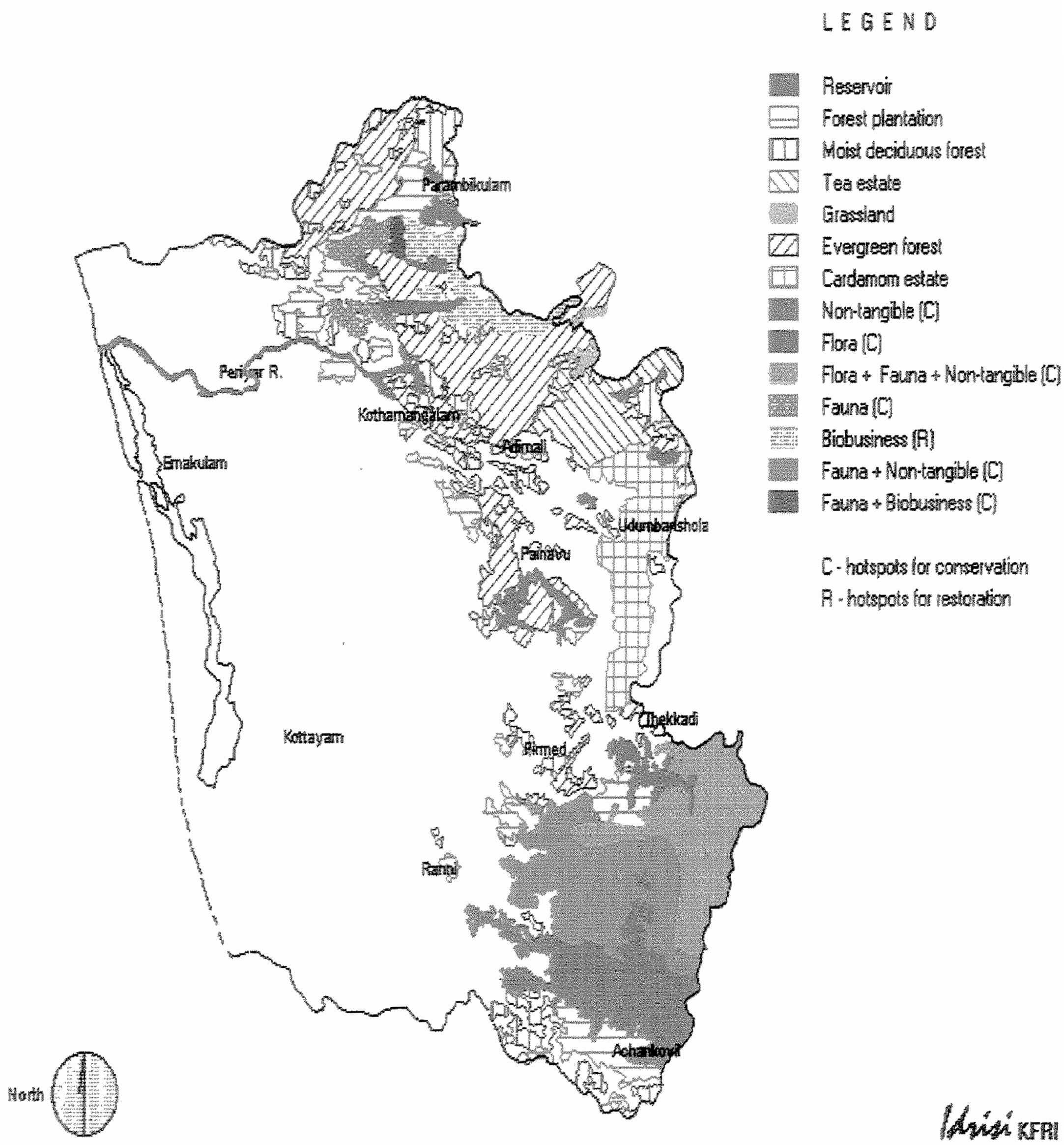

Fig. 5.1.5.1 : Terrestrial Biological Environment Hot spots

5.1.5 Biological Environment

5.1.5.1 Terrestrial Ecosystem / Hotspots

5.1.5.1.1 Flora

Among the floristically rich areas in the region, the areas of high conservation value are identified. Criteria for selection of hotspot for flora are in terms of number of angiosperms recorded from the area, exclusive species i.e., species which are recorded to be present in only one particular area in the region, and number of species under endemic, rare, threatened, vulnerable or endangered categories. Recent publications were used for this purpose **(Table 5.1.5.1)**.

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

5.1.5.1.2. Fauna

Among the faunistically rich areas in the region, attempts were carried out to find out the hot spots of conservation value in terms of habitat preferences of a wider array of larger mammals. Wildlife census of the state conducted by the Kerala Forest Research Institute and Kerala Forest Department in the year 1993 is used for the study. Relative density of sixteen mammals in different areas of the region was estimated **(Table 5.1.5.2)**. The area with high population density of each species is identified and a score is assigned. Hence higher cumulative score assigned for an area will indicate highest density of more number of species in any area. The contiguous forests of Vazhachal and Malayattoor and the forests of PTR and Ranni support high faunal diversity with relatively high density. These areas in the region deserve immediate attention in terms of relatively high habitat preference of highly dense and diverse fauna. This area is considered to be a hot spot of high conservation value.

5.1.5.1.3. Non Tangible benefits

Goods and services provided (value Rs. in crores) in relation to the growing stock, extent of forests and environmental value of dense evergreen forests is estimated **(Table 5.1.5.3)**. Contiguous evergreen forest patches of Ranni and Periyar Tiger Reserve together alone contribute goods and services worth 45% of the total value provided from the study region and hence are a hotspot of high conservation value.

Government of India assigned an environmental value of Rs 126.74 lakhs per hectare over a period of 50 years of fully stocked tropical forests for benefit cost estimates of development projects. The same has been adopted to calculate environmental value of fully stocked dense evergreen forests of each area in the region. The assumed average growing stock of timber under each vegetation type of the State and its average value has been used for this purpose **(Table 5.1.5.3)**.

5.1.5.2 Restorative hotspots

5.1.5.2.1 Tangible benefits

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

Forests in and around Sholayar have provided produce worth 14 lakhs (mean annual average) for the forests dwellers in this area **(Table 5.1.5.4)**. Resin is the item, which provides major portion of the income. Depletion of resources due to over-harvesting is an emerging threat to the resource base. To strike a balance between the maintenance of subsistence for livelihood of the forest dwellers and maintenance of ecosystem integrity is a challenge. Present marketing system is redundant and non enterprising which has affected the livelihood of forest dwellers in the region. Low returns from harvesting these products have persuaded them to forage more to meet subsistence for livelihood. This has also resulted in over-harvesting, early harvesting and destructive harvesting which has affected the resource base leading to forest degradation. Hence this area (forest patches in and around Sholayar) with maximum activity of collection and marketing is considered as a restorative hot spot warranting immediate attention.

Short Term & Long Term Management Plans for Terrestrial Biological Environment

Terrestrial Ecosystem (Conservation & Restoration)

For the conservation and restoration of terrestrial biological environment immediate, short term and long term management plans are delineated for each forest division falling under GKR alongwith the existing status for the forests summarized below:

1. Achencoil Forest Division, Kollam District (Grid 1)

Located in the southern most tip of GKR, these forests form the drainage basin of the headwaters of Achencoil River. Of the total area of 204 km^2, 60% belongs to natural forests and the rest teak plantations. Bulk of the natural forests is under different degrees of degradation. The area is prone to landslides & the watersheds are in a bad state.

Immediate : The forests are ravaged by fire annually. Implementation of fire protection is needed.

Short-Term: Improvement in plantation management, introduction of high yielding clones etc. Augmentation with species of cane may be strengthened. Achencoil forests have been identified as a satellite eco-tourism spot under the Thenmala eco-tourism Projects (TEPS). Eco-tourism activities may be encouraged. Restoration of sub watershed of Kallar and Kanayar on a war footing is needed.

Long Term : Protection and rehabilitation of natural forests – Assisted Natural Regeneration and Regeneration in Degraded Forests. The catchments of the headwaters of Achencoil River may be treated.

2. Konni Forest Division, Pathanamthitta District (Grid 2 & 3)

The Konni Forests Division occupies an area of 190 Km^2 of these 72 Km^2 belongs to teak plantations. Most of the natural forests are degraded.

Immediate: The main loss to the forests is due to fire and timber theft and these need attention.

Short-term: Improvement of productivity of teak plantation by adopting modern silvicultural protection.

Long Term : Rehabilitation of natural forests.

Ranni Forest Division

Ranni forest division of Pathanamthitta district has a forest cover of 794 Km^2 of which 400 Km^2 are under dense evergreen forests. This is the single largest contiguous dense evergreen forest of the study region with dense and diverse flora and fauna. This habitat is of prime concern due to its high conservation value with overlapping zones of floristic, Faunistic and nontangible hotspots. This area also has the potential of providing the largest stock of wood.

The richest habitats are contiguous with Varushanad hills of Tamilnadu. This also has an access to illicit woodcutters, poachers and smugglers of other NWFPs from Tamilnadu. Deaths of 31 elephants and one tiger have occurred due to electrocution from a transmission line passing through the reserve. There are private estates, settlements and agricultural activities within the reserve. 523 acres of Pachakanam estate, 1.5 acres of settlements at Kochupamba, 1.5 ha. at Chenppankuzhy near gurunathanmannu of malampandaram tribals, 400 acres of Kodampupara non tribal settlements with rubber tapioca and plantation, 75 acres of land in Chempanaruvi in Mannarapara range is with the non-tribals at Uliyanad for medicinal plant cultivation. Rubber is also planted in the land. The lease of this land in Naduvathumuzhi Range may be reconsidered. Non-tribals occupy about 2,000 acres of land in Appuppanthodu in Naduvathumuzhi range. 1,500 acres of land is under cultivation by non tribals in Kottampara (Neeramkulam).

Immediate : Strict measures has to be taken to ban or prevent any kind of illegal encroachments or any other activity.

Short-term : Development of forest based eco-tourism potential at Kochunpamba both with in the KFD and KFDC

Long-term: Conservation and protection of habitats, biodiversity and ecosystems.

Periyar Tiger Reserve, Idukki (Grid 4, 6, 7, 8, 9, 11, and 12)

Of the total forest area, natural forests occupy 546 Km^2 and the rest are plantation of eucalyptus under the Grassland Afforestation Scheme. This is the most unique, rich in flora forest chunk in the whole of the Western Ghats and is the only Tiger Reserve in Kerala. This reserve also shares the contiguous dense evergreen forests of the Ranni forest division along with its unique flora and fauna. The Mullaperiyar Reservoir, supplying water to Tamilnadu and the 100-year-old dam are also located here.

Immediate: Maintain the level of the water in Mullaperiyar Reservoir at B6. Any raising of water level will adversely affect the biodiversity of the Reserve, livelihood of tribals and also tourism potential.

Short Term: Consolidation of the area by taking over private estates, prevention of elephant poaching, control of Illicit collection of NWFP, easing the impact of pilgrimage at Sabarimala through scientific management and waste treatment.

Long Term: Conservation and protection of habitats, biodiversity and ecosystems, tourism management.

Idukky Wildlife Sanctuary

Idukky Wildlife Sanctuary occupies an area of 66 km^2 with majority of the natural forests in degraded state.

Encroachments and other developmental activities have largely affected the fauna of the region. The gaur became locally extinct. The largest predators have disappeared. Elephant population has skewed sex ratios. The vehicular traffic along the Idukki-thodupuzha road and the one, which separates, Kallar range from the adjoining forests of Nagarampara and Thodupuzha ranges, developing townships, increased human population pressure and settlements have affected the movement of animals. Isolation of elephant herds in the fragmented healthy habitats due to the availability of food and water during dry period deteriorates the habitat further.

Immediate : Ban on encroachments and legalization of squatters should be carried out on a war footing, as fragmentation of habitats results in habitat destruction and loss of contiguity is a major threat. Patrolling has to be strictly enforced to prevent illicit felling.

Short Term : Habitat improvement works have to be implemented in select degraded areas due to fire, soil erosion, plantation activities and fragmentation. Conversion of forest areas for any developmental activities, which could further obstruct migration corridors of animals, has to be banned.

Long Term : An integrated watershed development program protecting the soil, water and flora has to be initiated.

3. Mankulam Forest division

The Mankulam Forest division occupies an area of 55 km^2. Predominant vegetation type is evergreen and degradation constitutes 38 percent. A lionshare of the Montane subtropical and temperate forest of the regions is also found here.

Immediate : The forests are ravaged by fire annually. Implementation of fire protection and strict patrolling against further encroachments has to be ensured.

Short Term : The forests are ravaged by fire annually. Implementation of fire protection and strict patrolling against further encroachments has to be ensured.

Long Term : Rehabilitation of degraded forests has to be carried out through assisted natural regeneration and regeneration in degraded forests.

4. Munnar Forest Division

The Munnar forest division occupies an area of 446 Km^2 of which 8 per cent is under forest plantation and 53 percent are degraded forests.

Immediate : Boundaries of reserve forests with that of tea estates have to be clearly defined and demarcated.

Short Term : Plantations with exotic species like Eucalyptus and wattle needed to be dispensed with.

Long Term : Rehabilitation of degraded forests has to be carried out through assisted natural regeneration and regeneration in degraded forests.

5. Eravikulam National Park :

Eravikulam National Part is situated in the high ranges of the Southern Western ghats in Idukky district. The part is well known for the largest population of Nilgiri Tahr (Hemitragus hylocrius), an endangered mountain goat, endemic to South India. Anamudi, the highest peak (2697 msl) in Peninsular India is also situated here. The dominant shrub, Phlebophyllum Kunthiamum and Neela kurinji blooms once in every 12 years. These salient features attract a large number of Indian as well as foreign tourists, which account to over one lakh, annually. The Eravikulam National Park occupies an area of 76 km^2 of which 71 per cent belongs to grasslands and the rest under dense evergreen and montane sub tropical and temperate forests.

Immediate : As the shoal grassland vegetation and the Montane ecosystem of this area are unique, encroachments of all kinds should be strictly prohibited. Park boundary with that of Reserve Forests and tea estates has to be clearly defined and demarcated.

Short term: Shola afforestation in the fragmented and disturbed shoal patches to enrich the existing patches and to arrest degradation has to be initiated. Eco-development programmes to strengthen the park people interaction has to be initiated. Increasing tourism activities should not affect the ecosystem integrity. Awareness creation among the tourists about the do's and do not's within the context of biodiversity conservation and protection of unique habitat which cater to the rare, endemic and endangered flora and fauna is a pre requisite.

Long Term : Gradual conversion of the existing non productive plantation of Eucalyptus and Acacia along with eco-restoration of habitats protecting the soil, water and flora has to be initiated. Protection and conservation of the Shola grassland vegetation, montane ecosystem and a viable population of the Nilgiri Tahr should be the major goal for long-term management.

6. Kottayam Forest Division, Kottayam (Grid 5)

The Kottayam Forest Division occupies an area of 199 km^2 of which 48 Km^2 are under plantation. Of the total natural forests, 84 percent are degraded.

Immediate : The forests are ravaged by fire annually. Implementation of fire protection programmes is required.

Short Term : Improvement in plantation management. Augmentation with species of reed and cane and bamboo may be strengthened.

Long Term : Rehabilitation of degraded forests has to be carried out through assisted natural regeneration in degraded forests.

7. Kothamangalam Forest Division, Ernakulam (Grid 10)

The Kothamangalam forest division occupies an area of 182 km^2 of which 22 % are under plantations and 59% are under evergreen forests of which majority are degraded.

Immediate: Strict measures have to be taken to prevent / ban further encroachments.

Short Term: Improvement in plantation management and augmentation with species of reed, cane and bamboo may strengthen.

Long term: Rehabilitation of degraded forests has to be carried out through assisted Natural regeneration and regeneration in degraded forests.

8. Malayattoor Forest Division

The Malayattoor forest occupies an area of 477 km^2 of which 46% are dense evergreen forests. Plantations constitute an area of 70 km^2

Immediate : The forests are ravaged by fire annually. Implementation of fire protection plans is warranted.

Short Term : Improvement in plantation management and augmentation with species of reed, cane and bamboo may strengthened.

Long Term : Rehabilitation of degraded forests has to be carried out through assisted natural regeneration and regeneration in degraded forests.

9. Thattekkad Bird Sanctuary :

Thattekkad bird Sanctuary occupies an area of 35 km^2 of which 6 km^2 are under plantations. Majority of the forests (93%) are degraded.

Thattekkad Bird Sanctuary is the only bird sanctuary in kerala. Study conducted by BNHS during 1985 identified 235 species of birds from this area. This sanctuary has also been recognized as a paradise of bird watchers.

Residents of Kuttampuzha (a small township nearby) and the adjacent villages are dependent on the sanctuary for their subsistence. High degree of biotic interference in the form of collection of fuel wood, fodder green manure and other Non Wood Forest products (NWFPs) promote forest degradation.

Immediate: Patrolling has to be strictly enforced to check smuggling of timber and poaching. Occurrence of annual manmade fires also has to be prevented.

Short Term: Stakeholders or user groups receiving direct benefits have identified and a microplan for sustainable extraction of resources has to be developed. Formation of VSS (Vana Samrakashna Samity) involving the user groups, identifying their needs and catering their needs through allocation of clearly defined areas (Peripheral or buffer zones) is a prerequisite. Under the supervision of local bodies and forest department, there could be monitoring protocols to ensure extraction through ecologically sustainable, economically viable and socially just mechanisms.

Long Term: Eco-restoration of the degraded habitat, protecting soil, water and flora through a watershed-based program can be envisaged. Enrichment of existing degraded forests and plantations with fruit yielding trees will ensure food security for the local people and will maintain viable bird populations. Information on the habitat utilization of the migratory birds and its ecology and feeding habitats has to be researched upon which could provide inputs for a detailed habitat improvement/management program. Awareness programmes through educational camps and seminars for the tourists need improvement of the existing facilities and infrastructure.

10. Vazhachal Forest Division, Thrissur (Grid 13)

The Vazhachal forests occupy an area of 299 km^2 of which 68% are under dense evergreen forests plantation occupying an area of 69 km^2.

The natural forests in this region are heavily relying on extraction of Non Wood Forest Products by the forest dwellers living in and around this region. The collection depots of the Girijan Service Co-operative Society operated from sholayar and palappally has collected forest products from this area of over 100 MT of products generating an income of 2 million rupees annually (estimated annual average). During the year 1993-1997 forest dwellers of this region generated an income of rupees ten millions from five products; Resin, a bark exudates from an evergreen tree, canarium Strictum, Shikakai, the pods of the climber Acacia simuata, Honey and wax, cardamom and flowers of Myristica species.

Low market prices for the forest products and increasing living expenses create a wide gap persuading the people of extract more for their subsistence. This affects the sustainable harvest of the resource adversely through over harvest, early harvest and destructive harvest mechanisms.

Immediate : The forests are ravaged by fire annually. The proposed Athirappally hydroelectric project in the Vazachal division will destroy the waterfall and unique riparian floral and faunal elements. A few tribal settlements will also be displaced. It will affect the water availability to farmers of the thumboormuzhi irrigation project. An Environmental Impact Assessment study encompassing all these issues with the public hearing and conflict resolution with users need to be conducted immediately.

Short Term: Enrichment plantations with selected NWFP yielding species in the existing non-productive plantations and highly degraded areas will ensure source of income for the forest dwellers in the region.

Long Term : Protection and rehabilitation in natural forests through Assisted natural regeneration and regeneration in degraded forests.

11. Chalakkudy Forest Division

The Chalakkudy forest occupies an area of 111 km^2 of which 56% are under evergreen forests. Plantations constitute an area of 7 km^2.

Conversion of natural forests to plantations in this area and its surroundings has resulted in the loss of contiguity in the natural forest tract in between Nelliyampathy in the North and the Idamala Pooyamkutty basin in the south. This has also resulted in the fragmentation and degradation of natural forests in this area.

Immediate : The forests are ravaged by fire annually. Implementation of fire protection is warranted.

Short Term: Of the river basins in Kerala, the Chalakudy river basin receives maximum amount of rain and hence eco-restoration measures can bring about effective changes. Habitat improvement works and Assisted Natural Regeneration has to be carried out at strategic locations with watershed as a development unit. An integrated watershed development programme protecting the soil, water and flora has to be initiated in the degraded areas.

Long Term: Conservation and protection of habitats, biodiversity and ecosystems.

13. Nemmara Forest Division, Palakkad Grid 14

The Nemmara forest occupies an area of 161 km^2 of which 16 km^2 is under plantations. Majority of the forests (87%) are in the degraded state.

Immediate : Forest areas leased to private planters in Nemmara division should be taken back after the lease period is over. No fresh leases should be permitted. Implementation of fire protection is warranted

Short Term: Improvement in plantation management and augmentation with species of reed, cane and bamboo may be strengthened.

Long Term: Rehabilitation of degraded forests has to be carried out through Assisted natural regeneration and regeneration in degraded forests.

14. Parambikulam Wildlife Sanctuary :

The Parambikulam WLS occupies an area of 244 km^2 of which 102 km^2 of the total area (42%) are under forest plantations, 68% of the natural forests are in the degraded state.

The salient feature of this Sanctuary is the abundance of Wildlife with easy movement to the adjacent Anamalai Wildlife Sanctuary in Tamilnadu. Wildlife sightings attract good amount of tourists to this sanctuary. The rich habitats and ecosystems extensively used by the larger mammals frequently move around in this area.

Immediate : Protection of natural forests from annual fire has to be ensured. Measures may be taken to prevent construction of new roads to Parambikulam Wildlife Sanctuary.

Short Term: The poor quality plantations and the degraded forests, which constitute a major proportion has to be managed. Assisted Natural Regeneration (ANR) and effective rehabilitation programmes can help in restoration of habitats to an extent. Habitat improvement works with special emphasis on soil and water conservation in strategic locations coupled together with afforestation is needed.

Long Term: Long term strategies should be evolved to improve the living conditions of the local indigenous communities and provision of infrastructure and facilities to meet the basic needs like drinking water and education, health etc.

Participation of local communities in the protection of natural forests and conservation of biodiversity has to be ensured. The existing teak plantations have to be converted to natural forests through a very defined and systematic program.

5.1.5.3 Aquatic (Fresh water, estuarine water, coastal water) Hotspots

Coastal waters

The following criteria have been considered for delineation of "hot spot" in the biological environment of the coastal waters.

- An area either rich in biological diversity, in terms of a large number of species – populations, or has a representation of a number of habitats/ or microclimates
- An area possessing endangered, threatened, rare or vulnerable plant and/ or animal population
- Areas having a good representation of keystone species, both of ecological and socio-economic importance
- Areas, which harbored rich species diversity in the past, but, are presently in semi-degraded condition
- Existing protected areas like National Parks, Sanctuaries etc

The coastal waters (entire study area) of GKR can be termed as "hot spot" following the above first four criteria.

Biological environment of the coastal waters has rich bio-diversity. There are 65 species under 3 groups of phytoplankton, 89 species of zooplankton and 88 species of macro benthos under 32 families and 14 groups of meiobenthos, 113 species of fin fishes under 55 families and 31 species of shell fishes under 8 families, one species of whale accidental stranding and 4 species of dolphins have been reported from the coastal waters. The coastal ecosystem provides very many species of finfishes and shellfishes as food for human beings and therefore, is economically very important. Mainly exploited resources are the fishery resources from the coastal waters. The capture fishery is a traditional enterprise. Apart from providing the fish resources as food and nutrition, the fishery sector leads to a complex socio-economic domain among the coastal population. Hence, the biological environment of the sea has a direct bearing on the life of the general population and especially on the coastal communities.

Biological environment of the coastal waters of GKR can be termed as hot spot in view of the diversity and richness of fauna having representation of keystone species both ecological and socioeconomic importance. Due to higher exploitation level of the fishery resources, some of the important species have become vulnerable or endangered. Available records show that one species each of shark and sea turtle are endangered. Six species of finfishes and eleven species of shellfishes are reported vulnerable.

The information available on marine biodiversity appears to be incomplete, as it is believed that several species are yet to be studied or reported. Several of the faunal composition reported from the study area is still at the group level only. Identification of several groups to the species level is lacking due to lack of expertise in the field. Therefore, there is a need to properly register the marine biodiversity not only of the study area but also all along the Indian coast. A special inventory of each life support system of the coastal zone is also inevitable for the management.

The biological production is mainly related to the environmental conditions of the habitat. However, the coastal water (marine) quality in GKR does not appear to have undergone many changes as evident from the water quality data for the past decade. However, ocean climatic variations in relation to the biological environment need to be investigated.

Some of the causes for the changes noticed in the biological environment and for dwindling biological resources in the coastal waters appear to be related to the following factors:

a) **Overfishing:** Exploitation of fishery resources from the coastal region at present is above the sustainable yield. Input and output controls could not be satisfactorily applied due to socio-economic and political reasons besides the frequent insurge of technology creep. This is the case almost all along the Kerala coast.

b) **Loss of nursery grounds and habitats:** Some of the species of fishes and crustaceans migrate to estuarine waters at some stage of their life cycle making the estuaries (backwaters) as nursery grounds. There are nearly about 60 species of fishes, 6 species of prawns and 2 species of crabs, which migrate to the backwaters for feeding and for meeting various physiological requirements and make the backwaters as nursery grounds. Vembanad Lake, the largest estuarine and brackish water system in Kerala, is connected to the sea at Kochi and Azhikode (Munambam), and has been a nursery ground for several marine species. However, this system appears to have undergone visible environmental deterioration over the past few years, mainly due to human interference through reclamation of the back waters, discharge of industrial and municipal wastes into the back waters, coconut husk retting, bunding of water bodies, etc. Another important factor is the loss of mangroves, which existed decades ago is almost non existent now, except in a few scattered patches. These mangroves contributed a lot of detritus and formed nursery grounds and habitats for several estuarine as well as marine species.

All these factors contributed to the loss of nursery grounds to the marine migratory species, which in turn must have affected the regenerative capacity of the biological environment not only of the backwater ecosystem but also the coastal marine ecosystem in the recent past.

c) **Use of inappropriate gears:** Catching of juveniles using gears with small mesh sizes cause growth, overfishing and hence reduces their spawning stock both in the marine and estuarine environment. Although some regulations exist to control the operations of some inappropriate gears, the practice appears to be continuing.

d) **Ineffective legal interventions:** There are legal interventions such as Kerala Marine Fisheries Regulation Act regulating the fishing activities. Fishing by mechanised trawlers is banned for 45 days during monsoon to avoid fishing of spawning stocks. The state government every year announces the duration of this ban. There are also regulations to control the use of different gears. Implementation of these regulations does not appear to be satisfactory and the use of inappropriate gears and destructive methods of fishing continue. However, the ban on trawling for 45 days during monsoon appears to have yielded some positive results in the increase of fish catch and catch per unit effort (expert committee report 2000).

Short Term Management Plans

The strategy for conservation of the biological environment of the coastal waters of GKR should include the following suggestions

- Existing regulations on exploitation of living resources should be strictly implemented or enforced. Amendments may be required in the KMFR Act (1980) to regulate number of fishing vessels operating in an area, seasons, mesh size of gears, the size of fishes to be caught and sold, etc.
- A code of conduct for responsible fishing should be adopted with the consensus of the stakeholders to avoid overfishing and to prevent destruction of habitats by introducing quota systems, species - wise, area - wise and season - wise
- Since the backwater (estuarine) system is used as nursery ground by some marine migratory organisms, the deteriorating backwater system need to be restored by Controlling the reclamation, bunding etc; Controlling the water pollution resulting from industrial and municipal waste; Regulating the exploitation level of living resources species-wise and size -wise and Mangrove afforestation
- Prevent killing of brood fish at the time of spawning migration to the backwaters, which is being carried out using inappropriate gears and fishing methods
- Strict enforcement of fishery regulations and rules to prevent destructive methods of fishing such as the use of explosives, poisons, insecticides, electrocution etc.

Long Term Management Plans

- There is a need to register the marine biodiversity including the endangered, rare or vulnerable species, as the available data is incomplete

- Precise information on migratory and breeding habits of fishes of Kerala is lacking. Therefore, there is a need to study the migration pattern and breeding grounds of at least commercially important marine fishes. Based on the information so gathered, the feasibility of establishing fish sanctuaries can be worked out
- Establishment of a centre for the maintenance of brood stock of endangered, rare and vulnerable fishes, whereby periodic replenishment of the stocks in natural waters can be attempted by resorting to artificial propagation
- Preservation of germplasm of endangered and vulnerable species at selected centres
- Although there is no serious pollution of the coastal waters, any activity in the future that could affect the coastal water quality be undertaken only after specific environmental impact assessment studies
- Sea ranching or artificial replenishment with young ones (produced in hatcheries) in the coastal waters could enhance the depleting stock of the commercially important species (Reports from Japan indicate that the release of one million post-larvae shrimps into the sea will enable a catch of one tonne of shrimp)
- Artificial reefs could be created in the coastal waters to develop special habitats for the biota
- Community based fisheries management should be adopted replacing the fully government driven management practice for better management awareness among all stake holders in fishing sector and systematic implementation of management measures with full co-operation of the fishing community
- An aggressive education campaign on conservation and better management needs of the biological environment should be launched through the establishment of community learning centres in the coastal area
- Any management or conservation measure taken should be based on a combined bio-socio-economic mode.

Table 5.1.5.1

Criteria for Selection of Hotspot - Flora

Sr. No.	Area	Angio-sperms	Exclusive		Endemic		Rare/Threatened/ Vulnerable/ Endangered	
			No.	%	No.	%	No.	%
1	Periyar Tiger Reserve (PTR)	1965	777	39.54	515	26.20	150	7.63
2	Pathanamthitta	1250	202	16.18	253	20.24	175	14.00
3	Thrissur	1200	162	13.5	258	21.5	51	4.25
4	Eravikulam	274	138	50.36	62	22.63	29	10.58
5	Kottayam	885	211	23.84	--	--	--	--

Source : Secondary data collected by KFRI

Table 5.1.5.2

Criteria for Selection of Hotspots – Fauna
(Relative Density of Sixteen Mammals in the Region)

Forest Division / Region	Lion tailed maca-que	Bonnet Maca-que	Niligiri Langur	Com-mon Langur	Ele-phent	Gaur	Sam-bar	Spotted Deer	Barking Deer	Mouse Deer	Wild Bear	Sloth Bear	Wild Dog	Porcu -pine	Small Indian Civet	Toddy Cat
Nenmara	11.10	3.70	0.50	--	1.40	0.60	1.14	0.62	1.57	1.25	2.31	10.95	2.92	0.49	1.19	--
Parambi-kulam	11.10	3.10	4.40	--	1.70	36.70	9.15	7.79	2.79	2.22	3.32	18.99	2.77	2.79	9.89	--
Thrissur	--	3.10	--	--	--	0.82	15.63	20.53	4.87	6.38	3.69	26.84	6.38	27.37	48.41	--
Chalakkudy	3.70	7 10	0.80	--	0.50	0.36	3.50	--	2.75	0.96	4.78	--	15.85	6.65	--	--
Vazhachal	22.20	15.70	10.70	--	7.80	10.40	1.89	4.06	43.31	6.70	2.44	--	16.18	2.24	3.23	10.43
Malayattoor	7.40	8.60	0.50	--	7.20	0.13	13.11	--	5.57	10.51	8.27	1.27	8.32	4.57	10.33	13.03
Kotha-managalam	--	4.80	--	--	2.30	--	6.18	--	3.61	10.76	5.96	6.78	--	1.75	1.74	3.51
Mankulam	--	1.20	--	--	--	32.64	5.37	--	5.57	4.59	5.24	9.51	6.33	2.63	2.58	16.68
Munnar	3.70	14.40	6 90	--	8.60	3.15	0.81	0.94	5.65	7.66	--	--	--	2.15	--	2.84
Idukki (WL)	--	9.03	4.20	100.00	5.30	8.02	8.40	62.26	4.96	15.32	8.16	2.02	13.93	22.98	14.95	5.84
Kottayam	3.70	4.50	--	--	1.40	0.06	9.02	0.94	5.14	7.96	3.39	1.18	1.57	3.98	1.79	5.72
PTR	22.20	2.80	64 20	--	33.90	6.60	8.83	--	2 77	6.13	3.75	17.42	9.61	10.75	5.22	18.19
Ranni	14.80	15.70	7.90	--	23.90	0.25	11.65	--	8 05	16.99	45.16	3 87	9.56	10.44	0.65	19.39
Konni	--	6.10	--	--	6.10	0.19	5.31	2.86	3 39	2.55	3.53	1.17	6.55	1.26	--	4.37

Source : Secondary data collected by KFRI, Wildlife Census 1993

Table 5.1.5.3

Criteria for Selection of Hotspots – Non Tangible Benefits

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

Sr. No.	Forest Division	Value of the Growing Stock (Rs. in crores)	Environmental Value (Rs. in crores)	Total Value (Rs. in crores)
1	Ranni	5776.74	50603.48	56380.22
2	PTR	4507.52	42593.51	47101.03
3	Malayattoor	3419.88	27910.68	31330.56
4	Vazhachal	2088.17	25872.70	27960.87
5	Munnar	3212.04	23983.00	27195.04
6	Kothamangalam	1271.48	5979.59	7251.07
7	Chalakkudy	819.51	6297.71	7117.22
8	Achankoil	1340.38	4381.40	5721.78
9	Parambikulam	1602.78	3757.84	5360.62
10	Mankulam	396.45	4069.62	4466.07
11	Kottayam	1383.99	2590.56	3974.55
12	Eravikulam	162.68	2402.99	2565.67
13	Idukky	438.38	1316.83	1755.21
14	Nenmmara	1168.13	373.88	1542.01
15	Konni	1266.69	--	1266.69
16	Thattekkad	245.45	192.64	438.09

Source : Secondary data collected by KFRI

Table 5.1.5.4

Criteria for Selection of Hotspots - Tangible Benefits
(Revenue accrued through Collection of Non Wood Forest Products)

Area / Region	Revenue (Rs. in lakhs)
Sholayar	14
Palappally	6.1
Kuttampuzha	5.7
Devikulam	5.6
Kosadi	5.4
Adimali	4.2
Vazhathope	1.9
Nelliyampathy	1.8

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

Source : Secondary data collected by KFRI

5.1.6 Socio-Economic Environment

5.1.6.1 Identification of Panchayat-wise Hotspots in GKR

The hot spots in socio-economic environment are identified on the basis of the subjective Quality Of Life (QOLs) indices. Subjective QOL index is considered as a better indicator parameter than objective and cumulative indices, because it reflects the subjective attitude of the people towards each QOL parameter. Quality of life of people in a region with subjective QOL index in the range of 0 – 0.19 is considered critical, 0.20 – 0.39 very poor, 0.40 – 0.59 is poor, 0.60 – 0.79 is satisfactory and 0.80 – 1 is good. For each district of GKR, this classification is applied to identify the hot spots in QOL on panchayat basis.

Critical or very poor condition in the subjective QOL is not observed in any district under GKR. But majority of the panchayats in all the districts fall under the category of satisfactory. Few panchayats come under the class "poor" and some under "good". The panchayats with poor subjective QOL are identified as hotspots in the socio-economic environment, which require some short term and long term management strategies.

Alappuzha District

In Alappuzha district, out of 58 panchayats and 5 municipalities in the study area, 7 panchayats have subjective QOL index in the range 0.40 to 0.59 (poor category). These panchayats, with QOL(s) in brackets, are Kavalam (0.41), Veliyanadu (0.523), Pulimkunnu (0.537), all in Veliyanadu block, Karuvatta (0.473), Cheruthana (0.593), both in Harippadu block and Kainakari (0.501) and Edathwa (0.557) both in Chambakkulam block.

In Kavalam panchayat, 77.78% of the households are highly unsatisfied and 11.11% of the households are not satisfied with respect to water availability. Majority of the households are unsatisfied with medical, transportation, housing and sanitation sector facilities. In Veliyanadu panchayat, the problem sectors are sanitation, physical environment, water availability, medical facilities etc. In Pulimkunnu panchayat, physical environment and non-availability of water are the main problems. In Karuvatta panchayat, physical environment and non-availability of drinking water, transportation and housing are the main problems. In Cheruthana and Kainakary panchayats, the majority of the households are unsatisfied with physical environment and in Edathwa panchayat, non-availability of drinking water and poor quality of housing are the main problems.

There are 46 panchayats/municipalities in Alappuzha district having QOL(s) index in the range 0.60 to 0.79 (satisfactory category). Ten panchayats have subjective QOL index in the range of 0.80 – 1 (good category). These are Pattanakkadu (0.819), Kadakkarappally (0.917), Ezhupunna (0.867) in Pattanakkadu block, Kumarapuram (0.834) in Harippadu block, Panavally (0.849), Thykattussery (0.853), Chennampallippuram (0.856), Arookutty (0.873), Perumbalam (0.89) all in Thykattussery block, and Thakazhi panchayat (0.908) in Champakkulam block.

Ernakulam District

In Ernakulam district, there are 87 panchayats, 8 municipalities and one corporation. Out of these, 96 numbers of local bodies, 9 panchayats and one municipality are with subjective QOL index in the range of 0.40 – 0.59 (poor category). These are Chellanam (0.44) and Kumbalangi (0.448) in Palluruthy block, Maradu (0.472) and Kumbalam (0.475) in Vytila block, Kadamakkudy (0.504) in Edappally block, Mulavukadu (0.533) and Pallippuram (0.571) in Vypin block, Kuttampuzha (0.547) in Kothamangalam block and Chittatukara (0.580) in Paravoor block. The lone municipality that comes under this group is Trippunithura municipality with QOL(s) index 0.48.

In Chellanam panchayat, 100% of the households are unsatisfied with their social security, about 95% are unsatisfied with physical environment, water availability, fuel availability and the health status. In Kumbalangi, all the households are unsatisfied with the non-availability of water, health status, social security, physical environment and fuel availability. In Maradu and Kumbalm panchayats, almost all the households are unsatisfied with non-availability of water, social security and physical environment. In Kadamakkudy panchayat, 73.33% of households are highly unsatisfied and 26.67% are unsatisfied with the available transportation facilities and about 76% are unsatisfied with their health status. In Mulavukadu and Pallippuram panchayats, majority of the households feel that water availability and transportation are badly affecting their quality of life. In Kuttampuzha panchayat, around 90% of the households are unsatisfied with the transportation and social security. In Chittatukara panchayat, majority of the households are unsatisfied with fuel availability and transportation. In Thrippunithura municipality, the main problems which lead to a lower level of quality of life are that 100% households are not satisfied due to social security problems, 96.88% unsatisfied with the physical environment and about 85% are unsatisfied with the water availability.

Seventy-eight panchayats, seven municipalities and one corporation are having QOL(s) in the range of 0.6 - 0.79 (satisfactory category). There are no panchayats or municipalities in Ernakulam district falling under the category of good subjective quality of life.

Idukki District

In Idukki district, there are 50 panchayats and one municipality. Out of these, only one panchayat is in the range 0.40 - 0.59 (poor category). It is Idukki Kanjikuzhi panchayat with QOL(s) value of 0.553. In Idukki Kanjikuzhi panchayat, the main problem is with respect to communication facilities. About 82.14% of households are unsatisfied with available communication facilities and 74.47% of households feel that enough education facilities are not available in the panchayat. Medical and transportation needs deserve top priority. 73.21% of households are unsatisfied with available medical and transportation facilities. With respect to sanitation, 57.14% of the households are unsatisfied and 48.21% of the households are unsatisfied with physical environmental problems. Inadequate social security is another reason for people's poor satisfaction levels. About 44.64% of households are unsatisfied and 25% are highly unsatisfied with respect to the social security. With the available housing facilities, 16.36% of the households are not satisfied.

Forty-six panchayats and one municipality have satisfactory (0.60 - 0.79) subjective quality of life. There are three panchayats in Idukki district, which come under the index range 0.80 - 1 (good category). These are Chinnakanai (0.8) and Munnar (0.801) panchayat in Devikulam block and Velliyamattom (0.878) in Elamdesam block.

Kottayam District

There are 73 panchayats and 4 municipalities in Kottayam district. Out of these, 15 panchayats have poor subjective quality of life. These are Pallikkathodu (0.490), Kooroppada (0.518), in Pambady block, Thalayolaparambu (0.490), in Kaduthuruthy block, Thalayalam (0.515), Udayanapuram (0.522), Chembu (0.538), Maravanthuruthu (0.540), TV Puram (0.566), and Vechur (0.573) all in the Vaikom block, Thalappulam (0.539), Erattupetta (0.540) and Moonnilavu (0.564) all in Erattupetta block, Koottikkal (0.563) in Kanjirappally block and Kozhuvanal (0.578) in Lalam block.

In Pallikkathodu panchayat, the main problem is with respect to the availability of fuel and 80.52% of the households are not satisfied due to this problem. Nearly 72.22% of the households are unsatisfied with the inadequate sanitation facilities and 69.44% of the households feel that the quality of their housing is not satisfactory. Medical facilities, transportation, communication, social security, education etc. are other factors with which people are unsatisfied. In Elikkulam and Kooroppada panchayat, 75% of the households are unsatisfied in the social security and fuel availability. Housing, sanitation, medical facilities, communication and transportation etc. are other sectors of unsatisfaction. In Thalayolaparambu panchayat, 62.96% of the households are unsatisfied with the employment and working condition. In Thalayalam panchayat also, fuel availability is the main problem as reported by the households.

The education, health and water availability etc. are other sectors, which require urgent attention. In Udayanapuram panchayat, 79.55% of the households are unsatisfied with health status. Other parameters of unsatisfaction are fuel availability, education and employment and working conditions. In Chembu panchayat, 77.5% of the households are unsatisfied with the physical environmental problems. Other parameters of unsatisfaction are health, education, housing, water availability etc. In Maravanthuruthu panchayat, 88.1% of the households do not get enough fuel for cooking and lighting and 85.71% have health problems, water availability, employment and working conditions, housing etc. are the other problems.

In TV puram panchayat and Vechur also, non-availability of fuel is the main problem. In Thalappulam, 85.7% of the households are unsatisfied with their health status and in Erattupetta 97.73% of the households are unsatisfied with the quality of housing. In Moonnilavu panchayat, the main problem is with respect to the non-availability of fuel. About 91.67% of the households are not satisfied with respect to this aspect .In Koottikkal panchayath, 100% of the households are not satisfied with non-availability of fuels. In Kozhuvanal panchayath, 56.67% of the households are unsatisfied with the non-availability of drinking water.

Almost 55 panchayats and 4 municipalities have a satisfactory (0.60 - 0.79) subjective quality of life. Three panchayats, namely; Kidangur in Uzhavur block and Melukavu and Thalavady in Erattupetta block have subjective quality of life index in the range of 0.80 - 1 (good category).

Pathanamthitta District

In Pathanamthitta district, there are 45 panchayats and 2 municipalities in the project area. Sixteen panchayats have subjective QOL index in the range of 0.40 to 0.57 (poor category). Vadasserikkara panchayat (0.446), Naranamuzhi (0.487), Seethathode (0.516) and Chittar (0.537) all in Ranni block, Thannithode (0.454), Malayalappuzha (0.597) and Konni (0.537) in Konni block, Omallur (0.479), Cherukol (0.506), Mallapuzhassery (0.510), Kozhenchery (0.512), Ilanthur (0.518), Chennerkkara (0.54) and Naranganam (0.545) all in Ilanthur block, Kulanada (0.532) in Kulanada block and Kallooppara (0.561) in Mallappally block are the panchayats with poor quality of life. Panchayats like Peringara (0.808), Niranam (0.837), Kuttur (0.853), and Kadapra (0.967) all in Pulikkeezhu block, Thiruvalla municipality (0.824), Kottangal (0.827), Kunnamthanam (0.849) and Anikkadu (0.885) in Mallappally block, Koipram (0.889) and Airoor (0.891) in Koipram block have subjective quality of life index in the range of 0.80 - 1 (good category).

In Vadasserikkra panchyat, 58.33% of the households are highly unsatisfied and 18.75% are unsatisfied with the transportation facilities. About 56.25% are unsatisfied and 29.63% highly unsatisfied with the quality of housing. Other parameters of quality of life with no satisfaction are communication, medical facilities, water availability and physical environment. In Naranamuzhi panchayat, on an average 70% of the households are unsatisfied with medical, transportation, quality of housing, sanitation, communication, education etc. Seethathode is a panchayat with 47.83% of the households highly unsatisfied and 36.96% of them are unsatisfied with the medical facilities and their health status. About 47.83% of the households are unsatisfied and 10.87% of them are highly unsatisfied with the transportation sector.

Other sectors with which people are unsatisfied are education, housing, communication, employment and working condition, water availability etc. In Chittar panchayat, majority of the households are unsatisfied with respect to the present education, water availability, quality of housing and medical status. Thannithode is another panchayat with poor subjective quality of life. Majority of the households are unsatisfied with the present status of transportation, education, quality of housing, medical facilities, communication, physical environment and water availability. People in Malayalapuzha panchayat are mainly unsatisfied with the current fuel availability, medical facilities and education facilities. In Omallur panchayat, majority of the households are unsatisfied with lack of transportation facilities and water availability. The main problems in Cherukol panchayat are lack of transportation facilities, non-availability of water, poor quality of housing etc.

In Mallapuzhassery panchayat, transportation, employment and working conditions, sanitation, housing etc. are the parameters with which people are not satisfied. Non-availability of water, quality of housing is the problems in Kozhenchery panchayat. In Ilanthur and Chenneerkara panchayats, non-availability of water and quality of housing are the problems at the focus. In Naranganam panchayat transportation problem deserves attention. In Kulanada panchayat, sanitation and quality of housing are the sectors, which are facing people's dissatisfaction. In the Kallooppara panchayat, 88.1% of the households are unsatisfied with the social security, 69.05% unsatisfied with water availability and 64.29% unsatisfied with fuel availability.

Thrissur District

In Thrissur district, we have surveyed only three panchayats and all of them have subjective quality of life in the range of 0.60 - 0.79 (satisfactory category).

5.1.6.2 Short Term Management plans

In each district of GKR, panchayat wise hotspots are identified based on the subjective quality of life indices as presented in **Fig. 5.1.6.1**. Short term management plans for each of these panchayats are made along with the status on the existing scenarios as summarized below in **Table 5.1.6.1**.

5.1.6.3 Long Term Management Plans

Alappuzha district

The subjective QOL of Alappuzha district is 0.692. Management of the physical environment deserves first priority. Water logging and water pollution have been reported as the most important environmental problems faced by the households. Housing sector demands the second priority in Alappuzha district. About 30% of the houses are semi-pucca and 8.65% are huts. It is recommended to the District Planning Committee to consider these aspects while preparing the annual development plans. Sanitation is another sector, which requires attention. Employment and working conditions, drinking water and transportation are the other sectors, which have warrant improvement.

Ernakulam district

The subjective QOL index is 0.674. In Ernakulam district, the first priority sector is drinking water. Majority of households use untreated well water for drinking purposes. About 10.2% of the households are using water from public wells or rivers or canals. Treated potable pipe water is available only to 29.58% of the households. This also is not available through out the day. Very effective water supply schemes are to be formulated and the existing schemes are to be strengthened. Non-availability of fuel for cooking is the second priority problem in Ernakulam district. About 37% of the households use LPG for cooking while

23.78% use firewood for this purpose. Measures are needed to encourage the use of energy efficient stoves on a community basis. Environmental problems like water logging and noise pollution affect the quality of life of people negatively. Lack of security of women is a threat to the social security of Ernakulam district.

Idukki district

The subjective QOL index of Idukki district is 0.749. Sanitation has been identified as the only priority sector, which requires management.

Kottayam district

The subjective QOL index of Kottayam district is 0.688. Non-availability of fuels for cooking, poor quality of housing, non-availability of drinking water, health problems, unemployment, poor sanitation and poor communication and transportation facilities are the problems adversely affecting the quality of life. Firewood is the main type of fuel used by the households. Community based efforts are required to encourage the use of fuel-efficient chulas. About 31% of the houses are semi-pucca and 7% are huts in Kottayam district. Replacement of poorly constructed houses with small houses with strong basement and brick walls is recommended especially in the light of incidence of recent earth quakes in Kottayam district. About 18.7% of the households avail treated potable pipe water for drinking purpose. Efforts are needed to make potable drinking water available to the rest of the community also. Since it is reported that 92.94% of the households are suffering from air born diseases, management of the air environment and strengthening of the health centers are required.

Pathanamthitta district

The subjective QOL index is 0.666. The priority sectors for consideration are housing, drinking water, employment, health, transportation and communication, education and sanitation. About 42.8% of the houses are semi-pucca and 6.15% are huts in this district. Safe drinking water is available to only 16.85% of the households in this district. Measures are to be taken to make safe drinking water available to the rest of the community also. In the employment sector, it seem that this district presents the highest proportion of remittances from abroad. Long term perspectives are required to solve the problem of unemployment assuming that all these non-resident Indians return to the homeland. Strengthening of the network of health centers demands the next priority.

Thrissur district

In the three panchayaths, which we have studied, the non-availability of safe drinking water is the main problem.

Table 5.1.6.1

Hotspots and Management Plans for the Socio-Economic Environment

Sr. No.	Existing Status / Concern	Management Plan
Ernakulam District		
1.	**Pallippuram (0.571)**	
	Drinking water problems, non-availability of fuels, unemployment and transportation problems are existing along with sanitation and low quality housing	Permanent solution to the scarcity of drinking water, supporting the use of energy efficient chulas and provision of more number of boat services to Vypin from Ernakulam
2.	**Chittatukara (0.580)**	
	Non-availability of fuels, transportation problems, sanitation and non-availability of drinking water are the problems	Purchased firewood is to be used as the fuel, Energy efficient chulas may be encouraged and the latrines (extended to canals and streams) should be replaced by latrines with septic tanks
3.	**Kadamakkudy (0.504)**	
	Transport problems, non-availability of funds, unemployment, communication problems and quality of housing are the main problems. Being a panchayath in the vypin islands, the people face transport to the main land as the main problem	Measures are required to increase the number of boat service to the Vypin islands
4.	**Mulavukadu (0.533)**	
	Drinking water, conveyance and sanitation problems are prominent ones	Permanent solution to the scarcity of drinking water by implimenting special water supply schemes to the island, provision of more number of boat services from Ernakulam and also constructing enough number of latrines with septic tanks
5.	**Kuttampuzha (0.547)**	
	Transportation, employment, housing and drinking water are the problem sectors	Strengthen transportation networks by constructing new roads and efforts to increase the quality of housing
6.	**Trippunithura Municipality (0.480)**	
	A suburban area adjacent to the Kochi corporation. Water logging is projected as the main problem. Drinking water problem, non-availability of funds, poor quality of housing etc. are other problems	Remedial measures to increase the quality of life of people in the water logged areas. Even though pipe water is the main source of drinking water, steps should be taken to make water available throughout the year.

Contd....

Table 5.1.6.1 Contd....

Sr. No.	Existing Status / Concern	Management Plan
7.	**Maradu (0.472)**	
	Drinking water problem, environmental problems like water logging and poor quality of housing are the main problems.	Treated pipe water is used by majority of households, but supply is not available in the required time. Measures should be taken to solve the water logging and to improve the quality of housing
8.	**Kumbalam (0.475)**	
	Non-availability of safe drinking water, environmental problems like water logging and non-availability of fuels are the main problems	Majority of people depend on pipe water for drinking purpose, but since water is not available throughout the day, water supply schemes are to be strengthened, energy efficient chulas may be encouraged
9.	**Chellanam (0.440)**	
	Social security, environmental problems like water logging and non-availability of drinking water are the main problems. Scarcity of fuels, health problems, unemployment etc. also require attention	Security of women being a threat to the social security as reported by household. Urgent attention should be paid to solve this problem. Energy efficient stoves may be encouraged and steps may be taken to strengthen the primary health centres
10.	**Kumbalangi (0.448)**	
	Drinking water problem, lack of medical facilities. Poor social security and environmental problems like water logging are the main problems	Strengthen the water supply schemes and primary health centres. Social security problems like security of women needs urgent attention
	Kottayam District	
11.	**Chembu (0.538)**	
	Environmental problems like water pollution, poor quality of housing, scarcity of drinking water and sanitation problems exists	Source of water pollution may be identified and strengthen the water supply schemes and sanitation facilities.
12.	**Maravanthuruthu (0.54)**	
	Non-availability of fuels, poor quality of housing and unemployment are the main problems	Freely collected firewood being the main source of fuel, fuel efficient chulas may be encouraged. Better housing facilities are to be provided by special plan schemes like People's Plan Campaign. Solution to the unemployment problem also is to be tracked by local efforts

Contd....

Table 5.1.6.1 Contd...

Sr. No.	Existing Status / Concern	Management Plan
13.	**Udayanapuram (0.522)**	
	Non-availability of fuels, unemployment, water scarcity and poor quality of housing are the main problems	Freely collected firewood being the main source of fuel, fuel efficient chulas may be encouraged. Local efforts are needed to solve unemployment among rural poor & the quality of housing may be improved by special efforts
14.	**Thalayolaparambu (0.490)**	
	Unemployment, poor quality of housing, environmental problems like flooding are the main problems along with drinking water and sanitation problems	Self employment schemes & employment opportunities may be increased by local efforts. Measures to increase the quality of housing
15.	**Thalayalam (0.515)**	
	Firewood used as main fuel. dissatisfaction with water availability, quality of housing and unemployment problems also exists	Fuel efficient chulas may be encouraged. Eventhough treated water is used by majority of the people, measures are needed to make sure that safe drinking water is available throughout the day.
16.	**TV Puram (0.566)**	
	Non-availability of fuels, water scarcity, unemployment quality of housing etc. are the main problems	Purchased firewood being the main source of fuel, efforts are needed to support the use of energy efficient chulas. Even though treated pipe water is used by majority, water is available throughout the day. Strengthen the water supply schemes.
17.	**Vechur (0.573)**	
	Non-availability of fuels, water scarcity and physical environment problems are the main problems	Freely collected firewood being the main fuel used. But people are not satisfied with the availability. Fuel efficient chulas may solve the problem to a certain extent. Here also scarcity of drinking water is due to defects in the supply of pipe water.
18.	**Erattupetta (0.540)**	
	Quality of housing, poor transport and communication facilites are the main problems	Majority of houses semi pucca with thatched roof and some are pucca with tiled roofs. Epicentre of recent earth quakes (Dec 12) was located at Erattupetta. Measures are needed to construct small sizes strong houses With concrete foundation and brick walls. Strengthen the public and private transport & communication facilities

Contd...

Table 5.1.6.1 Contd...

Sr. No.	Existing Status / Concern	Management Plan
17.	**Vechur (0.573)**	
	Non-availability of fuels, water scarcity and physical environment problems are the main problems	Freely collected firewood being the main fuel used. But people are not satisfied with the availability. Fuel efficient chulas may solve the problem to a certain extent. Here also scarcity of drinking water is due to defects in the supply of pipe water.
18.	**Erattupetta (0.540)**	
	Quality of housing, poor transport and communication facilites are the main problems	Majority of houses semi pucca with thatched roof and some are pucca with tiled roofs. Epicentre of recent earth quakes (Dec 12) was located at Erattupetta. Measures are needed to construct small sizes strong houses With concrete foundation and brick walls. Strengthen the public and private transport & communication facilities
19.	**Kooroppada (0.518)**	
	Non-availability of fuels, sanitation, quality of housing and transportation and communication are the main problems which negatively affect the QOL	Semi pucca houses may be repaired to increase the quality of housing & strengthen the transport & communication facilities
20.	**Pallikkathodu (0.49)**	
	Non-availability of fuels, poor sanitation, low quality of housing, non-availability of better transportation and communication facilities are the prime problems	Fuel efficient chulas may be encouraged. Better housing quality may be ensured at low cost by constructing small houses with concrete basement. Better road networks and communication facilities
21.	**Kozhuvanal (0.578)**	
	Water scarcity. low quality of houses, poor transport facilities etc. are the main problems	Untreated well water is the main source of drinking water. Strengthen the public water supply schemes. Steps are to be taken to improve the quality of housing & transport facilities also
22.	**Thalappulam (0.539)**	
	Transportation and communication, fuel availability, quality of housing & environmental problems are the sectors requiring short term management plans	Majority use public telephone booths for communication & public transport for conveyance. Increase the number of public phone booths and strengthen the public transport system

Contd...

Table 5.1.6.1 Contd...

Sr. No.	Existing Status / Concern	Management Plan
23.	**Moonnilavu (0.564)**	
	Non-availability of fuels, water scarcity, poor transport and communication facilities and low sanitation are the main problems	Strengthen the public transport and communication facilities and encourage fuel efficient chulas. There are households with no latrine facilities. Measures may be taken to solve this problem
24.	**Koottikkal (0.563)**	
	Non-availability of fuels, poor transport and communication facilities, water scarcity and low quality of housing etc. are the main problems	Problem of non-availability of firewood has to be solved by promoting the use of fuel efficient chulas. Strengthen the communication and transport facilities. Water supply schemes are to be implemented and measures may be taken to improve the quality of housing
Idukki District		
25.	**Idukki kanjikuzhi (0.533)**	
	An interior area of idukki district, requires more communication and transport facilities. Other parameters of QOL which require urgent attention are better sanitation facilities and quality of housing etc	Since public telephones are being used by majority of people, measures should be taken to increase the number of public booths and number of private connections. Road network and public transport systems have to be strengthened
Alappuzha District		
26.	**Kainakari (0.501)**	
	Water pollution, sanitation problems and non-availability of funds are the main problems. Problems of quality of housing and transport do exist	Sanitary latrines to be provided for all households
27.	**Pulimkunnu (0.537)**	
	Water pollution problem is the prime problem affecting the QOL. Source of drinking water for the majority of Households is wells. But dissatisfaction exists due to poor quality of drinking water. Other problems are low quality of housing sanitation problems and public transport	Measures to abate the water pollution may be adopted and treated pipe water should be provided to the households
28.	**Kavalam (0.410)**	
	Non-availability of potable water is the main problem. Majority of people use untreated water from open water bodies. Other problems are quality of housing, sanitation & communications	Supplement water supply and augment and strengthen public road transport and water transport facilities

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Table 5.1.6.1 Contd...

Sr. No.	Existing Status / Concern	Management Plan
29.	**Veliyanadu (0.523)**	
	Most people use pit latrines and sanitation problems predominate. Pesticide pollution has been reported as the second important problem. Lack of drinking water, unemployment and low quality of housing are the other problems	Measures should be adopted to build latrines with septic tanks for all the households. Use of bio-pesticides should be encouraged
30.	**Edathwa (0.557)**	
	Drinking water problems, sanitation, poor quality of housing etc. are the main problems. Even though well water is being used by majority of households, the quality of water is poor	Measures to supply treated water is the only solution
31.	**Cheruthana (0.593)**	
	Water pollution and related drinking water problems and low quality of housing are the main problems	Well water and untreated water from ponds, and streams are the main sources of drinking water. Measures may be adopted to increase the QOL of people by solving their problems
32.	**Karuvatta (0.473)**	
	Water logging & flooding are the main problems which adversely affect the QOL. Drinking water problem comes second. Transportation, quality of housing sanitation etc. are other main problems	Rehabilitation of people from water logged areas & provision of safe drinking water require urgent attention
Pathanamthitta District		
33.	**Kallooppara (0.561)**	
	Water scarcity, fuel deficiency. quality of housing and environmental problems like air pollution are the main problems	Well water is used by majority of households. Freely collected firewood is the main fuel. Majority of houses are semi pucca. Measures are needed to solve this problem
34.	**Kozhenchery (0.512)**	
	Water scarcity. low quality housing unemployment and sanitation problems adversely affects the quality of life	Measures to provide the treated pipe water and quality of semi pucca house have to be improved. Special efforts to solve unemployment and sanitation problems
35.	**Cherukol (0.506)**	
	Transport, drinking water, housing, sanitation and employment are the problem sectors	Road networks has to be strengthened. Majority of households use pit latrines. Sanitation programmes are needed to improve this condition

Contd...

Table 5.1.6.1 Contd...

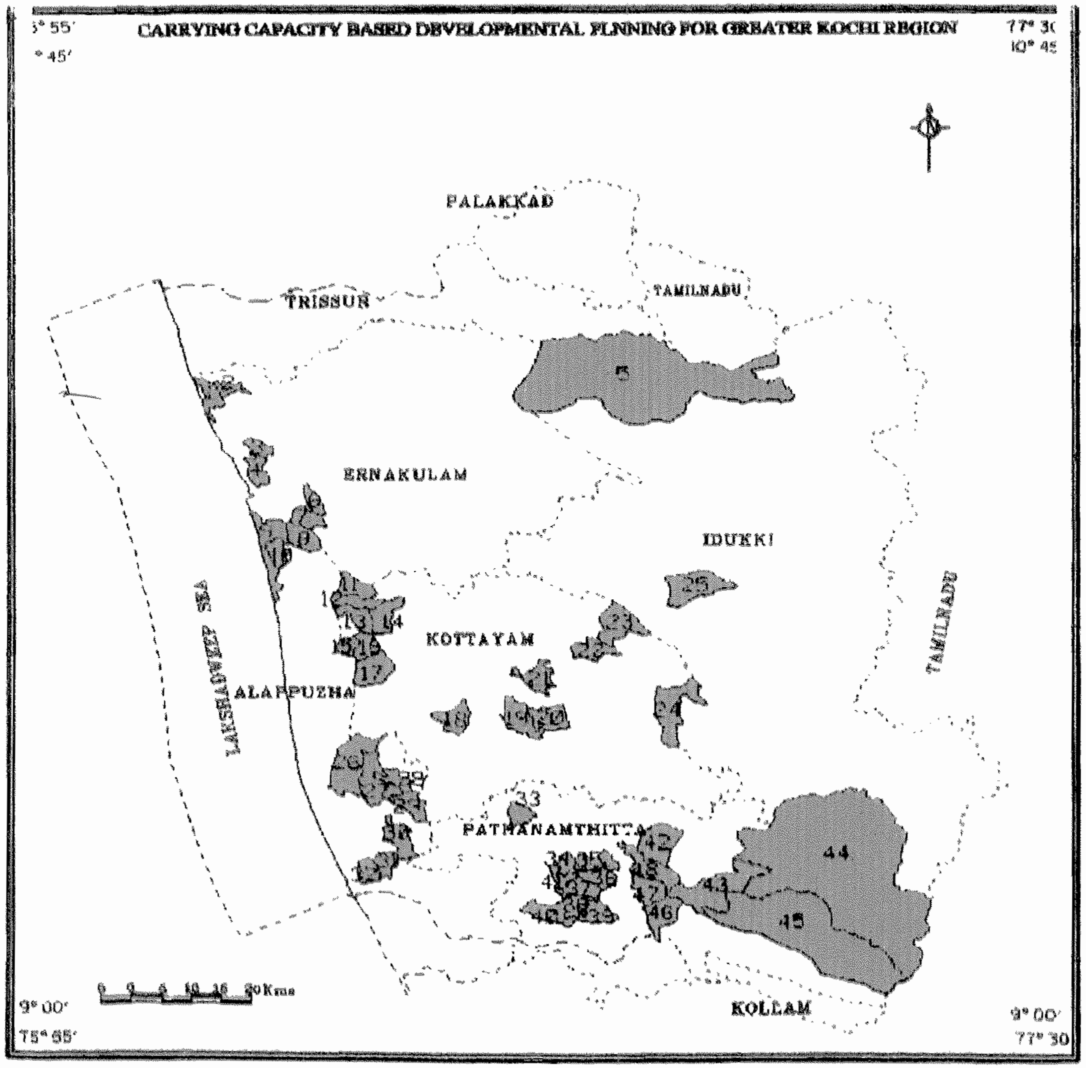
Sr. No.	Existing Status / Concern	Management Plan
36.	**Naranaganam (0.545)**	
	Transport, drinking water, employment and housing are the sectors which require urgent attention	Majority uses well water for drinking. Transport systems and housing sectors to be improved
37.	**Hanthur (0.518)**	
	Water scarcity, poor quality housing, poor transport facilities etc. are the main problems	Measures to provide treated pipe water and quality of semi pucca houses have to be improved. Better transport systems are to be needed
38.	**Chennerkkara (0.540)**	
	Water scarcity, poor transport networks are the main problems	Majority of people depend on well water for drinking purpose. Measures are needed to provide treated pipe water & the roads have to be repaired
39.	**Ommallur (0.479)**	
	Transport, drinking water, housing, employment and sanitation are the problem sectors	Public transport system has to be strengthened. steps to be adopted to implement water supply schemes
40.	**Kulanada (0.532)**	
	Housing, employment, transport and sanitation are the problems in the descending order of priority	Majority of houses are semi pucca. Measures are needed to repair them and transport and sanitation facilities are to be improved
41.	**Mallapuzhassery (0.510)**	
	Transport, employment, sanitation and, housing are problem sectors which adversely affect the QOL	Strengthen the road networks and public transport systems. Pit latrines have to be replaced by latrines with septic tanks
42.	**Naranamuzhi (0.487)**	
	Transport and communication, housing, sanitation, drinking water etc. are the main problem sectors	Public transport & communication facilities have to be strengthened. Majority of households do not possess latrine facilities. Measures are needed to solve those problems along with solution to drinking water problem and quality of housing
43.	**Chittar (0.537)**	
	Water scarcity. poor quality of housing, poor transport and communication facilities etc. are the main problems	Majority of households depend on wells for drinking water, special water supply schemes are to be implemented. Strengthen the transport and communication facilities

Contd...

Table 5.1.6.1 Contd...

Sr. No.	Existing Status / Concern	Management Plan
43.	**Chittar (0.537)**	
44.	**Seethathode ((0.516)**	
	The parameters of QOL with people's unsatisfaction are transport, communication, housing, employment and water availability.	Being a panchayat in the high ranges, steps to improve the transport and communication need top priority
45.	**Thannithode (0.454)**	
	Transport & communication, housing and physical environment are the priority sectors which needed urgent attention	Strengthen the transport and communication facilities and measures are to be adopted for concentration of top soil from erosion
46.	**Konni (0.537)**	
	The problem facing sectors in the decreasing order of priority are housing, drinking water, sanitation, transport and communication etc	Quality of housing has to be improved. Majority of households depend on wells for drinking water, measures are needed to implement water supply schemes. Pit latrines are used by majority of households. Solution to these problems is needed. Improve the transport and communication facilities
47.	**Malayalappuzha (0.597)**	
	Transport & communication, housing, sanitation and fuel deficiency are the main problems	Majority of people depend on public transport and the telephone facility is not accessible to them. Pit latrines are used by most of the households. Solution to these problems requires urgent attention
48.	**Vadasserikkara (0.446)**	
	The main problems are poor transport and communication facilities, low quality of housing, water scarcity and environmental problems	Strengthen public transport & communication systems. Majority of houses is semi pucca. Untreated well water is used by majority of households

Source : Primary data collected by KSSP



LEGEND

ERNAKULAM DISTRICT

1. Pallippuram
2. Chittattukara
3. Kadamakudy
4. Mulavukadu
5. Kuttampuzha
6. Trippunithura (M)
7. Maradu
8. Kumbalam
9. Chellanam
10. Kumbanji

KOTTAYAM DISTRICT

11. Chembu
12. Maravanthuruthu
13. Udayanapuram
14. Thalayolaparambu
15. Thalayazham
16. T.V.Puram
17. Vechur
18. Erattupetta
19. Kooroppada
20. Pallikkathodu
21. Kozhuvanal
22. Thalappalam
23. Moonnilavu
24. Koottikkal

IDUKKI DISTRICT

25. Idukki kanjikuzhi

ALAPPUZHA DISTRICT

26. Kainakari
27. Pulinkunnu
28. Kavalam
29. Veliyanadu
30. Edathua
31. Cheruthana
32. Karuvatta

PATHANAMTHITTA DISTRICT

33. Kallooppara
34. Kozhencherry
35. Cherukol
36. Naranganam
37. Elanthur
38. Chennerkkara
39. Omallur
40. Kulanada
41. Mullapuzhassery
42. Naranamuzhi
43. Chittar
44. Seethathode
45. Thannithode
46. Konni
47. Malayalappuzha
48. Vadasserikkara

Hotspots : QOL (s) < 0.60

Fig. 5.1.6.1 : Socio-Economic Environment : Hotspots

5.2 Limiting Resources and Resource Management Plans

5.2.1 Land

Land is the most limiting resource in Kerala and in specific in GKR. Based on 1991 census, per capita availability of land was 0.15 ha in GKR as against 0.13 ha for Kerala, against the figure of 2.0 ha, as recommended by the famous ecologist Eugene Odum for an environmentally sound requirement. This indicates the extent of stress on the land of GKR and its highly sensitive ecosystems. With respect to the operational holdings, during 1990-91, about 91.84% of land was under Marginal, i.e. Below 1 ha, 8.1% under the class small medium (1-10 ha) and 0.06% under Large (about 10 ha. and above). This also speaks of the difficulty in implementing mechanized agricultural farming in this region.

Management Plans

This is the most critical issue that may not have any immediate resolve in Kerala (or in GKR). Land area cannot be increased unless land is reclaimed from water bodies, substantially. Though on a relatively low pace, the reclamation of water bodies is steadily growing. However, on ecological and legal grounds, this activity is undesirable and punishable. The midland (35.90% of GKR) and the highland (50.00% of GKR) are highly vulnerable to soil erosion. For any land based major developmental activity, these terrains are unsuitable on environmental and economic grounds. This being so, the lowland, covering hardly 13.60% of GKR area, alone is available for any kind of land based development activities. Unfortunately, this region is the most densely populated with most fragmented holdings in the State. In 1996, per capita availability of land in the districts of Alappuzha and Ernakulam, forming part of the lowland region, was only 0.07 ha and 0.08 ha respectively. With the available population projections, this will come down to 0.05 and 0.07 ha, respectively, by 2026.

Under the existing law of inheritance, the fragmentation of land will continue further. There is hardly any resurgence from this highly difficult situation. However, there will be hope if a "U" turn takes place in our policy decisions, political will and social acceptance in the immediate future, which is a difficult proposition indeed. Some of the opinions that are to be given very serious considerations are:

- Arrest the fragmentation of holding within a fixed time frame. The land of inheritance may be changed such that only the eldest member of a family inherits the family property, while the other members may be entitled to an equal share of wealth that may be generated.
- Scientifically decide the minimum average size of holdings that is needed for specific landuse(s) based on landuse zonation, whether it is for agriculture, industrial siting etc. With policy and legal framework, consolidate the required number of holdings into one. For such landuses Resource or profit sharing with owners of such holdings may be done as per the size of the holdings or as per predetermined resource that could have been generated from such unit holdings.

- With the land area getting reduced, year after year, there cannot be any more luxury for Keralites to expand horizontally. Therefore, strictly regulate construction activities in this direction.

5.2.2 Water

River basin wise annual water availability, demand and quantum of deficit is given in **Table 5.2.2.1** which indicates that all the seven river basins will face water deficit in due course of time. The data on seasonal availability, demand and deficit/ surplus are furnished in **Table 5.2.2.2.**

5.2.3 Energy

Table 5.2.2.1

Basin wise Annual Water Availability and Demand (Mm^3)

River Basin	Utilizable Potential			Present Utilization					
	Surface	Ground	Total	Dome-stic	Live stock	Irri-gation	Indus-tries	Total	Return to Potential
Chalakudy	1493	204	1697	28	3	318	15	364	80
Periyar	6305	460	6765	155	12	1700	250	2117	425
Muvattupuzha*	1859	306	2165	47	7	647	80	781	162
Meenachil**	1056	242	1298	35	5	436	9	485	109
Manimala	888	245	1133	23	3	419	5	450	105
Pamba***	3297	212	3509	30	5	945	5	985	236
Achencoil	1343	232	1575	23	5	430	51	509	108

River Basin	Future Demands-2025 AD					Minimum Flushing of Pollutants	Total	(+) Surplus / (-) Deficit
	Dome-stic	Live stock	Irri-gation	Indus-tries	Pligri-mage			
Chalakudy	72	5	854	45	-	642	1618	79
Periyar	349	22	3525	750	-	404	5050	1715
MuvattuPuzha*	183	7	1196	240	-	-	1626	539
Meenachil**	118	6	875	27	-	-	1026	272
Manimala	88	4	980	15	-	-	1087	46
Pamba***	116	7	1185	15	10	4745	6078	-2569
Achencoil	128	8	1175	153	-	-	1464	111

* Half of the tailrace from Idukki now flowing into the Muvattupuzha will be utilized at Malankara dam.

** This river is practically dry during the summer months; backup of freshwater from other rivers, flowing into Vembanad, help to maintain the drinking water requirements of Kottayam municipality (intake point at Peroor)

*** Flushing requirements for the rivers directly falling into Vembanad estuary are shown against Pamba because of its locational and hydrological advantages.

Source : Secondary/Primary data collected by CWRDM

Table 5.2.2.2

Basin-wise Annual Water Availability and Demand in Monsoon and Non-Monsoon Periods (Mm^3)

River Basin	Sea-son	Utilizable Potential			Present Utilization					
		Surface	Ground	Total	Dome-stic	Live stock	Irri-gation	Indus-tries	Total	Return to Potential
Chalakudy	M	1375	102	**1477**	14	1	106	7	**128**	27
	NM	118	102	**220**	14	2	212	8	**236**	53
Periyar	M	5387	230	**5617**	77	6	567	125	**775**	142
	NM	918	230	**1148**	78	6	1133	125	**1342**	283
Muvattupuzha	M	1562	153	**1715**	23	3	215	40	**281**	54
	NM	297	153	**450**	24	4	432	40	**500**	83
Meenachil	M	1013	121	**1134**	17	2	145	4	**168**	36
	NM	43	121	**164**	18	3	291	5	**317**	73
Manimala	M	835	123	**958**	11	2	140	2	**155**	35
	NM	53	122	**175**	12	3	279	3	**297**	70
Pamb	M	2835	106	**2941**	15	1	315	2	**333**	79
	NM	462	106	**568**	15	2	630	3	**650**	158
Achencoil	M	1209	116	**1325**	11	2	143	25	**181**	36
	NM	134	116	**250**	12	3	287	26	**328**	72

River Basin	Season	Future Demands-2025 AD					Minimum Flushing of Pollutants	Total	(+) Surplus / (-) Deficit
		Dome-stic	Live stock	Irri-gation	Indus-tries	Pligri-mage			
Chalakudy	M	36	2	384	22	-	321	**765**	712
	NM	36	3	470	23	-	321	**853**	-633
Periyar	M	174	11	1586	375	-	202	**2348**	3269
	NM	175	11	1939	375	-	202	**2702**	-1554
MuvattuPuzha	M	91	3	538	120	-	-	**752**	963
	NM	92	4	658	120	-	-	**874**	-424
Meenachil	M	59	2	394	13	-	-	**469**	665
	NM	59	3	481	14	-	-	**557**	-393
Manimala	M	44	2	490	7	-	-	**543**	415
	NM	44	2	490	8	-	-	**544**	-369
Pamba	M	58	3	593	7	-	2372	**3033**	-92
	NM	58	4	592	8	10	2373	**3045**	-2477
Achencoil	M	64	4	577	76	-	-	**721**	604
	NM	64	4	598	77	-	-	**743**	-493

M - Monsoon; NM - Non-monsoon

Source : Secondary/Primary data collected by CWRDM

5.2.4 Industrial Minerals and Building Materials

5.2.4.1 Minerals

Industrial minerals are the backbone of any kind of economic development. Unfortunately, minerals have never been a positive contributor to the economy of Kerala State. In terms of percentage of contribution, Kerala's share from mineral resource is a bare 0.12% to the national revenue. This, in turn, tells the story of the industrial backwardness of the State, in general. In other words, lack of mineral resources can be said to be the major reason for the sluggish economic growth of the State.

Almost 100% of the limeshell deposits of Kerala is found in Vembanad estuary of GKR. About 33% of glass deposits of Kerala have been reported to be present in Cherthala-Alappuzha region. Graphite and china clay deposits have also been reported from GKR whose economic and environmental viability is yet to be established. Therefore, so far as industrial minerals are concerned, GKR has only limeshell and glass sand deposits worthy of mention. There are two types of limeshells, viz. black and white shells, which are being utilized for making white cements. The main consumer of white shells is the Travancore Cements Lts.(TCL) located at Kottayam, consuming about 40,000 MT of white limeshells, annually.

As per the GSI estimate, the total white shell reserve of Vembanad region is around 3.75 million MT. Operating since 1947; TCL has already consumed about 2.1 lakh MT of white shells. Optimistically, assuming a recovery rate of 50%, the remaining deposit can support the present industry for another 20 years or so. The industry cannot meet the resource crunch by utilizing the black shells because of its high demand by a number of local Co-operative Societies engaged in the manufacture of raw lime, locally.

Management plans for sustainable minerals extraction for shell limestone, tiles and brick clays and silica sand are suggested here.

Shell limestone

It is desirable to raise the black shell production to the Maximum Sustainable Yield (MSY) and utilize the resource only for producing value added products. The use of this high purity lime source for brick manufacture and other low-priced products should be banned / discouraged. Since the white shell resources are very limited and industries like Travancore Cement Ltd. etc. solely depend on this, a detailed investigation on the lime shell resources left out in Vembanad Lake and the adjoining regions has to be carried out by the State Mining and Geology Department, before planning any expansion of the concerned industrial sectors. Equally important is to prohibit interstate flow of this limited raw material for the sustenance of the indigenous industries.

The production trend of white shells was on the decline during the period 1992-98 (**Fig 2.4.2- Chapter 2**). If not immediately, the 'non-renewable' fossilized lime shell is likely to get exhausted within the foreseeable future. This would imply that the existing industries would have to depend solely on the renewable black shell resources - the exoskeleton of the living bivalves being collected manually by the local people every day. For the same reason, a stage will come in the near future, when the black shell resource would become non-renewable on account of over exploitation beyond the sustainable yield. Therefore, it is of paramount importance to keep the level of exploitation of black shell within the Maximum Sustainable Yield (MSY). A Research and Development programme is to be initiated to estimate the MSY of black shell from the Vembanad Lake. It is also in the sustainable interest of over 2000 laborers who are engaged in the collection of black shell, every day.

- It is rather inappropriate and impracticable, suggesting prohibition of dredging of white shell from the lake, right now. The Travancore Cements, the prime consumer industry, which solely depends on white shells, cannot immediately switch over to another source. In the circumstances, it is suggested that dredging may be allowed, if at all, only at sites so widely apart that the physico-chemical changes are localized and not regionalized.
- Manual collection of black shells (exoskeleton of living shells) within the MSY and its utilization for the industry - both commercial and cottage seems to be the best option in terms of sustainability of the resource vis - a-vis development perspectives.

Tile and Brick Clays

- The tile and brick clay resources of GKR should be quantified based on their grade. The State Mining and Geology Department can be advised to undertake this work.
- Limit the extraction of tile / brick clays to meet indigenous demand only. This is to save the prime agricultural land and also to increase the rice production in the State.
- Institutions like RRL; Thiruvananthapuram can undertake research activities to find in new building blocks that consume only low quantities flood plain clays.
- Regulate location specific extraction of the clay resource under well formulated guidelines,
- Prohibit mining below the level of depth to water table of adjacent areas.
- Convert the already mined areas found as fallow lands or water logged areas to farm ponds or irrigation ponds. The possibility of fresh water pissi-culture need also be looked into through R&D activities.
- Create awareness among the public to use laterite blocks for construction purposes; recycling of building materials, etc.

Silica sands

Silica sands of Cherthala are currently sold to the user industries working in Kerala and in the neighboring States. The major local user agencies are the

Excell Glass Industries Ltd., located at Alappuzha; the Kerala Construction Company Ltd. located at Cherthala and also by the numerous smaller silicate manufacturing industries. Also, a substantial quantity of silica sands is being transported to neighboring States mainly for foundry application and silicate production.

Regional Research Laboratory (RRL), Thiruvananthapuram has carried out qualitative studies in detail, of these silica sands. The study has revealed that that the sands are of very high grade (**Table 5.2.4.1**) and are suitable for glass industry as well as foundry applications. The silica sands of certain pockets have $Si0_2$ content of over 99% and are suitable for sheet, rolled and polished glasses, float glass and even for optic ophthalmic glasses.

It is surprising to note that a substantial amount of silica sand is being utilized for brick making with $CaCO_3$ as the binding material. This has got to be stopped forthwith. This high-grade sand can be used for the manufacture of many value added products. The scope for beneficiation of the sand to scale down the impurity level to that of the special grade for making optical and ophthalmic glasses was investigated by the RRL, Thiruvananthapuram, on a laboratory scale with positive results. Regarding the scope for development, the Task Force on Mining (State Planning Board, 1996) has stated that the very large resources of high quality silica sand in Cherthala could constitute an ideal raw material for glass industry, foundries, silicate industry, etc.

- Silica sand deposits in Alappuzha District are having large reserves of the order of 70 million MT. Of this, about 30 million MT are present in blocks covering Pallippuram, Thycauttusseri and Panavally villages, which form the main mining centres. The sand is of very high grade and suitable for glass industry and foundry applications.
- So far, the deposits have been worked only in a number of small mines and after manual screening, it is sold to consumers in the state and other neighboring States, mainly for ordinary glass bottles and foundry application. Beneficiation tests carried out on the sands have demonstrated their amenability for being suitably upgraded to suit the specifications for manufacture of sheet rolled and polished glasses, sheet glass and even optic and ophthalmic glasses. In this background, measures have to be taken for the optimal utilization of the deposits for more value added products.
- For attracting entrepreneurs for exploring the scope for establishment of industries for more value added products based on the silica sand deposits of the area; as a first step, it would be essential to carry out a detailed investigation / exploration for assessment of mineable reserves in potential large size blocks taken by the DMG.

5.2.4.2 Building Materials

Because of the Gulf boom and a new construction culture, there has been an exponential increase in construction activities. Consequently, and significantly so, there has been mounting pressure on the river sand and bricks made out of clay, two essential ingredients for the construction industry. Since demand exceeds availability, not only that the price accelerates but also the environmental conditions deteriorate, often beyond redemption.

River Sand

Because of exponential increase in construction activities, sand is fast becoming a scarce commodity through out the State. The increasing trend of exploitation is reflected in the tables and illustrations given in chapter 2.

Based on the existing information, the following management plans are suggested:

- Interstate transportation of sand should be banned
- Utilization of river sands for purposes other than construction should be banned
- Scientific and technical assessments should be made to delineate areas from which the extraction can be done and the quantity that can be extracted
- The sites will normally be changed every year to reduce intensive exploitation.
- A replenishment assessment should be made every year immediately after the monsoon to estimate the sustainable replenishment of the resource
- Strict vigilance is needed at each *kadavus* for clandestine mining
- Pass systems have to be introduced and sand extraction should be allowed only during specific hours of the day
- Strictly enforce the existing sand mining rules enacted by the Government
- Auctioning of river sand should be discontinued. Amount payable for each load should be fixed. This revenue should be divided among the local bodies and laborers. The local body should set apart certain amount for environmental cleansing
- EIA should be done for all future mining sites. Existing environmental impacts should be assessed and remedial measures are to be suggested for implementation and monitoring
- No vehicle should be allowed inside the river channel for loading sand directly from the river bed
- Alternative source of sand for building purposes have to be found out or developed
- Low cost, 'Baker Type' building constructions needing very low quantity of sand should be promoted with incentives such as house tax reduction / exemption, preference in the allotment of power / water connection, etc.

Tile and Brick clays

These are mined from paddy fields, mainly from Trichur and Ernakulam districts of GKR for the purpose of manufacturing decorative roof tiles, wire cut and ordinary bricks etc. As in the case of river sands, exponential increase in exploitation of these resources will soon cause resource crunch in near future. Environmental problems created by the mining will impose restrictions on further resource recovery, and call for the demand of new materials for manufacture of roof tiles and bricks.

There are valleys and flood plains, which have already been silted up, needing a level of deepening to be useful for cultivation or agricultural practices. These are to be mapped for sustainable resource exploitation by a competent authority(ies), and mining should be carried out within the sustainable limit.

It is reported that while in the districts of Thrissur and Ernakulam, the tile and brick manufacturers use clay mined from paddy fields, in the southern districts, clay mined from the backwaters (estuaries) are used. A study by RRL, Thiruvananthapuram, confirms that the clays mined from the backwaters are equally good for brick and tile industry. Commercial mining would also help deepening the backwaters, whose silting up has been cited as one of the ecological problems faced by them.

5.2.5 Resource management plan for Fisheries

- There is an urgent need to restore the Vembanad Lake and to protect the habitats
- On an experimental basis, at least the lower reaches of the Kochi backwaters may be declared as a protected sanctuary
- Strict prohibition of catching, landing, holding, selling, processing and exporting of undersized fishes should be implemented. Allowable catch size of each species should be prescribed and popularized. This is required to avoid using of inappropriate gears
- Educating the fishermen on the need for conservation of the juveniles of prawns and fishes
- Strict prohibition of unauthorized stake nets and Chinese dip nets
- Mesh size regulation of the gears operated in the inland water bodies of Kerala, especially the stake nets and cast nets
- Banning of smaller sized shrimps from export
- Banning of reclamation of inland water bodies
- Protection of spawners of the commercially important species during the spawning season
- Setting up of adequate number of fish and shrimp hatcheries in different parts of inland water bodies and coastal area and periodic release of seeds into the natural environment (Ranching)

- The 'relaying of clams', as adopted by some clam fishermen of Vembanad Lake by which spat collected from the natural bed are stocked in the water bodies adjacent to the fisherman's residence where they are grown to marketable size is a good conservation measure. By this method, the clam is protected from depletion. Considering the high spat fall in certain areas in Vembanad Lake, it is suggested that some initiatives need to be taken to relay the clam spat from the high-density areas to suitable locations in densities 450-600 for further growth of the clams
- Strict measures have to be enforced to keep the water and sediment quality within the prescribed limits
- Reclamation of backwaters should be stopped to protect the nursery grounds ~~and the area~~ covered by the water body
- A campaign for mangrove afforestation should be undertaken to revive the nursery grounds and mangrove ecosystem in backwaters
- The operation of stake nets (fixed nets) in the backwaters and inland water bodies should be restricted to the ebb tide periods and the code end of the stake nets may be limited to 30 mm and above to avoid destruction of juveniles
- Thanneermukkam bund may be kept open permanently and fish farming encouraged in Kuttanad area, as the bund has not yielded much benefit for agriculture but caused pesticide pollution and destruction of biota
- Since the resources of grey mullets and chanos are getting depleted, sea ranching may be introduced by getting seeds through induced breeding
- Restrict the fishing at the Kochi bar mouth area during December to April since seaward spawning migration of commercially important fishes take place during that period
- About 5000-6000 ha of the shallow peripheral area of the Vembanad Lake can be developed for semi-intensive fish farming
    - The northern sector of the lake (Kochi area) can be used for culturing prawns and euryhaline fishes
    - The central sector can be used for true brackish water fishes, as salinity is less in this area
    - The southern sector can be used for culturing freshwater species like Indian major carps
- Introduction of exotic species in the water bodies without quality control and ecological balancing to be stopped.
- Standardization of aquaculture practices and technology along with quality standards for seed and feed is essential.
- Set limit to the fishing effort, species wise catches (quota) and minimum mesh size of gears
- There is a need to have a proper account of the fishing crafts and gears used. Unauthorized or illegal fishing operations appear to be considerable.

- Cold storages and marketing outlets should be set up at important landing centres. Lack of these facilities force fishermen to discard catches during peak season when surplus landing takes place.
- No further fishing effort is required in capture fisheries in the 0 to 50 m depth zone in coastal waters. Available fishing fleet may be used with essential modification to exploit the resources in the deep sea. Efforts in this direction by a few people operating from Munambam fishing harbour appear to have yielded good results. However, precaution should be taken to avoid overexploitation. This requires a proper assessment of stock and sustainable yield
- A moratorium on catching of fishes, which are depleting, vulnerable, rare or endangered for a specific period, may be imposed to revive the stock of these species. Sea ranching may also be adopted for rehabilitation of the stock
- Seasonal ban on trawling (since 1988 during the monsoon period) for about 45 days appears to have yielded some positive results in total catch and catch per unit effort. Therefore, the ban may be continued. High powered OBM crafts (> 25 HP engine) operation may also be banned during the ban period
- Fishing space allocation for different groups like traditional fishermen and mechanized boats need to be implemented to avoid conflicts. Existing regulations in this respect may incorporate high powered country crafts (> 25 HP engine) as a separate category
- Regulations on the use of inappropriate gears (ring seine, purse seine, pelagic trawl, mid-water trawl and others) should be implemented strictly
- Existing regulations on exploitation of living resources should be strictly implemented or enforced. Amendments may be required in the KMFR Act (1980) to regulate number of fishing vessels operating in an area, seasons, mesh size of gears, the size of fishes to be caught and sold, etc.
- Optimization of fishing crafts and gears need to be worked out and popularized
- Nearly 20% of the exploited fishery resources are used on industrial scale for processing and export. Hence only 80% of the fish catch is available for domestic consumption. Although exports reduce the availability of fish as food domestically, earning of foreign exchange helps the general economy and enhances the earning of fisheries sector including the fisher folk. Therefore, the allocation of fishery resources to the industry for export at the present level of 20% of the total catch need not be enhanced considering the stagnation of fish catch and food habits of the domestic population. Exclusive export oriented aquaculture production of fishes is being encouraged by the Marine Products Export Development Authority. Since the aquaculture has the potential to grow, even though the environmental problems are yet to be solved, the export growth should be attained through aquaculture production and not through the capture fisheries.

- Traditional management system of fisher folk should be integrated with the modern management practice
- A stakeholder consultation and awareness building mechanism need to be evolved for better management. This process should include identification of stakeholders, stakeholder analysis and stakeholder perception analysis.
- Awareness building and consultation among stakeholders should focus on

  - needs, benefits and methods of fisheries management,

  - alternative fishery options, and

  - offshore fishery options

  Participatory fisheries management practice can be evolved and enforced through

  - establishment of community learning centers,

  - meetings with fishermen and stakeholders,

  - awareness building materials development and distribution ,

  - technical assistance, and

  - capacity building through training of extension staff
- Government has been involved in fisheries development and management over the past half a century. But poverty persists in the Fisheries Sector. Environmental and resource problems are at the root of much of this poverty. Fisheries poverty cannot be alleviated without fisheries sustainability. In order to effectively manage the fisheries sector, planning should be based on the following premises.

- Acceptance of the fact that fisher folk are fast learners, who adjust quickly to changing circumstances that affect their way of life and livelihood security because their survival instinct is very rational.
- Not enough emphasis is paid in fisheries management to control fishing effort and capacity. There still remains great resistance throughout the world to cutting back fishing effort and capacity. This is mainly because any exercise to work out the cost of production of fish landed fails to consider the real cost of fishing especially the cost of using open-access common property resources. Fishery resources are free-access resources as compared to other resources. Fish producers are too less in number but fish harvesters are plenty in number since the capture fisheries is an enterprise of only exploitation of naturally occurring resources without paying for the cost of resource. Fishing effort will automatically decline once all the cost of fishing, including resource cost, are taken into consideration in calculating production costs and final market price of fish.
- There is a real need for fisheries managers and management to adjust to technology change – particularly technology advances in fisheries – at both the pre-harvest and post-harvest levels.
- Fisheries and aquatic resources management is still government-driven, though experiences worldwide show that partnership between government and industry strengthens management. Community-based management is the need of the hour.

- Government managers may be active but there is a need to be proactive if they are to encourage fisheries management. They have to work in tandem with the fisherfolk and win the trust of the fisherfolk.
- There is insufficient effort to increase awareness among fisherfolk about the need for, the benefits and methods of management.
- The socio-economics of fishing communities suffers neglect, though experience has shown that fisheries management has as much to do with fishing communities as with fisheries biology.
- Licensing has been just a procedure for registration of fishing boats, it has to be converted as an active tool to promote and strengthen fisheries management.
- Licensing should be used to generate revenues to pay for management cost, to separate legal and illegal fish harvesters, to apprehend illegal harvesters, to monitor the compliance of management rules by licensed fishers. Licensing can also be used to delineate clear physical and geographical boundaries of operation for various groups and allowable catch.
- Jobs are needed, but not enough are created to supplement fishing as an occupation. Unless alternative or supplemental jobs are found for these fisher folk to improve their purchasing power, no amount of management can succeed in promoting sustainable fisheries

5.2.6 Agriculture

The strategy for agricultural development should be one of maximizing the income from unit land through a systems approach to resource use and management, integrating crop, livestock and fisheries. The focus will have to be on ensuring the livelihood security to the population dependent on agriculture rather than enhancing commodity production *per se*. The ultimate objective would be strengthening the income base of the small and marginal farmers by enabling them the optimal utilization of the biophysical resources available at their command and of the agricultural labour by enlarging the employment opportunities.

Realization of this objective depends, on the one hand, fostering the natural strengths and advantages emanating from the resource endowments, and, on the other, sharpening the competitive edge of the State's agriculture through improvement in productivity and quality and reduction in cost. Agriculture including cropping, animal rearing, fisheries and agro-forestry being the mainstay of the State's rural economy, the responsibility for planning and development of this vital sector is entrusted to the local bodies consequent to the introduction of the Panchayat Raj System. The State level machinery will have to assume a different role under the new dispensation and play primarily a facilitating role, which enables the local bodies in discharging their responsibilities more effectively.

It is with lot of expectations that the new Panchayat Raj System has been entrusted with the responsibility of development of agriculture in the State to maximize income from unit land through an integrated approach. A lot had been spent already in the sector. However, it is too early to gather data and assess the overall impact of the new set up in the agricultural economy of the State. Agricultural development with people's participation has been a well-orchestrated slogan since many years. If it can bring forth the desired impetuous in the agricultural sector, especially in food crops, fisheries etc., it would be highly rewarding. Probably, it is the last hope for Kerala, and for that matter for GKR in an otherwise ailing agriculture sector.

In the case of policy measures at the operational level, the problems of major plantation crops of coffee, cardamom, tea and rubber can not come within the mandate of the State as the Commodity Boards come under the Ministry of Commerce, Government of India. The major agro-management issues and marketing problems come under the purview of the Commodity Boards, whereas, the major part of the contentious area of taxes and duties fall in the borderlines of the State Government. However, there is enough scope for meaningful dialogue between the State Government and the Commodity Boards as many spheres of critical initiatives and actions are complementary and concurrent. Since the largest share of contribution of the plantation crops comes from the GKR, it is most relevant and of contextual significance.

5.2.6.1 Coconut

Low Productivity and Productivity Potential

The productivity of GKR is less than that of the State. The State, in turn, has less productivity as compared to the national average. The very low productivity of GKR is nothing but due to the debilitating Root (wilt) disease afflicted by the palm in all districts of GKR.

A survey conducted by CPCRI in 1984-85 has indicated that the average productivity of the healthy tracts of Kerala is 61 nuts per palm. The responses of the west-coast tall coconut palms to different management practices has shown that irrigation alone can boost up production to the extent of 131% and irrigation coupled with manuring to the extent of 216%. The increase in productivity, in that case, comes to around 94 nuts per palm per year.

Good management practices with irrigation can produce about 17500 nuts/ha/year (@100 nuts/palm/year X 175 palms/ha). Similarly, the productivity of a palm in the disease affected tracts of GKR can be raised at least up to 50 nuts/palm/year, a revenue of Rs.1862 crores (@ Rs. 5 per nut) can be generated instead of the present revenue of about 1143 crores. If this can be achieved, it will be a good performance from the disease-affected palms. Further, multiple cropping in coconut garden would greatly enhance the productivity per unit area and stabilize the price structure of coconut products. Some of the management perspectives of coconut and its economy are:

a. The basic need for increasing the productivity of coconuts in the State is promotion of a regular system of under planting / replanting of the existing plantations and irrigation. To ensure effective management practices, all young palms that have contracted the disease before the onset of flowering and even the palms in the advanced stage of the disease need removal alongwith the trunks, which otherwise would become the source of pests and pathogens. Adoption of an integrated management system will enhance the palm productivity. Mixed farming with livestock or cultivation of non-competitive intercrops will increase the income from unit area in the holdings. Irrigation is the most assured single component that promotes productivity: its impact is visual and significant irrespective of the incidence of coconut root (wilt) disease. This will further ensure confidence among the coconut growers.

b. Use good quality, disease free and high yielding (100 nuts/yr) seedlings. Vigorous seedlings should be selected on the basis of early germination, number of leaves, girth at collar and early splitting of leaflets. Such selections should be rigorous with 65% acceptability. The tall cultivers of West Coast Tall, Laccadive Ordinary and Andaman Ordinary are recommended for the production of seeds / seedlings in Kerala State. Among the dwarfs, Chowghat Orange Dwarf and Malayan Yellow Dwarf are recommended for using as female parents in DxT hybrid production. Mother palms must have stout, straight trunks with over 30 leaves and 12 inflorescence.

c. Spurious supply of seedlings needs restriction. Registration of coconut nurseries is to be introduced and the quality of seedlings ensured by proper supply of seed nuts and periodical inspection. Movement of seedlings from the diseased tracts to the disease-free area needs an absolute ban.

d. Pests and diseases need prompt attention. Prophylactic crown treatment of palms with an insecticide-sand mixture prevents the infestation of major pests. Biological suppression with entomopathogens and the maintenance of field sanitation shall be resorted to. The leaf-rot disease superimposed on coconut root (wilt) disease will be disastrous and needs control by regular sprayings of fungicides. The bud rot and stem bleedings can be kept under control by the recommended procedures.

e. Further, research efforts are needed to handle this deadly disease of coconut root.

Products and By-products

a. Post harvest processing should be exploited to the fullest extent for various other by-products alongwith the extraction of oil and fibre from the husks. The high potential of the by products should be fully exploited.

b. Promotion of research efforts to achieve complete utilization of the products and by-products of coconut in the most remunerative manner with commercial and optimal utilization of available technologies.

c. Research needs for better utilization of various products, viz.

   - use of appropriate fractions of coconut oil for possible power generation,

- use of kernel (about 50% of the nut) for the production of a variety of food products, like coconut cream, cream powder etc. Fresh coconut kernel contains 37% fat and 45% water, which can be bottled. According to one estimate, 10,000 dehusked nuts yield 1000 Kg coconut water and 1500 kg coconut shell. It is possible to convert the shell into activated charcoal or shell powder used as filler in laminated building materials.
- Extraction of quality coir fiber from husks
- Proper use of coconut pith (about 70 % of the husk) for briquetting etc. The coconut trunk can be used for the construction of rural houses, temporary sheds and buildings and rural bridges.
- Use of coconut shell (about 17 kg/100 husked coconuts) for the construction of cellular blocks and sandwich panels.
- Use of coconut trunks having excellent grain characteristics as wood panels and flooring materials, etc.

d. Retting of husks is an art acquired by retters that needs natural facilities. It is also possible to extract the bristle and hard fibres by mechanical means. Hand spinning of the coir fibre into yarn is yet another art that is traditional. But the fibre can be spun into yarn in other area with the aid of simple devices.

e. Unfermented coconut toddy has its identity for colour, flavour and taste and a suitable method to preserve this identify over a period of time is yet to crystallize. The fermented toddy on distillation yields the 'coconut feni' that is distinct in an individual manner. Such individuality is comparable to that of the 'cashew feni' of Goa and the 'Japanese sake' (fermented rice distillate). Coconut feni is produced commercially in Sri Lanka. Coconut feni is far superior to other low cost alcoholic drinks and can match any sophisticated blends.

f. From the marketing angle, the price of coconut oil needs stabilization. At present, the price is fixed in the terminal markets, far away from the State where almost the entire copra is produced. The middlemen abuse the procurement from the farmers. The violent fluctuations in the price stability are attributable to speculations on weather and supply A supply management scheme has to be carefully organized. The production of copra should be continuous in spite of the weather and its likely vagaries. This can be achieved with the aid of large-scale copra driers in adverse circumstances and quality control ensured with moisture metres.

g. Involvement of farmers in the primary level and development of basic infrastructural facilities at the village level is essential for large-scale production of copra. These primary level units need linking with district level units that are assigned the task of milling and processing of products and by-products. The total impact envisaged in a cohesive system comprising of increased productivity, continuous production of copra with assured quality (assuring a supply on demand) and the best exploitation of the post harvest processing of the products and by-products with the available technology, will facilitate an integrated development.

5.2.6.2 Rice

Salvaging the rice economy by arresting further fall in area under rice cultivation has been one of the major objectives of agricultural development since the 8th Five Year Plan, however, only very little progress could be achieved till now. Further, the area under rice has declined from 4.30 lakh ha to 3.87 lakh ha in Kerala till 1997-98. Similar situation prevailed in GKR as well. The productivity of rice in GKR recorded a decrease of 159 kg/ha in 2 years time (from 1995-96 to 1997-98). The production of rice touched its all time lowest level of 6.06 lakh MT during the 1997-98, against the target of 12.5 lakh MT.

Area under paddy cultivation decreased considerably, almost in all the districts of GKR. The decrease in area was maximum in Trichur district (-10567 ha) followed by Ernakulam (-7836 ha), Palakkad (-7550 ha) and Kottayam (-6446 ha). These are the districts, which account for the major proportion of the area under the crop (57%), and where onslaught of the declining trend in area was comparatively lower all these years. The area benefited by the major irrigation projects also, by and large, was localized in these districts. Local interventions with the active support of the district and block panchayats for preserving the prime paddy lands of GKR include:

- Strengthening the infrastructural facilities including streamlining of the schedule of water releases from the major irrigation projects,
- Fostering of group interventions in a really functional manner by creating required facilities by the planning authorities
- Encourage group farming system with the support of various common facilities like tillers, transplanters, harvesters, storage etc. to augment productivity and irrigation facility
- Developmental activities basically require proper application of Technology, Resources, and Will, to achieve best outputs.

Rice is grown under different situations with specific locational problems and accordingly the crop yield varies, which can be enhanced through proper management practices. It has been recorded that even in a district like Calicut where the present average yield is only about 1.2 MT/ha, it was possible to harvest 6.421 MT/ha and even upto 901 MT/ha. It was observed that in all the districts, which yielded above 6 MT/ha paddy, had no assured irrigation from an irrigation project. This means that sufficient technology exists to maximise rice production to the tune of 6.6 MT to 9.3 MT of paddy/ha. The state has potential to produce, on an average, 36 lakh MT of paddy (approx. 24 lakh MT of rice) from 6 lakh ha of paddy fields. However, even with maximum efforts, total self-sufficiency in the case of rice production cannot be achieved in Kerala.

- Better utilization of existing irrigation projects, with improved irrigation efficiency through proper field layout, installation of flow control structures and proper on-farm development to ensure water control are basic requirements for profitable rice production, should be looked into.

- Encourage labourers/farmers or look for mechanisation. (Non-availability of labour is a serious problem in rice production since nearly 51% of the cost of production is accounted by labour cost. Scarcity of labour is very acute for the second crop since the harvest of the first crop and transplanting of the second crop has to go simultaneously. This calls for change of agronomy of the crop.)

It is reported that advancing the first crop by one month will give an additional yield ranging from 500 to 750 kg/ha, whereas advancing the second crop would give at least an extra yield of 250 kg/ha. This can be achieved by dry sowing / dibbling under dry condition in the ayacut areas of irrigation projects. However, dry sowing may cause heavy infestation of weeds. Dibbling followed by compaction of soil and application of the weedicide "Butachlor" will effectively control weed growth and ensure a uniform stand of the crop.

The goal in potential rice production can be achieved only through the spread of the high yielding varieties. National demonstrations conducted by the Kerala Agricultural University in 1975-76 have revealed that yields as high as 8.7 MT/ha is realizable. The average yield for 18 cultivators for Rabi season of 1975-76 worked out to be 5.6 MT/ha. The Agricultural Department has conducted Crop Competition in 12 districts of the State as part of the programmes for rice production. These districts include all the districts of GKR. The results of the crop competition programme are given earlier in **Table 2.6.1.3**. The data reveals that a yield ranging from 15.9 MT/ha (Palakkad District) to 6.9 MT/ha (Pathanamthitta district) is possible even with the present varieties and technology. Realization of even 6 MT/ha will be a real boost to GKR in as much as these most important cereals is concerned. For full expression of the yield potential of these varieties, good management including proper water control is needed. Therefore, it is necessary to take up land development work in all rice growing areas to ensure independent irrigation and drainage channels for effective water control, even if the areas do not come within the ayacut of an irrigation project.

Even then, because of competing demand for land for various landuses, it is rather difficult to protect paddy cultivation and paddy land from encroachment. In fact, a cause effect impact analysis (**Fig. 5.2.6.1**) suggests that because of the highly complicated interplay of cause effect relationships, rice crop cultivation in Kerala can hardly get back to its original position.

5.2.6.3 Rubber

Both long and short-term measures are suggested to increase the productivity of Rubber. It is estimated that in Kerala about 75000 ha are overdue for replantation. Mostly, these are smallholdings and the poor planters are continuing to keep and tap these trees that have already completed their economic life of about 30 years.

People are reluctant to go in for replanting, as they will have to go without production and income for the next 6 years. The possibility of a good income from intercropping is limited. Sufficient planting materials and money are available. But in many areas, often the small grower finds it difficult to cut down the trees due to inter-union rivalries of workers. Income from timber for the small growers will improve if the Kerala Government lifts the ban on interstate transport of rubber wood. Setting up of rubber wood processing units will also help in value addition for rubber wood. Following measures for improvement in the productivity of rubber are suggested;

- Manuring only after testing of soil and leaf. A massive campaign for this is to be launched, which will decrease expenditure on manure and will improve yield
- Adoption of rain-guarding – at least 10% addition to the crop will result from this measure
- Better tapping tools and techniques
- Tapping after using chemical stimulants in trees more than 20 years old
- Prevention of weeds, conservation of soil moisture and enrichment of soil by growing cover crops
- Adoption of appropriate plant protection measures
- Motivating the rubber producing farmers/societies
- Promotion of rubber processing in cottage as well as corporate sector
- Better processing & efficient marketing of rubber products

This approach to rubber-based industrialization can change the rural scenario. Further, commercial exploitation of the potential of intercropping and rubber honey may be looked into even in the immature and mature phases of rubber plantations, even though intercropping in the immature phase of rubber plantations with an estimated net income in the range of Rs. 22000 – Rs. 27000 per ha in the first three years is relatively popular. Region specific recommendations on the suitability of competing intercrops such as pineapple, banana, ginger and tapioca are important. The estimated yield of honey in mature phase is about per 182 kg/ha and the estimated net income is about Rs.5000/ha.

A cause-effect- impact network of increased rubber production and fall in rubber price is shown in **Figs. 5.2.6.2** and **5.2.6.3** respectively. This also suggests the direction in which one should move to salvage the rubber sector form its present sorry position.

5.2.6.4 Coffee

The Task Force on Plantation Crops of the State Planning Board has addressed a policy and agro-management issue of this cash crop.

A comparatively higher degree of structural and geographical concentration of cultivation and production has important policy implications in terms of increasing productivity and production of coffee in Kerala compared to Karnataka and Tamilnadu. The estimated share of the small holdings (below 10 ha) in total coffee production in Kerala is about 80% and therefore, policy imperatives have to be invariably focused on the issues confronting this sector.

and recommendations of the Central Coffee Research Institute (CCRI) for the farmers availing the subsidy for various schemes."

Quality upgradation and value-addition

The Task Force further states that "two aspects are important ingredients for the sustained growth of coffee cultivation in the post-liberalized coffee trade scenario due to three main reasons".

- coffee is basically an export oriented crop and the Robusta variety grown in Kerala has a market in the global trade,
- quality improvement and value-addition at the producers' level are essential prerequisites to withstand the vagaries of the world market and
- positive effects of productivity improvements will be nullified unless such achievements are not matched by the increases in the net returns of the producers as in future there would be well defined limits for subsidies at different levels by the government. These issues assume added significance in Kerala, arising from the small grower dominated structure of production and inadequate infrastructure facilities for quality up gradation, value-addition and primary marketing compared to their counterparts in Karnataka."

Further, coffee cultivation can also be introduced in lower elevations like that of tea with adequate technological and R&D backup.

5.2.6.5 Tea

Role of State Planning Board is limited in the preparation of strategic management plan for increasing the productivity of tea in the region, probably, because the major producers in the region are private holders who do have their own management practices and research priorities. Slow pace in productivity increase compared to other regions and the escalation in cost of tea production are the issues of concern, for which it is important to delineate the agro-management issues affecting tea industry in Kerala into :

- agro-climatic factors and
- agro-management practices

The agro-climatic factors prevailing in Kerala are not ideal for tea cultivation as evident from the uneven distribution of rainfall, long droughts and steep terrain, resulting in higher incidences of pest attack, and hence affecting productivity, and cost of production. The net effect of soil erosion and long drought has a comparatively higher vacancy ratio in Kerala compared to other regions. In fact, as a consequence of the combined negative effect of hostile agro-climatic conditions and non-remunerative prices for tea-leaf offered by the private owned/bought-leaf factories, there was a large scale shifting to rubber by the small and marginal tea growers in Kottayam and Idukki districts since 1970 as documented in the Tea Board's Techno-Economic Survey Report published in 1979.

More specifically, due to not so congenial agro-climatic conditions and operational level problems related to primary processing and marketing of tea in Kerala, the small growers having less than 50 ha has been reduced to an insignificant group over the time. The small tea growers in Kerala numbering around 4000, control about 10% of the area under the crop, whereas in Tamilnadu, the relative share of this group is 28%. Therefore, in the Kerala context, any serious attempt to streamline a revival strategy in terms of agro-management issues has to focus on the large-size groups having a vertically integrated system of green leaf production, primary processing and marketing."

Another major issue relating to slow pace of productivity increase in Kerala is the need for proper attention for agro-management. Tea bushes being main assets of a tea garden determining the economic viability start declining after 50 years of age for want of adequate care. Recent research indicates that higher plant population per ha and newer technique of bringing young tea into bearing has been useful in enhancing the productivity. Unfortunately, the current Kerala tea scenario stands in sharp contrast to the two agronomic aspects mentioned above. First of all, the relative share of area in the age-group of above 50 years is the highest in Kerala (73%) compared to Tamilnadu (42%), West Bengal (48%) and Assam (32%).

At a disaggregated level, it is important to note that, in Kerala, the share of area in the above 50 years age group is the highest in Idukki district (79%) having serious policy implications as the district's share in total area under tea in the state is 68 per cent. It is also worthwhile to mention that the tea estates in the largest size-group are concentrated in this district. Latest Tea Board statistics reveal that replanting in south India, as a whole, is less than 1% as a proportion of area under the uneconomic age group. The share of replanting was less than 2% as a proportion to the total capital expenditure during the period between 1973-83 in the case of 24 estates. The vacancy percentage of Kerala (20-30%) is also the highest in the country.

The cumulative effect of by-passing/postponing the replanting/ replacement requirements would certainly have a 'backwash effect" in the long run. The emerging picture of tea industry in Kerala with the highest cost of production in South India is of a "vicious circle" as the present situation is not conducive to any long term sustained increase in productivity unless the important agronomic requirements of replanting / replacement are initiated on a warfooting basis by the management rather than completely depending on concessions and institutional support.

Rejuvenation, pruning, consolidation of existing plantations by in- filling, improvements in pruning, plucking, balanced manuring and application of growth promoters are some of the factors useful in enhancing productivity of tea plantations in Kerala. It is also true that the unit cost of production of tea and labour wages are higher in Kerala and labour productivity is relatively lower. The issue of enhancing labour productivity and introducing productivity-linked wages do not imply any operational level significance unless commensurate increases are achieved in yield. Time bound adequate measures need to be taken systematically for survival of tea industry with productivity potential of 7.5t/ha in Kerala.

The crisis faced by the tea sector can be analysed by the cause-effect-impact network (**Fig.5.2.6.4**), highlighting the type of interventions needed.

5.2.6.6 Pepper

Annual production target of pepper was fixed at 1.12 lakh MT in the 9th five-year plan against the production of about 0.5 lakh MT during 1997-98. The additional increased production is to be achieved through increase in productivity.

The principal reason for the low productivity of pepper is the large proportions of existing pepper plantings have outlived their economic bearing period. Further, the old and senile plants have lost their capacity for resilience and as a result they have become vulnerable to lethal diseases like Quick Wilt. Plant protection for combating the disease may help in protecting the plants. However, a permanent solution lies in massive rehabilitation of old plants.

As in the case of coconut, pepper is also a traditional crop of GKR, confronting problems like large proportions of old, uneconomic, populations; rapidly spreading Quick Wilt disease, poor management, etc. resulting in very low productivity, which is hardly 1/3 of its potential. These challenges have got to be met as early as possible through:

- Massive rehabilitation programme
- Popularization and use of developed biotechnical tools for transfer of resistance, conservation of elite genotypes, callus-mediated short regeneration resistant to phytophthora, etc. at the earliest, breaking traditional reluctance of farmers
- Popularization and use of new developed 10 high yielding varieties / hybrids in black pepper among planters
- Make available rooted pepper cuttings through significant increase in nursery capacities through Spices Board
- Provide adequate irrigation facilities in drought – prone areas
- Resolve marketing problems and work out new strategies for export promotion
- Amendment of the purchase tax such that pepper exported within six months of purchase is exempted from the purchase tax
- Sufficient long-term credit facilities are to be made available to exporters to improve the processing and storage facilities
- Motivating and Educating the growers to produce good quality pepper

- To ensure stability in pepper industry, a sound marketing system should be developed
- Efforts made for the promotion of export of pepper shall be sustained and even identified in the fields of packaging, popularization in West Asia, North America, Western Europe, etc.

5.2.6.7 Cardamom

Production Constraints and Management Plans:

Low productivity is the main problem encountered in cardamom production in India. Lower productivity results in higher unit cost of production. For improving the productivity of cardamom, the Spices Board has been implementing a number of developmental programmes. The main schemes implemented are the following:-

- Cardamom Replanting Finance Scheme
- Water harvesting for cardamom irrigation in Udumbanchola Taluk
- Schemes for supply of irrigation pumpsets
- Soil Conversation Scheme
- Scheme for raising and distributing cardamom seedlings through nursery maintenance
- Scheme for supply of plant protection chemicals and equipments at subsidised rates.
- Extension advisory services through field officers
- Maintenance of demonstration plots
- Scheme for processing and sale of inferior grades of cardamom
- Assistance for arrangement of institutional finance

The Spices Board has also taken up research activities for improving the productivity of cardamom through the Indian Cardamom Research Institute with headquarters at Myladumpara in Idukki District.

Strategy for Production and Marketing

Production Strategy:

If India is to achieve at least 40% share in the world market, it must be able to export about 5000 MT of cardamom. Present requirement of cardamom in the country is about 2500 MT. In order to strengthen the industry and to sustain it on a viable basis, it is necessary to support a major domestic market development programme. This will give the growers the financial strength required to produce more and to re-establish our position in the world market. The state has a potential of producing over 9000 MT of cardamon annually for which concentrated efforts on implementation of long term development schemes, especially irrigation, soil conservation and replantation needs to be looked into carefully.

Equal emphasis needs to be given to research so that high yielding, drought resistant varieties are identified and multiplied and problem of diseases and pests mitigated. It is important also to improve post-harvest technology so that curing of cardamom for retention of green colour becomes cost effective.

Marketing Problems

Unlike pepper, cardamom marketing is more organized. The system of open auctions all through the producing areas has been prevailing traditionally. The growers sell about 60 to 70% of the cardamom produced in the State through auctions. However, there are problems in the marketing of cardamom.

Taxation Problems

A major problem that the cardamom growers and the exporters in Kerala have been facing is in regard to the payment of sales tax on stocks offered for auctions. These problems have now been sorted out; so also the agricultural income tax to some extent following marketing strategies are suggested:

Marketing strategies

- The core market for Indian cardamom consists of the Middle East and the Saudi Arabia. A programme for developing these markets has been under implementation. Efforts have been made for major publicity programmes with the objective of establishing the image of Indian Cardamom and other spices in these markets.
- The Board has an office at Bahrain, which maintains close contact with Middle East buyers.
- More buyer-seller meets, and sponsorship of exporters delegations etc. to promote export of Indian cardamom in the Middle East Markets.
- Projects for developing new food products using cardamom have been taken up with assistance of International Trade Centre, Geneva. A new end product namely "cardamom cola" has already been developed and the technology is now available for transfer to appropriate entrepreneurs. Another project for developing non-food products using cardamom flavour has also been taken up with the assistance from the European Economic Community.
- The Regional Research Laboratory, Thiruvananthapuram and the Central Food Technological Research Institute, Mysore has also taken up studies for developing new products using cardamom. Projects for identifying nutritional and medicinal value of cardamom and other spices have also been taken up through the Indian Institute of Nutrition, Hyderabad.
- Increasing productivity through a package of measures involving both research and development.

- Widening the demand base for cardamom in international markets for developing new end products using cardamom, and
- Increase domestic demand.

5.2.6.8 Vegetables, Fruits and Banana

The cultivable area remaining uncultivated in GKR comes to about 93410 ha. If irrigation facilities are available, possibly, a good part of the demand could be met from the area, provided, competing demands for other land uses are met. In any case, the challenge of meeting the actual requirement of vegetables, whether at the reduced moderate level or at the recommended level of ICAR, it would be difficult to achieve. Some of the suggested management measures include:

- Increasing the area by cultivating vegetables in cultivable area remaining uncultivated
- Utilization of paddy land remaining fallow after the first and second crop of paddy
- Use of high yielding and disease resistant varieties of vegetables
- Research back up on physiology of vegetable crops and improvement in photosynthetic efficiency of plants by genetic engineering
- Identification of promising hybrids and their adoption by farmers
- Improving the labour efficiency, etc.

Table 5.2.4.1

Specifications of Glass Sands (ISI 488:1953) and Comparison with Cherthala Sand

Constituents	Quality of Sand (%)			Cherthala Sand
	Grade I	Grade II	Grade III	
SiO_2	97.50	95.00	92.50	96.00
Fe_2O_3	0.53	0.13	0.50	0.17
TiO_2	0.10	0.10	0.50	0.12
Moisture	5.00	5.00	5.00	5.00

Source : Secondary data collected by CESS; RRL (1994)

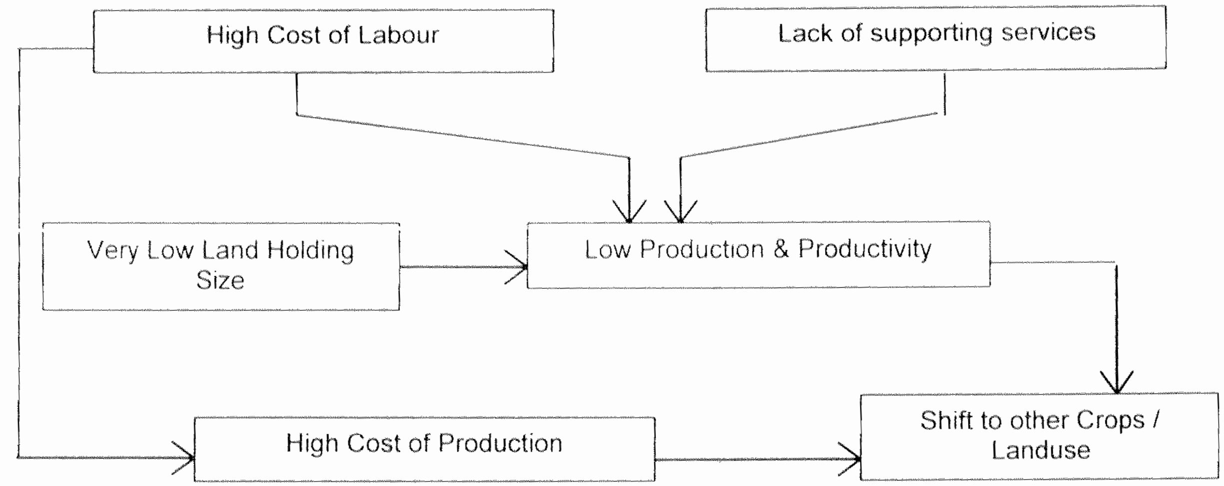


Fig. 5.2.6.1 : A Cause – Effect – Impact Network of a Declining Rice Production

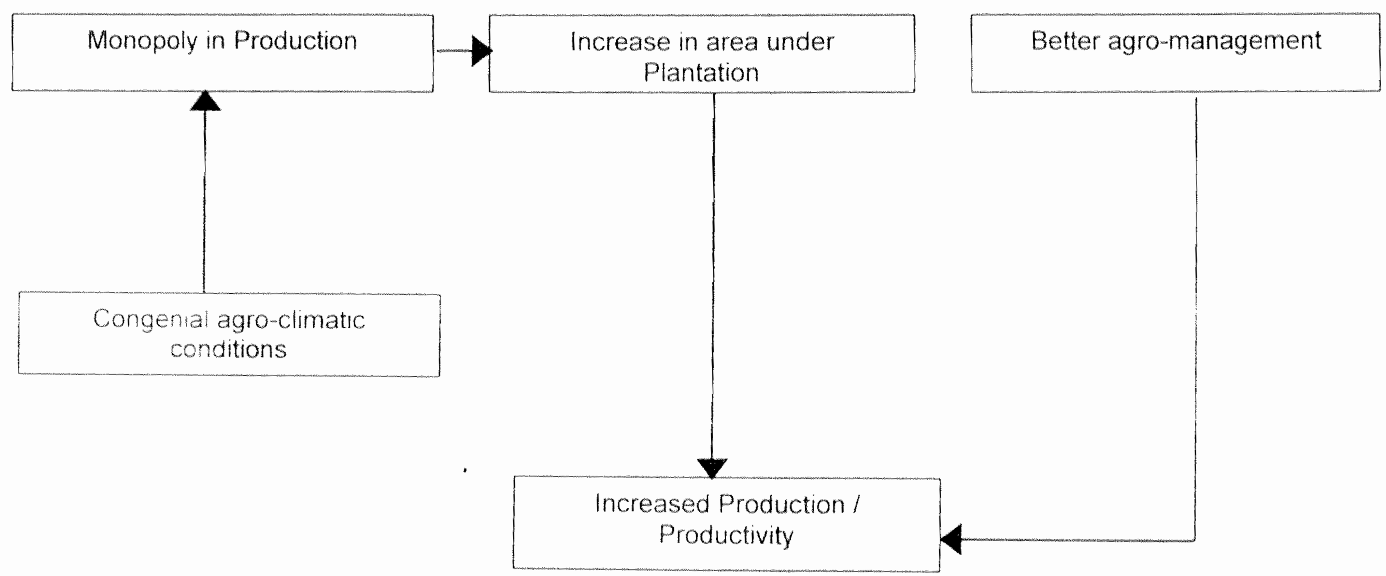


Fig. 5.2.6.2 : A Cause – Effect – Impact Network of an Increasing Rubber Production in GKR & Kerala

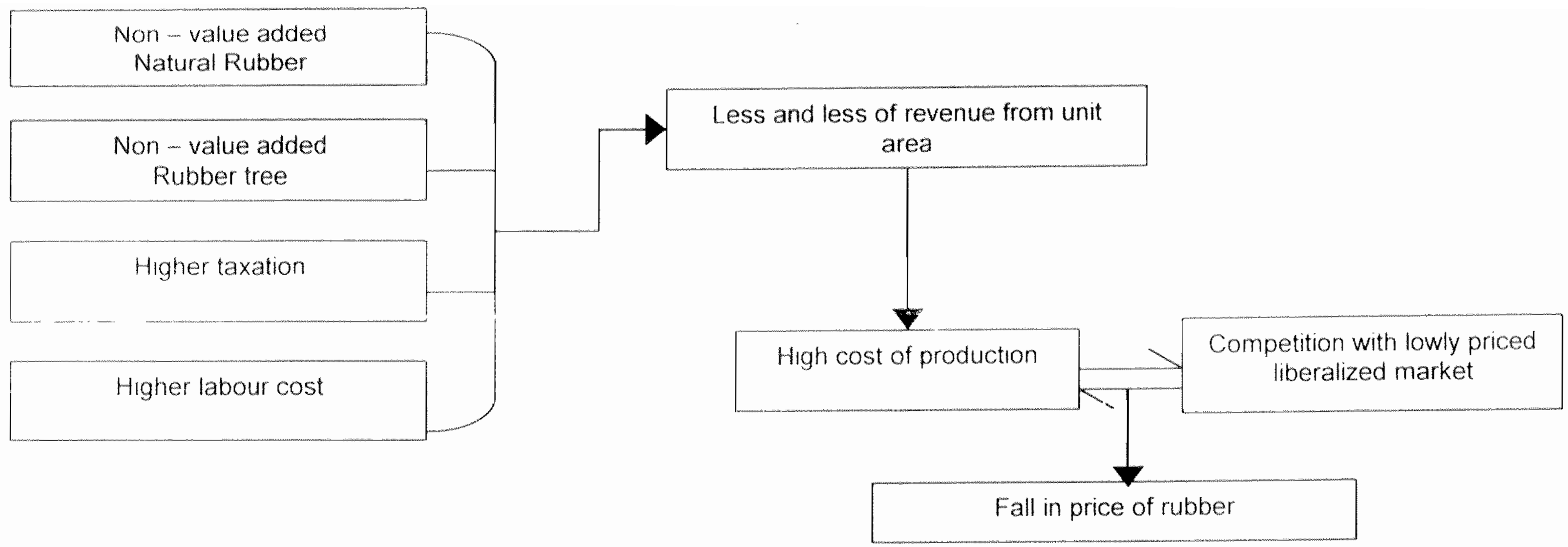


Fig. 5.2.6.3 : A Cause – Effect – Impact Network of a Higher Cost of Production & Fall in Price of Rubber in GKR & Kerala

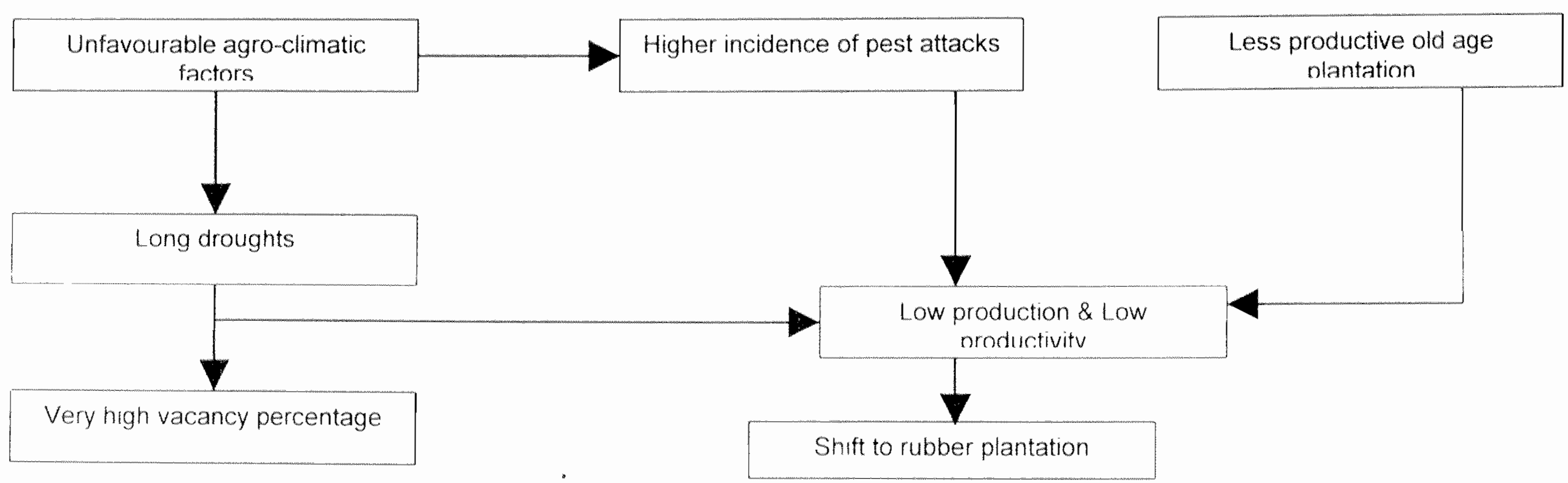


Fig. 5.2.6.4 : A Cause – Effect – Impact Network of a Declining Tea Industry in Kerala

5.3 Prioritization of Environmental/Resource Management Problems

Biological Environment (Coastal waters)

- Overexploitation of biological resources (Fisheries)
- Deterioration in the backwater quality affecting the biological environment of the coastal waters
- Loss of nursery grounds and habitats of marine species that migrate into the backwater system
- Destruction of mangroves in the backwaters

Greater Kochi Region as a whole

In Greater Kochi Region, it is seen that non-availability of cooking fuel is the main problem faced by the households. Non-availability of treated potable drinking water comes second. The poor quality of houses requires the next consideration. Management of the physical environment is fourth in the list of problems. The other sectors in the decreasing order of priority are the health, sanitation, transport and employment.

Firewood is the main fuel used by the households for cooking. About 58% of the households use firewood for cooking. Community based efforts to encourage the use of fuel efficient chulas is recommended. It is seen that in GKR, only 34.56% of the households get treated potable drinking water. About 57% of the households depend on well water for drinking purpose and the rest use water from public wells or ponds or rivers for drinking purposes. About 30% of the houses in GKR are semi pucca and 5.42% are huts. Regional housing schemes for GKR so as to replace huts with pucca-houses and to repair semi-pucca houses are recommended. Water logging and water pollution are the prime environmental problems in GKR as identified by our household survey. Inputs from the water environment component of the study are needed for the management of this problem. Among the diseases reported from GKR, majority is air borne. Strengthening of the health centers and medical colleges demand the attention in this regard. Provision of latrines with septic tanks for each household is recommended to solve the sanitation problems. Strengthening of the road networks and public transport systems is needed to manage the transportation sector.

Guidelines to formulate resource allocation strategies

Based on the present quality of life levels in the GKR, it is suggested that the Plan Funds for the socio-economic sector may be apportioned so as to get the following breakup.

Fuel sector	-	22.63%
Drinking water sector	-	15.00%
Housing sector	-	13.24%

Physical environment management	-	11.15%
Health sector	-	9.93%
Sanitation sector	-	9.46%
Transport sector	-	9.37%
Employment generation	-	9.22%

It is envisaged that in the regional perspective plan for GKR for the next 20 years, if the socio-economic sector allocation is made within the above broad framework, the equity in quality of life in the region may be attained with a proportional increase in the overall quality of life situation.

6.0 Estimation of Assimilative and Supportive Capacity

6.1 Estimation of Assimilative Capacity

6.1.1 Air Environment

Assimilative capacity of air environment is defined as the maximum load of pollutants it can assimilate without adversely affecting the air quality of the region. Assimilative capacity depends on a variety of environmental parameters like meteorological conditions, terrain characteristics, emission characteristics etc. Since an air mass constitutes a dynamic system, the assimilative capacity of air mass also varies in relation to the changes in environmental conditions.

6.1.1.1 Ambient Air Quality Status

Primary data on ambient air quality was collected within GKR by KSPCB for industrial, commercial, residential and sensitive areas during the year 1999-2000. In coastal districts (Alappuzha and Ernakulam), the average concentrations of SPM, SO_2 and NO_2 were found to be in the range of 10-140 $\mu g/m^3$, 3-18 $\mu g/m^3$, and 7-52 $\mu g/m^3$ respectively. The AQI in the district varied from Fair to Excellent category. In hilly regions (Idukki & Pathanamthitta districts), average concentration of SPM, SO_2 and NO_2 were in the range of 10-160 $\mu g/m^3$, 2-43 $\mu g/m^3$ and 5-119 $\mu g/m^3$ respectively and the AQI was found to be in the range Fair to Good category.

In plain region (Kottayam district), average concentration of SPM, SO_2 and NO_2 were in the range of 18-83 $\mu g/m^3$, 7-26 $\mu g/m^3$ and 22-80 $\mu g/m^3$ respectively and the AQI was found to be in the range Fair to Excellent category. In Thrissur district, average concentration of SPM, SO_2 and NO_2 were found to be in the range of 13-24 $\mu g/m^3$, 6-8 $\mu g/m^3$ and 22-52 $\mu g/m^3$ respectively and the AQI was found to be in the range Good to Excellent category.

Overall AQI for different seasons showed that the air quality in the region falls under the category Good and Excellent, especially in the industrial areas where the pollution load is well within the limits. Comparatively, Thrissur, Alappuzha, Kottayam and Pathanamthitta have lower AQI than Ernakulam with. respect to industrial area.

6.1.1.2 Emission Inventory

The emission inventory data for the whole GKR was categorized into three main source categories i.e., point (industrial), area (domestic) and line (vehicular) sources. Further, the study area was divided into square grids each of size of 10 km × 10 km and emission loads in each grid for different pollutants were estimated as detailed earlier in Chapter 3 (Section 3.1.2).

Point Sources : In the present context, industrial stacks are referred to as point sources. Details about these stack emissions collected by KSPCB show that point sources in GKR are located mainly near towns and urban areas. Industries are present in pockets outside the major cities like Kalamassery, Udyogmandal, Aluva, Cherthala, Kottayam etc.

Area Sources : Area source emissions are mainly due to domestic fuel consumption as there are no open pit mines or any other type of area source in the GKR region. Analysis of secondary and primary data indicates that wood is the dominant fuel being used in the study region, as it is abundantly available. Burning of wood causes high emissions of SPM, CO and HC. Kerosene results in high emissions of SPM, SO_2 and CO. Further, in the rural areas, high amount of wood is consumed because of its easy availability and low cost.

Line Sources : Since the GKR is situated on the western ghat section, there is relatively less rail transportation. Hence, traffic burden falls more on roadways. Three national highways (No. 17, 47 and 49) pass through GKR. All these national highways meet at Cochin resulting in high vehicular pollution in the Cochin-Ernakulam region. The total length of the national highways in GKR is around 400 km. Besides national highways, there is a total 874 km of state highways and 3105 km of local roads spread all over in GKR.

Emissions load from the vehicular activities were calculated using the data on number of different categories of registered vehicles in each district and the relevant emission factors derived for the Indian conditions.

6.1.1.3 Meteorological Data Analysis

Primary data were recorded continuously at five meteorological stations in GRK for seven parameters; temperature, wind speed, wind direction, rainfall, relative humidity, solar radiation and sunshine duration from November 1998 to October 1999. In addition, upper air temperature profile for each station was also recorded.

Analysis of primary data on temperature indicates that in general, there is not much variation in temperature at different locations in GKR even during different seasons, except in the hill region, where a relatively less temperature was recorded than the mid land or low land regions.

Wind movement is caused by land-sea breeze. Air mass moves from land to sea during the day and in reverse direction during nighttime. Calm conditions frequency is high during nighttime. The wind data shows that the wind velocity has more or less same pattern in all the stations except Kulamavu, a high land station, where wind velocity is higher as compared to low/mid land other stations. In general, wind flow tendency during the daytime is towards east and northeast.

The maximum mixing height value recorded was around 1500 m during winter. The mixing height values are lower during monsoon and high during winter season.

Ventilation Coefficient (VC) is an important parameter in estimating assimilative capacity of an air shed. It followed the same pattern as that of the mixing height. High values of VC were observed from January to May. From June to September, the VC is considerably low despite strong winds. The maximum value of VC observed was 6000 m^2/s. VC values were found to be low during night time and reached maximum during afternoon hours.

6.1.1.4 Methodology for Estimation of Assimilative Capacity

Methodology chosen for estimation of assimilative capacity for GKR depends on the very definition of assimilative capacity which is given by the maximum emission load that a region can assimilate without disturbing the natural quality/ecological integrity of the region. The maximum load that a region can take is dependent on many factors like wind speed, wind direction, distribution of emission sources, emission load etc. Hence, it is difficult to set the assimilative capacity of region as a single specific quantity. Practically, it is defined as the maximum emission load that the region can take for critical conditions without deterioration in ecological integrity. Critical conditions mean the conditions at which the assimilative capacity is minimum, e.g. conditions when the wind speeds are minimum or mixing height is low and atmospheric stability is high etc.

There are numerous methodologies, which have been adopted in the past studies relevant to carrying capacity based planning of regions, but a different technique had to be chosen to suit the limitations and shortcomings in data available for this study. Assimilation capacity was calculated for an air volume of 24 km x 24 km x 100 m above study areas in five selected districts / regions. For each study area, the critical season was selected i.e., the season during which there is lesser dispersion of pollutants. For different emission loads (existing and future), the occurrence of maximum pollutant concentration anywhere in the study area was tested.

The emission load at which the maximum allowable concentration is reached for the critical conditions is set as the assimilative capacity of the region As the assimilative capacity also depends on the type of pollutant, modeling studies are carried out for different pollutants. Since emission loads of SO_2 and NO_2 were same, the assimilative capacities with respect to these pollutants are also same.

6.1.1.5 Air Quality Modeling - Approach and Assumptions

In order to assess the assimilative capacity of air environment in GKR, it is necessary to study the effect of various parameters like wind movement in the region, ambient air temperature, pollutant load etc. on the quality of air mass. In this regard, simulated models provide an effective approach to study all the parameters that determine the air assimilative capacity of the region.

In the whole of GKR, five representative zones were selected for modeling exercise. The details of five stations where meteorological measurements were made, are given below:

Sr. No.	District	Place	Zone Classification
1	Ernakulam	Kalamassery	Lowland (Coastal), Industrial & Mixed activities
2	Ernakulam	Kodanadu	Midland, Mixed activities
3	Idukki	Kulamavu	High land, Hill terrain nearly pristine
4	Alappuzha	Cherthala	Lowland (Coastal), Mixed activities
5	Kottayam	Kottayam	Midland – Plain, Industrial & Mixed activities

Each of the selected area represents the industrial/mixed type of activities where the pollution levels are reasonably significant. Each of the study area zone chosen is of 24 km x 24 km size with meteorological station being at the centre. Further, this area is sub-divided into smaller grids of 2 km x 2 km size. **Fig. 6.1.1.1** shows the meteorological stations and the study area. Reference to all other locations is made in Cartesian form with respect to the bottom-left corner, which is considered to be the origin for each sub-study area.

The following broad assumptions were made in the modeling exercise:

- The type of terrain and activities in the five selected study areas/zones represent the conditions of whole of the GKR
- Assimilative capacity of air environment is related mainly to elevated emission sources (industrial), hence future emission growth will be mainly due to point source emissions
- The present yearly meteorological scenario is valid for future also
- Macro and micro level modeling give representative results for the selected study regions

6.1.1.5.1 Air Quality Model

Modeling on macro scale gives predicted concentrations indicating the combined effect of distributed sources of emission. Models are the tools, which help in determining the pollution load an air mass can take and thus help in formulating guidelines for management plans.

There are numerous models available in order to predict likely concentration of air pollutants in a region. In view of the data available and output required at desired accuracy, ISCST-3 simulation model was used to predict the quality of air in the region. This model is based on Gaussian dispersion equation and the assumptions of Gaussian Model apply here also.

Input Data Requirement

ISCST-3 calculates dispersion for point, area and volume sources. Line sources are studied by making suitable assumptions, which are given in next section. In general, model requires data regarding : source location; source emission characteristics; prevailing meteorological conditions and receptors. The parameters required as inputs include :

- Location of the sources in m (x, y, z)
- Stack height in m (for point sources only)
- Stack diameter in m (for point sources only)
- Exit velocity in m/s (for point sources only)
- Temperature of stack gas in ^{0}K (for point sources only)
- Pollutant emission rate in g/s
- Width of source in m (for area sources only)
- Height of source in m (for area sources only)

The model also requires the following meteorological data to be furnished separately:

- Date of observation
- Wind direction in degrees
- Wind speed in m/s
- Ambient air temperature in ^{0}K
- Stability class (1-6)
- Mixing height in m

In the present study, the model was used to predict spatial distribution of pollutants from point, line and area sources. Simulation runs were made and concentration isopleths were drawn for each pollutant using SURFER-32 Graphics software and isopleths were overlaid onto the study region map tc identify the possible hotspot activities for each sub study area.

6.1.1.5.2 Emission Scenarios and Assumptions

Point Sources

From pollutant emission point of view, industrial stacks are regarded as point sources. Data available on the industrial emissions were found to be inadequate for the modeling studies. Non-availability of various input data required like exact location of stacks, pollutant discharge rate from these stacks resulted in conducting macro scale modeling studies. However, important industrial pockets of GKR are shown in **Fig 6.1.1.2.** Accordingly, following assumptions were made during modeling studies:

- It was assumed that the maximum pollution load a region can assimilate is the load at which the maximum concentration at any receptor point is below the permissible level for industrial/commercial/sensitive area category of CPCB classification.

- The difference between the maximum allowable concentration for a given area and the present average ambient concentration in that region gives an indication about the amount of pollution load that the region can assimilate. Present average levels of SO_2 and NO_2 are in the range of 20-30 µg/m^3, whereas SPM concentration is in the range of 100-200 µg/m^3. Therefore, 75% of maximum concentration was set for corresponding regions to calculate the amount of load it can take in future. With these assumptions, figures of maximum allowable concentration for future were arrived at.
- Based on the maximum allowable concentration derived, allowable emission load was calculated for the study region (24 km x 24 km) assuming that the pollutant disperses up to 100 m height since most of the stacks in the region were observed to be below 30 m height. The emission loads thus calculated are given in **Table 6.1.1.1**. The above load was distributed equally into 10 industrial complex sources, which include existing as well as proposed locations. All the emissions in an industrial complex are considered to be released from a 0.5 m diameter stack of 30 m height with exit gas velocity of 5.0 m/s at 373 ^{0}K temperature (assumed similar to the existing industries in the region).

The first model runs results at the above elevated loads were analyzed. If the predicted maximum concentration in the study area was found to be still below the maximum allowable concentration, the emission load was increased equally from all the stacks in the study region till a maximum allowable concentration levels are reached. The total emission load arrived at in the final run was calculated and considered as assimilative capacity of the study region under the above specified conditions.

The same exercise was repeated for all the five study zones and the final emission load arrived at in these locations are summarized in **Table 6.1.1.2**.

6.1.1.5.3 Meteorological Scenarios and Assumptions

As mentioned earlier also, five met stations of 10 m height were installed to represent the meteorological conditions in GKR at Kalamassery (Ernakulam), Kodanadu (Ernakulam), Kulamavu (Idukki), Cherthala (Alappuzha) and Kottayam. Since the meteorological data collected in winter, summer, monsoon and post monsoon seasons from November 1998 to October 1999 indicated almost identical trends between winter & summer and monsoon & post monsoon seasons, the met data of winter and post monsoon were used for modeling studies. Observations on meteorological parameters used for modeling exercise are briefly described here.

Temperature

Temperatures were observed to be high during the month of March and April and low during the month of January. Although there is no considerable difference in temperature among the five study areas in general, Idukki was found to have lesser temperature in all the seasons. Temperature varied from 18.6 ^{0}C to 32.4 ^{0}C in winter and from 19.9 ^{0}C to 31.1 ^{0}C in post monsoon. Diurnal variation of temperature in these stations show that temperature is minimum at around 0700 hrs and gradually starts increasing and reaches maximum at 1300 hrs and then starts decreasing with the night fall. Pattern of variation in both the seasons is similar, the difference being the maximum and minimum temperatures attained.

Wind Direction and Wind Speed

During winter, the wind is observed to flow from southwest to northeast direction and during post monsoon; the direction slightly shifts to southwesterly direction. The direction of wind reverses during the nighttime. Wind direction plays an important role in pollutant distribution, and determines the likely place of maximum concentration occurrence.

Diurnal variation of wind speed shows that the speed is high during the day time, reaches maximum at around 1400 hrs and gradually decreases with night fall, reaching minimum during midnight. The frequency of calm conditions occurrence varies from 41.6% at 1200 hrs to 68.3% at 2100 hrs. Maximum calm conditions frequency of 84.4% is observed at 2400 hrs. Wind speed was observed to vary from calm conditions to 2.48 m/s during mid day. Higher wind speeds up to 2.63 m/s were observed in Idukki during day time in winter.

Stability Class

To represent different stability classes of atmosphere; the classification used in modeling studies are: Very Stable: 1; Moderately Stable: 2; Slightly Stable: 3; Neutral: 4; Slightly Stable: 5; and Moderately Stable/Highly Stable: 6. In Kochi, in general, stability class 6 prevails from 1700 hrs to 0600 hrs in the morning hours during winter and post monsoon. Stability gradually changes from 0600 hrs due to sunshine and rise in temperature. Air mass reaches highly unstable class during mid day when wind speed is maximum indicating better mixing of pollutants during daytime and poor mixing during nighttime. These pollutants may also cause smog in the morning hours during winter, which may prove to be dangerous.

Mixing Height

Mixing Height is completely dependent on the vertical ambient air temperature profile i.e. the temperature lapse rate with height. It varies with stability class and its diurnal variation is similar to that of stability class. In Ernakulam, the mixing height varies from 100 m at 0000 hrs to 1100 m at 1300 hrs during post-monsoon. In winter, it varies from 100 m at 0600 hrs to 1600 m at 1500 hrs indicating that the air mass enhances mixing of pollutants in air environment during mid day hours.

The following assumptions were made in order to fill missing data:

- the upper air data (stability class & mixing height) were assumed to be almost same for all the five stations keeping in view the non-availability of data for stations other than Ernakulam and
- the minimum wind speed was assumed to be 0.5 m/s for modeling purposes.

6.1.1.6 Analysis of Results and Assimilative Capacity of the Region

The model runs were made for two parameters (SO_2/NO_2 and SPM) and for the two seasons (winter and post monsoon). Each run was made for industrial, mixed and sensitive areas for all the five study areas. Various assumptions made in the modeling exercise are described in previous section. The model results for each study zone are discussed here:

Kalamassery (Ernakulam District)

The study area of size 24 km x 24 km has Kalamassery at the center and covers Ernakulam, Kochi, Aluva, Udyogmandal etc. Ernakulam is an industrially established area and major industries of GKR are located in the area. It also has the capacity to further support industrial growth. In the present exercise, the region's air assimilative capacity is tested to see if further industrial growth can be supported or not.

Fig. 6.1.1.3 shows distribution of Industrial sources. **Figs. 6.1.1.4 to 6.1.1.15** show isopleths for different pollutants in different seasons at Ernakulam. It is seen that wind flows from southwest to northeast, and so is the distribution of pollutants. Post monsoon season has lesser dilution effect; hence the emission load was critically set for post monsoon season.

Prevailing wind movement disperses the pollutants in northeast and southwest region. This leads to low concentrations in southeast region. The main areas, which are going to be affected by high GLCs, are Alengad, Parur, Cochin and Ernakulam. Distribution pattern does not vary much with respect to different pollutants but only the concentration levels vary. Summary of model results for Ernakulam is given in the **Table 6.1.1.3**.

Kodanadu (Ernakulam District)

The study area of size 24 km x 24 km, has Kodanadu at the center and includes Angamali, Koovapady etc. Industrial sources are distributed as shown in **Fig. 6.1.1.16**. Winter season has lesser dilution effect; hence the emission load was critically set for winter season.

From the isopleths drawn in **Figs. 6.1.1.17 to 6.1.1.28**, it can be seen that during winter and post monsoon seasons, the pollutants get distributed in the north direction and results in low GLC in southern part. The areas that are going to be affected by high concentrations are also given in the accompanying tables of isopleths figures and they include Koovapady and Angamali. The study area has less assimilative capacity as compared to other districts owing to lesser wind speeds, which hinder the dispersion of pollutants. The summary of model results is given in **Table 6.1.1.4**.

Kulamavu (Idukki District)

The study area of 24 km x 24 km size has Kulamavu at the center and includes Idukki, Arakkulam, Vazhathope etc. Industrial sources are distributed as shown in **Fig. 6.1.1.29**. Post monsoon season has lesser dilution effect due to lesser wind speed; hence the emission load was critically set for post monsoon season.

Predominant wind direction was towards north and hence it can be seen from the Isopleths in **Figs. 6.1.1.30 to 6.1.1.41** that the pollutants are moving towards north leaving southern part with very low pollutant concentration. This pattern is observed both in winter and post monsoon. Model studies imply that during post monsoon, the dispersion is low and hence result in higher concentrations.

The prime areas, which are going to be affected by SO_2/ NO_2 and SPM, are Idukki municipality area, Vazhathope, Idukki-Kanjikuzhy, Arakkulam and Vettimattom. The top five regions experiencing maximum concentration are given in the tables accompanying isopleths figures. Comparatively Idukki region has more air assimilative capacity due to higher wind speed and less number of industries in the locality. The summary of model results is given **Table 6.1.1.5**.

Kottayam (Kottayam District)

The Kottayam study area of 24 km x 24 km size has Kottayam at the center and includes Nattakom, Pallom, Chenganacherry block etc. Industrial source's are distributed as shown in **Fig. 6.1.1.42**. During post monsoon, air mass in the study area has lower dilution capacity than in winter. Therefore, the emission load was critically set for post monsoon season. Predominant wind movement is from south to north during winter and along northwest during post monsoon. It can be seen from the Isopleths in **Figs. 6.1.1.43 to 6.1.1.54** that pollutants are distributed in these directions. Southeastern and eastern parts do not have high concentration zones during post monsoon season. The highest concentration reached in case of each parameter in each season is also given along with the place of occurrence in the accompanying tables of isopleths figures.

Important areas which are going to be affected from the given pollution load are Kottayam, Madapally, Nattakom, Pallom and Chenganacherry. The maximum load that the study area can take (for different parameters) in different seasons is given in **Table 6.1.1.6**.

Cherthala (Alappuzha District)

The Alappuzha study area of 24 km × 24 km size with Cherthala at 6 km in the east, 10 km in north direction from the origin, includes Cherthala, Kanjikuzhy, Pathanamkad, Viakom etc. The land availability is less due to presence of Arabian Sea on the left and Vembanad Lake on the right. Distribution of sources is shown in **Fig 6.1.1.55**. In Alappuzha, winter has slightly lesser dilution capacity than in the post monsoon. Therefore, the emission load is critically set and tested with winter season data. Predominant wind direction during winter is towards northwest and during post monsoon; it varies between northwest and northeast. **Figs. 6.1.1.56 to 6.1.1.67** show the concentration distribution for the given emission loads of SO_2/NO_2 and SPM under different scenarios. There is lesser pollution in southern side during both the seasons, which implies that there is ample scope for industrial growth in these places. The areas that are likely to be affected if the pollution load increases further are Cherthala, KanjiKuzhy, Vaikom and Pattanakad. The model results and the emission loads in different seasons are summarized in **Table 6.1.1.7**.

6.1.1.7 Assimilative Capacity based Industrial Development Plan - Illustrative Case Study

The Assimilative Capacity of Ernakulam (Kalamassery) region was compared with the typical SO_2 emission data of a refinery. The Ernakulam study area of 576 km^2 was considered for the study. Assumed SO_2 emission load in Ernakulam area was distributed uniformly in 10 industrial pockets having 25 stacks or point sources. The modeling results showed that a maximum concentration of 42.78 $\mu g/m^3$ occurs near Vazhakkulam block.

Isopleths for SO_2 concentration distributed in the study area of Ernakulam are shown in **Fig. 6.1.1.68** and five highest maximum concentrations are given in the accompanying table. The present exercise shows that the region can assimilate the SO_2 emission load of approximately 24 tons/day from each of the 10 proposed pockets with maximum ground level concentration not exceeding beyond 50 $\mu g/m^3$ within the study area.

Another run was carried out to assess the influence of different meteorological scenarios i.e., the above refinery data were analyzed for different districts (Alappuzha, Ernakulam, Idukki, Kottayam). Sources were located with respect to met stations and keeping emission rates from the sources same in all the districts (met stations), the model was run to see the impact of meteorological parameters in different districts.

Kalamassery (Ernakulam), situated near the coastal line has moderate capacity to assimilate pollutants in spite of presence of large number of industries in the vicinity. The highest concentration recorded under the above emission scenario in the study region of 10 km x 10 km size was 16.5 $\mu g/m^3$ occurring at Kochi. Kodanadu (Ernakulam) also has similar meteorological conditions; therefore the model output was also similar. The maximum concentration that occurred was 16.6 $\mu g/m^3$ occurring at Vazhakkulam.

In Alappuzha, the maximum concentration reached due to assumed emission equivalent to a refinery was found to be 24.5 $\mu g/m^3$ occurring at Ariyad. In Idukki, the maximum concentration predicted was 32.9 $\mu g/m^3$ occurring at Erattupetta. In Kottayam, the maximum concentration reached due to assumed emissions (24 MT/day) was found to be 28.2 $\mu g/m^3$ at Changanacherry. This indicates that air mass has good turbulence and mixes well.

From the above exercise, it is clear that the meteorological conditions of Ernakulam are most favorable for industrial pollutant dispersion. Alappuzha, Kottayam and Idukki rank next, in assimilative capacity.

6.1.1.8 Conclusion

Based on the modeling exercise, it can be observed that the meteorology plays very important role in pollutant distribution and dispersion in a given air shed. Comparative evaluation of all the study areas modeling results reveals that Idukki has more capacity to assimilate pollutants than other districts due to higher wind speed. However, being a complex terrain and hilly region, chances of pollutant trapping are more leading to buildup of pollutant concentration. The region has the least number of industries among districts of GKR and hence least polluted so far.

Setting up of large industries in Idukki district would be difficult due to limited transportation system, non-availability of raw materials and long distance of market/commercial places from it. However, small and cottage industries utilizing raw materials and other resources should be encouraged. All these factors suggest that there is more scope for developmental activities in non-industrial sectors like enhancing yield of forest products, supporting eco-tourism.

Kottayam and Alappuzha resemble each other in many aspects including number of industries present, distribution of industries and meteorological conditions. Both the districts are moderately industrialized. Both have enough infrastructural facilities to support large industries. Modeling with refinery emission data shows that the air in the region can take emission load up to 24 MT/day.

The region can assimilate more loads, if the sources are carefully distributed. Hence, both the regions can accommodate new industries but their locations must be carefully planned so that there is no combined effect of emissions from two or more industries. The southern and southeast parts of both Kottayam and Alappuzha are favorable for locating new industries.

Majority of industries present in whole GKR are located in Ernakulam region. The air environment in the region is agile and presently is affected by the emissions from existing industries. Occasionally, under adverse meteorological conditions, the GLCs exceeded the limits in the past.

The location of industries should be uniformly distributed in the region in order to maintain uniform quality of air. It is better to locate the industries/industrial estates in the southern part of the region so that the emissions from new industries get distributed uniformly and avoid pollutant accumulation in northeastern part of Ernakulam Industrial area.

Predictions made (using models) reveal that the concentration due to assumed emissions loads would be around 16 μg/m^3. This GLC may occur around northeastern part of Ernakulam study area. It is further observed that even at higher emission loads, which are uniformly distributed in Ernakulam region, predicted a maximum concentration of 45 μg/m^3, which is still below the maximum allowable concentration and hence the region still has sufficient assimilative capacity. The assimilative capacity of air environment in southern part is unutilized. Hence, locating new industries in this region will help in sustainable development of the region.

Table 6.1.1.1

Summary of Modeling Exercise Results for Greater Kochi Region

Season	Type of Area	Estimated Max. Conc. from Model Run (µg/m³)					Permissible Emission Rate /Stack (g/s)				
		Alp	Kal	Kod	Idk	Kot	Alp	Kal	Kod	Idk	Kot
SO_2 / NO_2											
Winter	Industrial	37.1	32.8	58.5	25.3	38.2	15.0	12.0	9.0	15.0	14.0
	Mixed	24.7	21.8	39.0	16.8	25.5	9.0	8.0	6.0	10.0	9.0
	Sensitive	8.3	7.3	13.0	5.5	8.5	3.0	2.7	2.0	3.0	3.0
Post Monsoon	Industrial	35.7	46.8	41.8	35.6	41.1	15.0	12.0	9.0	15.0	14.0
	Mixed	23.8	31.2	27.8	23.7	27.4	10.0	8.0	6.0	10.0	9.0
	Sensitive	8.3	10.9	9.4	7.9	9.2	3.5	2.7	2.0	3.0	3.0
SPM											
Winter	Industrial	154.3	136.6	243.9	105.3	159.2	60.0	50.0	38.0	63.0	55.0
	Mixed	61.7	54.6	97.6	42.1	63.7	22.0	20.0	15.0	25.0	22.0
	Sensitive	30.8	27.3	48.8	21.1	31.8	11.0	10.0	8.0	12.0	11.0
Post Monsoon	Industrial	148.8	195.1	174.2	148.4	171.2	60.0	50.0	38.0	63.0	55.0
	Mixed	59.5	78.1	69.7	59.4	68.5	25.0	20.0	15.0	25.0	22.0
	Sensitive	21.7	39.1	34.8	29.7	34.2	13.0	10.0	8.0	12.0	11.0

Contd...

Table 6.1.1.1 Contd...

Season	Type of Area	Permissible Maximum Conc. from Model Run (µg/m^3)					Permissible Emission Load in Region (Kg/d)				
		Alp	Kal	Kod	Idk	Kot	Alp	Kal	Kod	Idk	Kot
SO_2 / NO_2											
Winter	Industrial	92.6	65.6	87.8	63.2	89.1	12960	10368	7776	12960	12096
	Mixed	55.6	43.7	58.5	42.1	57.3	7776	6912	5184	8640	7776
	Sensitive	18.5	14.7	19.5	12.6	19.1	2592	2333	1728	2592	2592
Post Monsoon	Industrial	89.3	93.6	62.7	89.0	95.8	12960	10368	7776	12960	12096
	Mixed	59.5	62.4	41.8	59.4	61.6	8640	6912	5184	8640	7776
	Sensitive	20.8	21.1	13.9	17.8	20.5	3024	2333	1728	2592	2592
SPM											
Winter	Industrial	370.4	273.3	370.7	265.3	350.2	51840	43200	32832	54432	47520
	Mixed	135.8	109.3	146.4	105.2	140.1	19008	17280	12960	21600	19008
	Sensitive	67.9	54.6	78.1	50.5	70.0	9504	8640	6912	10368	9504
Post Monsoon	Industrial	357.1	390.2	264.8	373.9	376.5	51840	43200	32832	54432	47520
	Mixed	148.8	156.1	104.5	148.4	150.6	21600	17280	12960	21600	19008
	Sensitive	77.4	78.1	55.7	71.2	75.3	11232	8640	6912	10368	9504

Table 6.1.1.2

Details of Estimated Emission load for the Study Grids (24 Km x 24 Km)

Season	Type of Area	Permissible Conc. (µg/m³)	Maximum Allowable Conc. (µg/m³)	Estimated Emission Load (Kg/d)	Estimated Emission Rate per Stack (g/s)
SO_2 / NO_2					
Winter	Industrial	120	90	5184	6.0
	Mixed	80	60	3456	4.0
	Sensitive	30	20	1152	1.4
Post Monsoon	Industrial	120	90	5184	6.0
	Mixed	80	60	3456	4.0
	Sensitive	30	20	1152	1.4
SPM					
Winter	Industrial	500	375	21600	25.0
	Mixed	200	150	8640	10.0
	Sensitive	100	75	4320	5.0
Post Monsoon	Industrial	500	375	21600	25.0
	Mixed	200	150	8640	10.0
	Sensitive	100	75	4320	5.0

Table 6.1.1.3

Details of Estimated Emission Load from Modeling Exercise for Kalamassery (Ernakulam District)

Season	Type of Area	Estimated Max. Conc. from Model Run ($\mu g/m^3$)	Permissible Emission Rate /Stack (g/s)	Permissible Maximum Conc. from Model Run ($\mu g/m^3$)	Permissible Emission Load on Region (Kg/d)	Receptor Location (km)		
						East	North	Area
SO_2 / NO_2								
Winter	Industrial	32.8	12.0	65.6	10368	1	4	Cochin
	Mixed	21.8	8.0	43.7	6912	1	4	Cochin
	Sensitive	7.3	2.7	14.7	2333	1	4	Cochin
Post Monsoon	Industrial	46.8	12.0	93.6	10368	5.5	22	Alengad
	Mixed	31.2	8.0	62.4	6912	5.5	22	Alengad
	Sensitive	10.9	2.7	21.1	2333	5.5	22	Alengad
SPM								
Winter	Industrial	136.6	50.0	273.3	43200	1	4	Cochin
	Mixed	54.6	20.0	109.3	17280	1	4	Cochin
	Sensitive	27.3	10.0	54.6	8640	1	4	Cochin
Post Monsoon	Industrial	195.1	50.0	390.2	43200	5.5	22	Alengad
	Mixed	78.1	20.0	156.1	17280	5.5	22	Alengad
	Sensitive	39.1	10.0	78.1	8640	5.5	22	Alengad

Table 6.1.1.4

Details of Estimated Emission Load from Modeling Exercise for Kodanadu (Ernakulam District)

Season	Type of Area	Estimated Max. Conc. from Model Run (µg/m^3)	Permissible Emission Rate /Stack (g/s)	Permissible Maximum Conc. from Model Run (µg/m^3)	Permissible Emission Load in Region (Kg/d)	Receptor Location (km)		
						East	North	Area
SO_2 / NO_2								
Winter	Industrial	58.53	9.0	87.80	7776	12.5	16.5	Kovappady
	Mixed	39.02	6.0	58.53	5184	12.5	16.5	Kovappady
	Sensitive	13.07	2.0	19.51	1728	12.5	16.5	Kovappady
Post Monsoon	Industrial	41.81	9.0	62.71	7776	17	18.5	Kovappady
	Mixed	27.81	6.0	41.81	5184	17	18.5	Kovappady
	Sensitive	9.34	2.0	13.93	1728	17	18.5	Kovappady
SPM								
Winter	Industrial	243.9	38.0	370.74	32832	12.5	16.5	Kovappady
	Mixed	97.56	15.0	146.35	12960	12.5	16.5	Kovappady
	Sensitive	48.78	8.0	78.05	6912	12.5	16.5	Kovappady
Post Monsoon	Industrial	174.21	38.0	264.79	32832	17	18.5	Kovappady
	Mixed	69.68	15.0	104.53	12960	17	18.5	Kovappady
	Sensitive	34.84	8.0	55.75	6912	17	18.5	Kovappady

Table 6.1.1.5

Details of Estimated Emission Load from Modeling Exercise Results for Kulamavu (Idukki District)

Season	Type of Area	Estimated Max. Conc. from Model Run (µg/m^3)	Permissible Emission Rate /Stack (g/s)	Permissible Maximum Conc. from Model run (µg/m^3)	Permissible Emission Load in Region (Kg/d)	Receptor Location (km)		
						East	North	Area
SO_2 / NO_2								
Winter	Industrial	25.3	15.0	63.17	12960	3.5	17.0	Arakkulam
	Mixed	16.8	10.0	42.11	8640	3.5	17.0	Arakkulam
	Sensitive	5.5	3.0	12.64	2592	3.5	17.0	Arakkulam
Post Monsoon	Industrial	35.6	15.0	89.02	12960	17.0	10.5	Idukki
	Mixed	23.7	10.0	59.35	8640	17.0	10.5	Idukki
	Sensitive	7.9	3.0	17.80	2592	17.0	10.0	Idukki
SPM								
Winter	Industrial	105.3	63.0	265.34	54432	3.5	17.0	Arakkulam
	Mixed	42.1	25.0	105.24	21600	3.5	17.0	Arakkulam
	Sensitive	21.1	12.0	50.54	10368	3.5	17.0	Arakkulam
Post Monsoon	Industrial	148.4	63.0	373.89	54432	17.0	10.5	Idukki
	Mixed	59.4	25.0	148.37	21600	17.0	10.0	Idukki
	Sensitive	29.7	12.0	71.22	10368	17.0	10.5	Idukki

Table 6.1.1.6

Details of Estimated Emission Load from Modeling Exercise Results for Kottayam

Season	Type of Area	Estimated Max. Conc. from Model Run (µg/m³)	Permissible Emission Rate /Stack (g/s)	Permissible Maximum Conc. from Model Run (µg/m³)	Permissible Emission Load in Region (Kg/d)	Receptor Location (km)		
						East	North	Area
SO_2 / NO_2								
Winter	Industrial	38.20	14.0	89.14	12096	5	10	Panachikkad
	Mixed	25.47	9.0	57.30	7776	5	10	Panachikkad
	Sensitive	8.53	3.0	19.10	2592	5	10	Panachikkad
Post Monsoon	Industrial	41.07	14.0	95.84	12096	3	12.5	Nattakom
	Mixed	27.38	9.0	61.61	7776	3	12.5	Nattakom
	Sensitive	9.17	3.0	20.54	2592	3	12.5	Nattakom
SPM								
Winter	Industrial	159.18	55.0	350.19	47520	5	10	Panachikkad
	Mixed	63.67	22.0	140.08	19008	5	10	Panachikkad
	Sensitive	31.83	11.0	70.04	9504	5	10	Panachikkad
Post Monsoon	Industrial	171.15	55.0	376.54	47520	3	12.5	Nattakom
	Mixed	68.46	22.0	150.62	19008	3	12.5	Nattakom
	Sensitive	34.23	11.0	75.31	9504	3	12.5	Nattakom

Table 6.1.1.7

Details of Estimated Emission Load from Modeling Exercise Results for Cherthala (Alappuzha District)

Season	Type of Area	Estimated Max. Conc. from Model Run (µg/m^3)	Permissible Emission Rate/Stack (g/s)	Permissible Maximum Conc. from Model Run (µg/m^3)	Permissible Emission Load in Region (Kg/d)	Receptor Location (km)		
						East	North	Area
SO_2 / NO_2								
Winter	Industrial	37.04	15.0	92.6	12960	9.0	18.5	Cherthala
	Mixed	24.69	9.0	55.6	7776	9.0	18.5	Cherthala
	Sensitive	8.27	3.0	18.52	2592	9.0	18.5	Cherthala
Post Monsoon	Industrial	35.70	15.0	89.27	12960	9.5	18.5	Cherthala
	Mixed	23.80	10.0	59.51	8640	9.5	18.5	Cherthala
	Sensitive	8.33	3.5	20.83	3024	9.5	18.5	Cherthala
SPM								
Winter	Industrial	154.34	60.0	370.4	51840	9.0	18.5	Cherthala
	Mixed	61.73	22.0	135.8	19008	9.0	18.5	Cherthala
	Sensitive	30.86	11.0	67.9	9504	9.0	18.5	Cherthala
Post Monsoon	Industrial	148.78	60.0	357.1	51840	9.5	18.5	Cherthala
	Mixed	59.51	25.0	148.8	21600	9.5	18.5	Cherthala
	Sensitive	21.75	13.0	77.37	11232	9.5	18.5	Cherthala

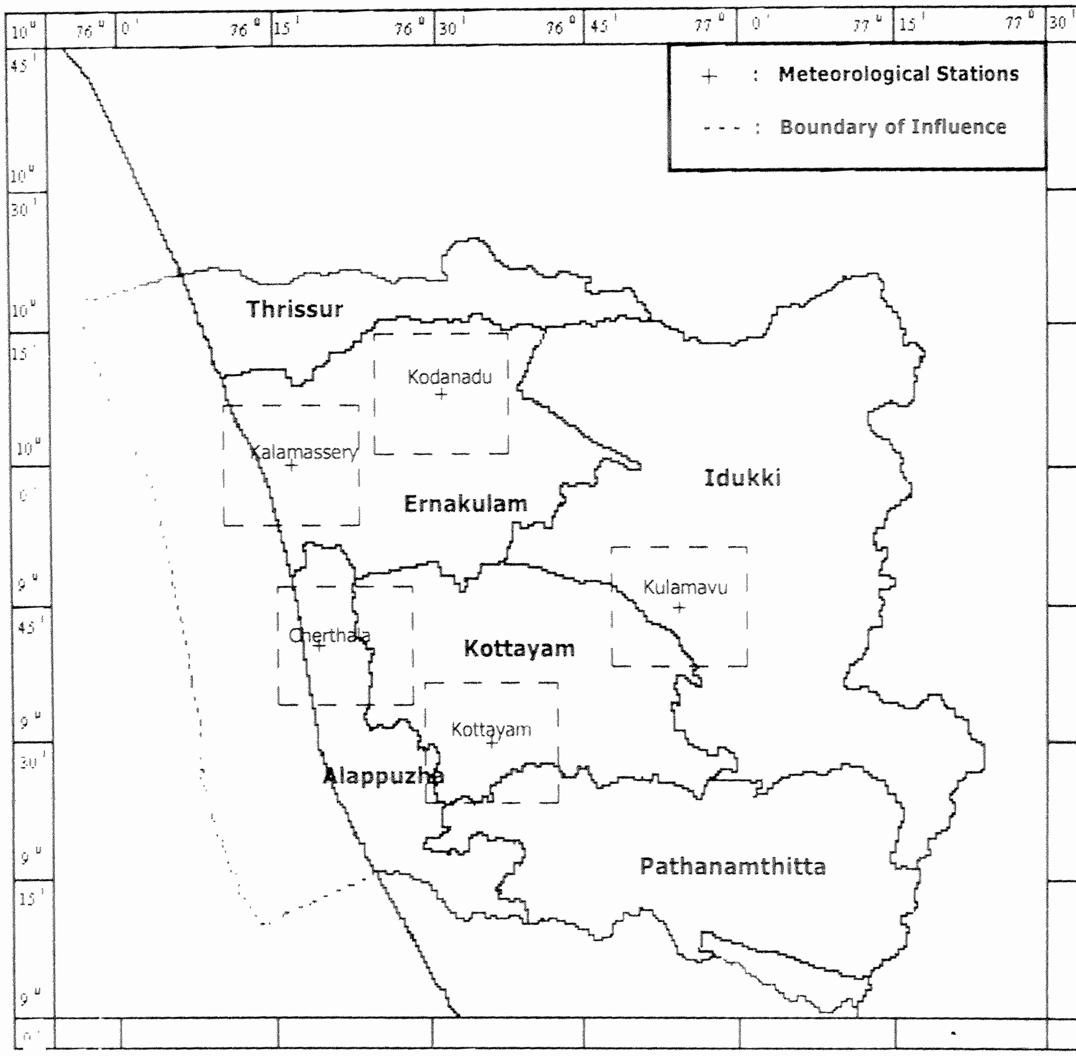


Fig. 6.1.1.1 : GKR Study Area - Meteorological Stations with Boundary of Influence

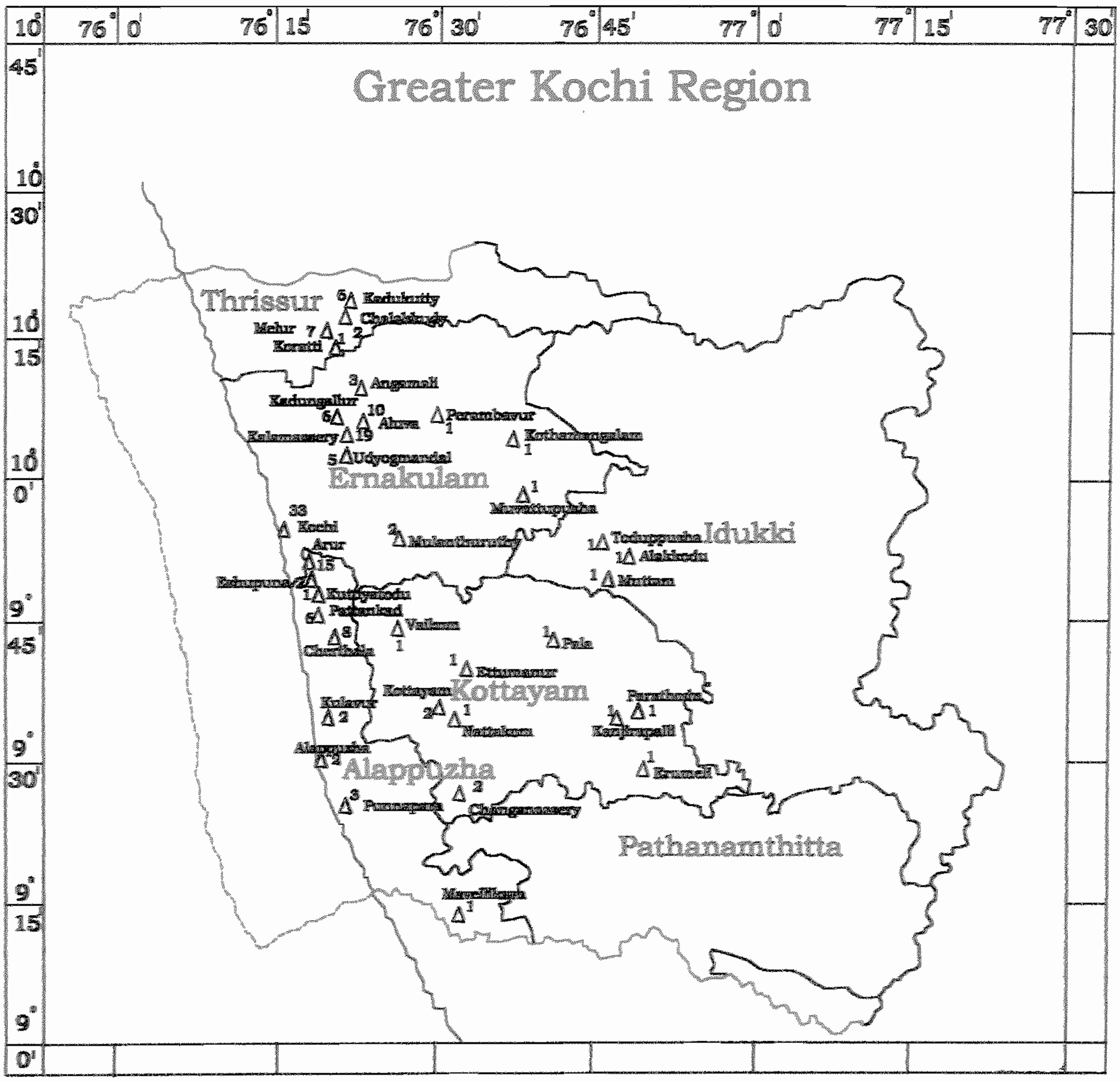


Fig. 6.1.1.2 : Locations of Major Air Polluting Industries in GKR

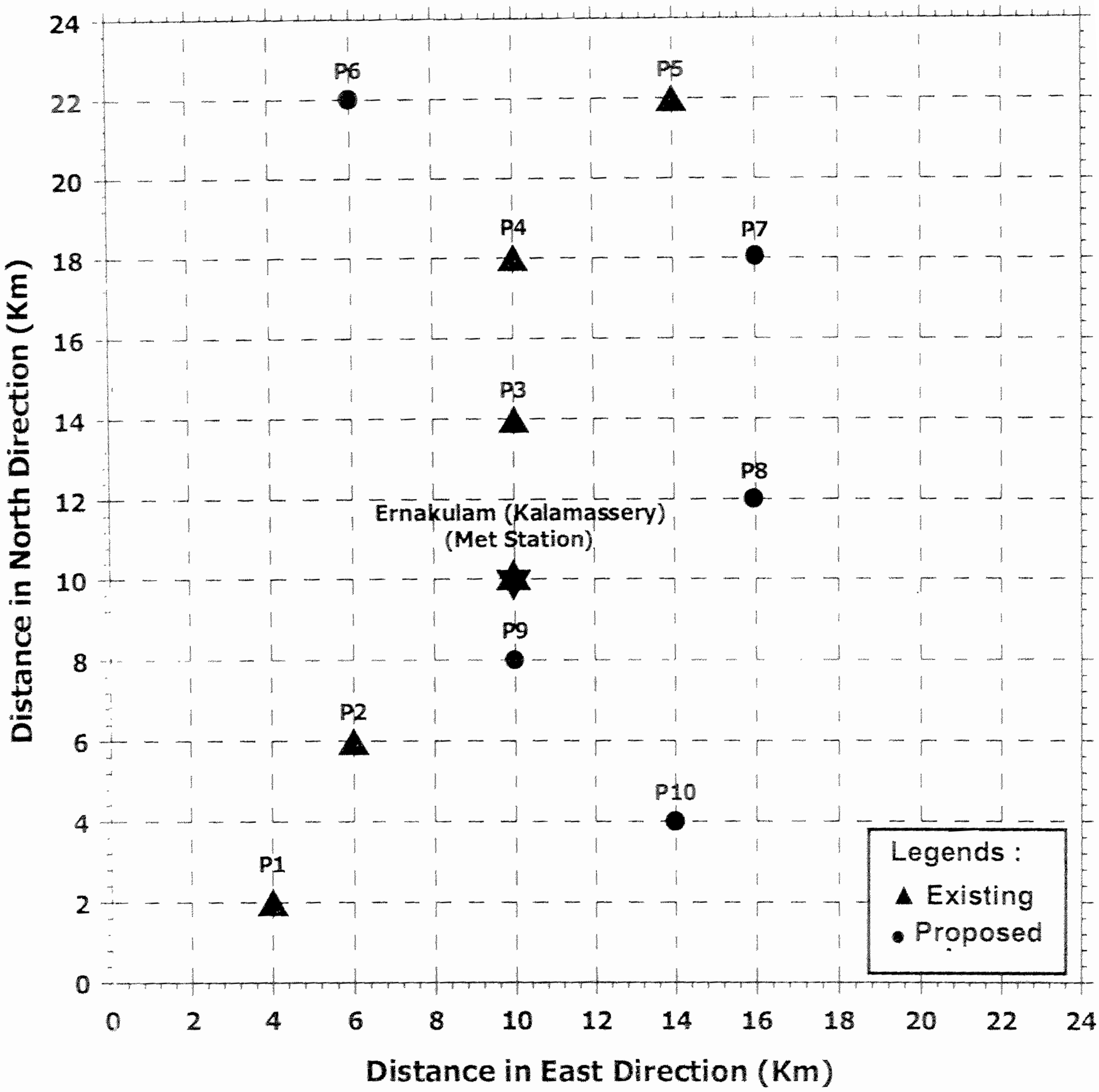


Fig. 6.1.1.3 : Existing and Proposed Point Sources in Kalamassery, Ernakulam District

Source	X	Y	Location	
			Place	Block
P1	4000	2000	Kochi	------
P2	6000	6000	Ernakulam	------
P3	10000	14000	Kalamassery	------
P4	10000	18000	Udyogmandal	------
P5	12000	22000	Aluva	------
P6	6000	22000	Karamallur	Alengad
P7	16000	18000	Kizhmadu	Vazhakkulam
P8	16000	12000	Kunnathunadu	vaduvacode
P9	10000	8000	Trikkakara	Edapally
P10	14000	4000	Vaduvacode-Puthencruz	Vaduvacode

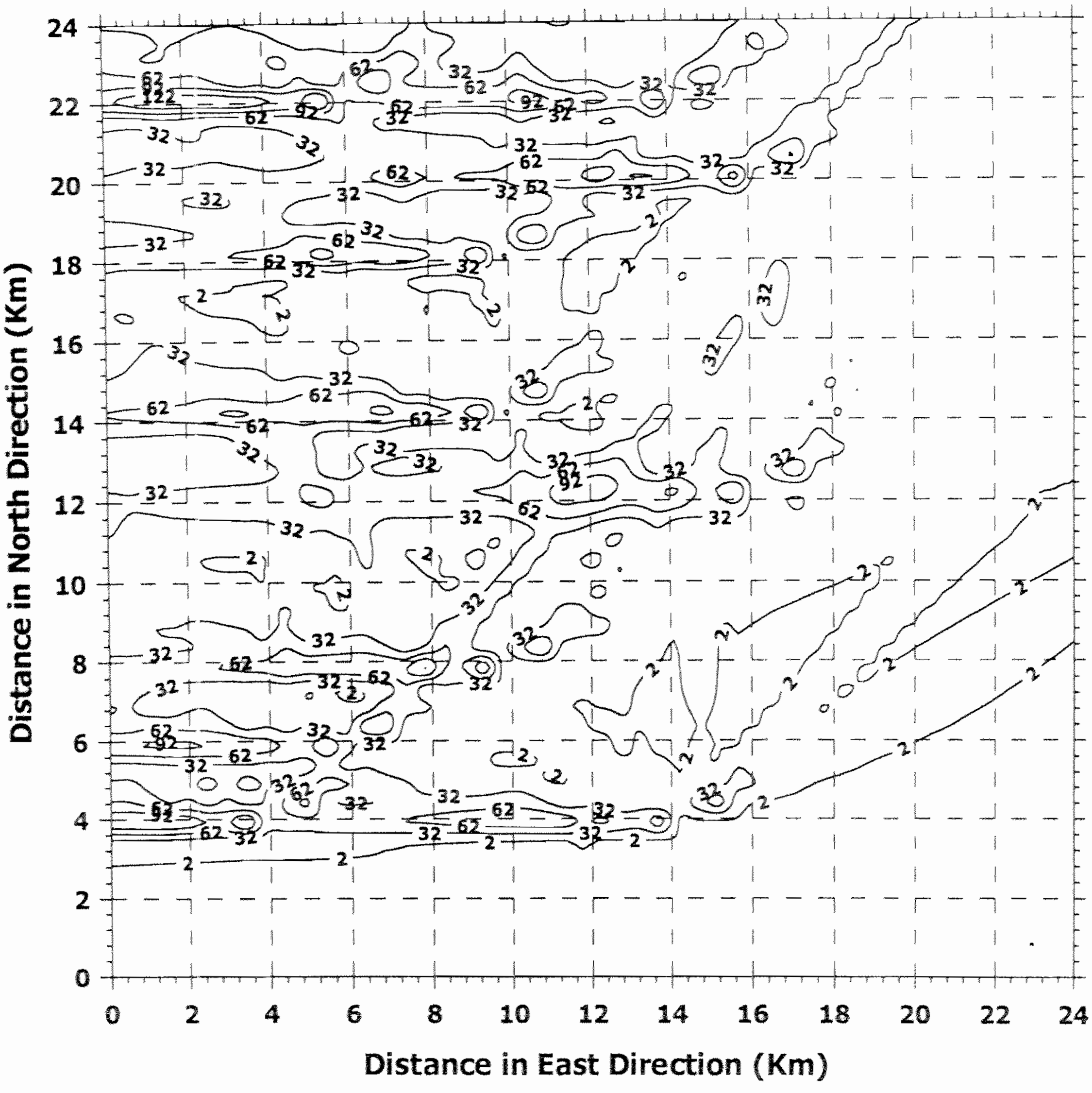


Fig. 6.1.1.4 : Predicted SPM Isopleths : Post Monsoon - Kalamassery (Ernakulam) [Emission Load : 17280 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	156	5.5	22.0	Alengad
2nd	141	3.0	22.0	Parur
3rd	139	2.5	22.0	Parur
4th	139	1.5	22.0	Parur
5th	137	2.0	22.0	Parur

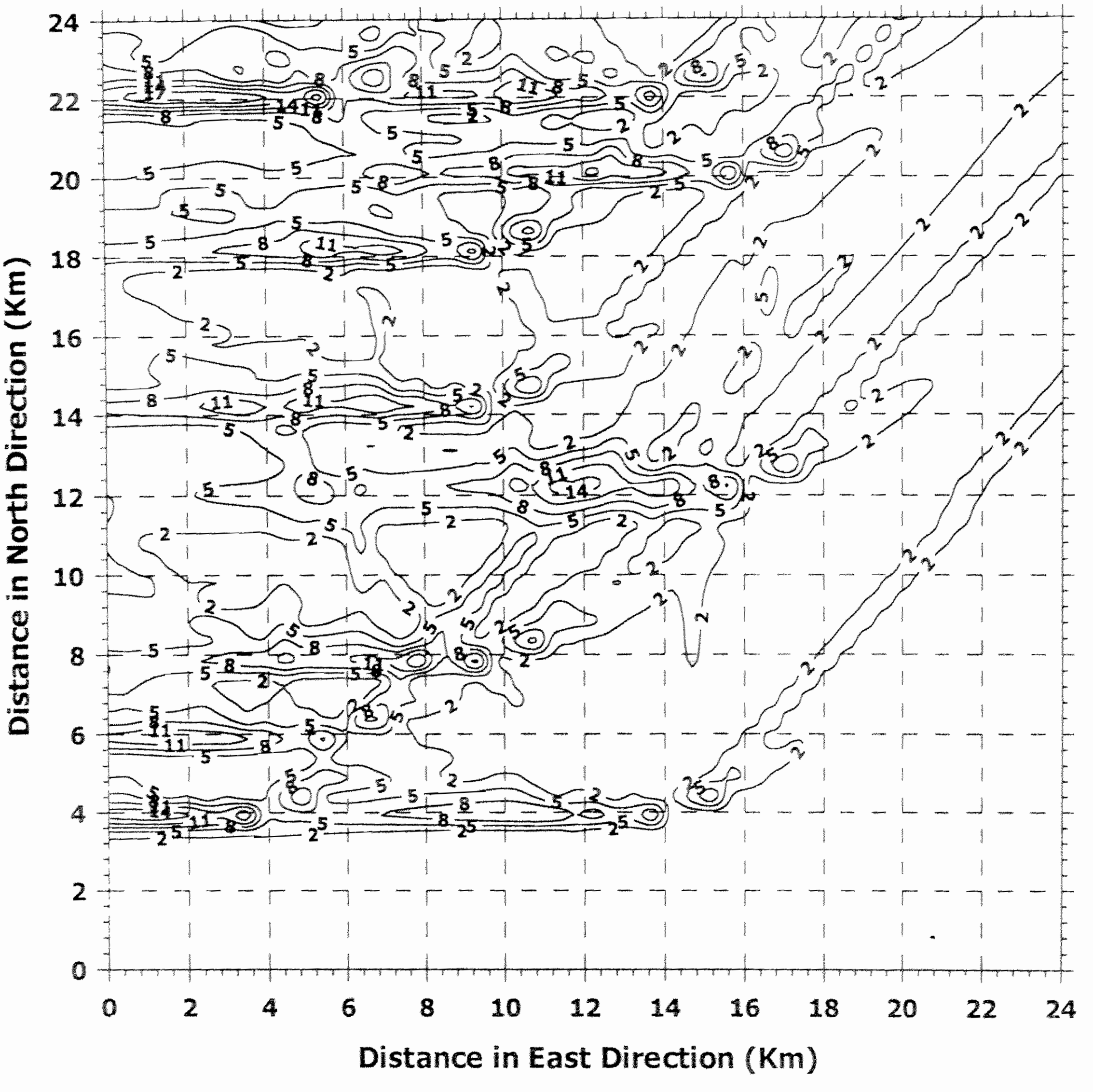


Fig. 6.1.1.5 : Predicted SO_2 Isopleths : Post Monsoon - Kalamassery (Ernakulam) [Emission Load : 2332.8 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	21	5.5	22.0	Alengad
2nd	19	3.0	22.0	Parur
3rd	19	2.5	22.0	Parur
4th	19	1.5	22.0	Parur
5th	19	2.0	22.0	Parur

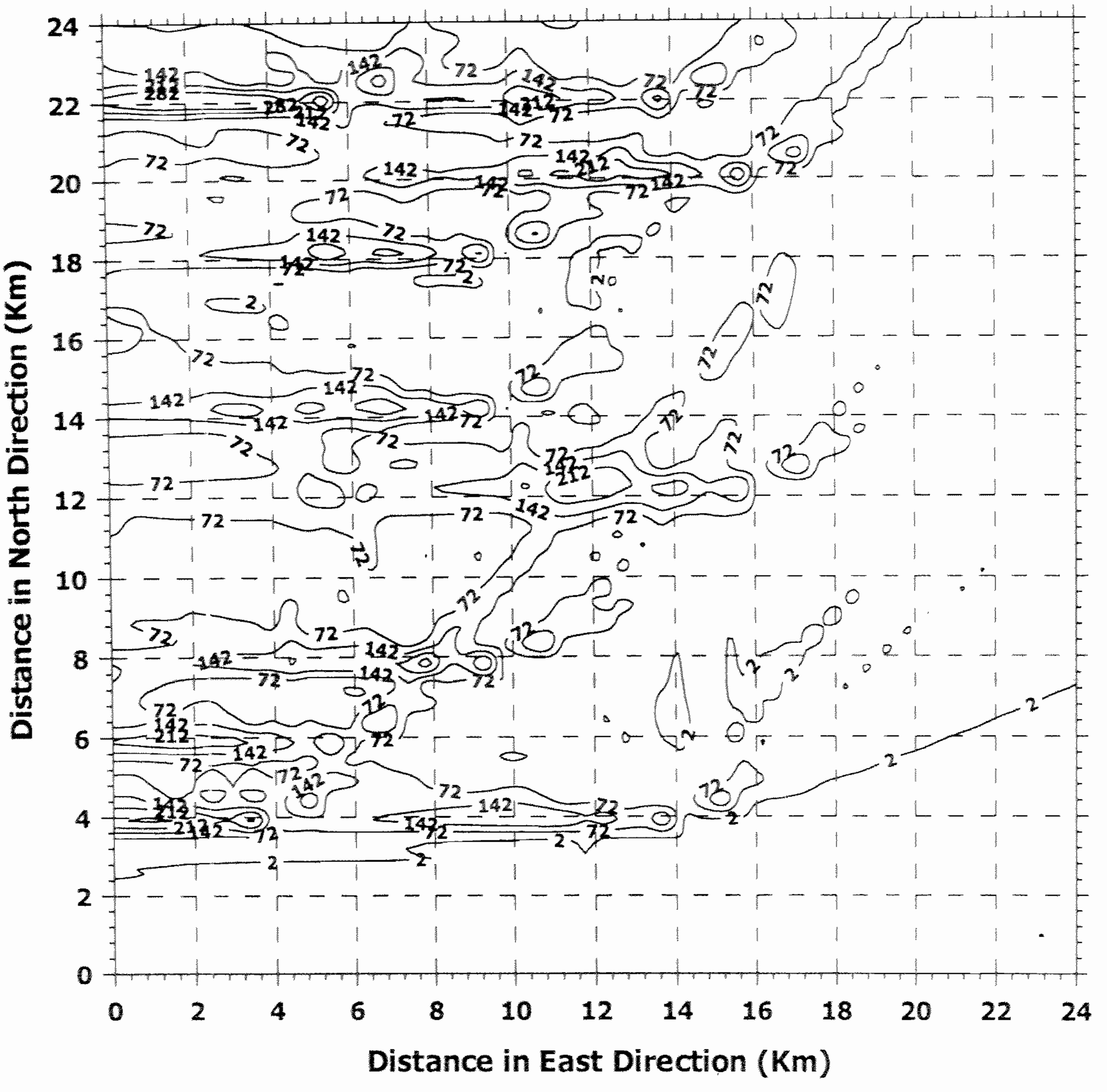


Fig. 6.1.1.6 : Predicted SPM Isopleths : Post Monsoon - Kalamassery (Ernakulam) [Emission Load : 43200 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	390	5.5	22.0	Alengad
2nd	351	3.0	22.0	Parur
3rd	348	2.5	22.0	Parur
4th	346	1.5	22.0	Parur
5th	343	2.0	22.0	Parur

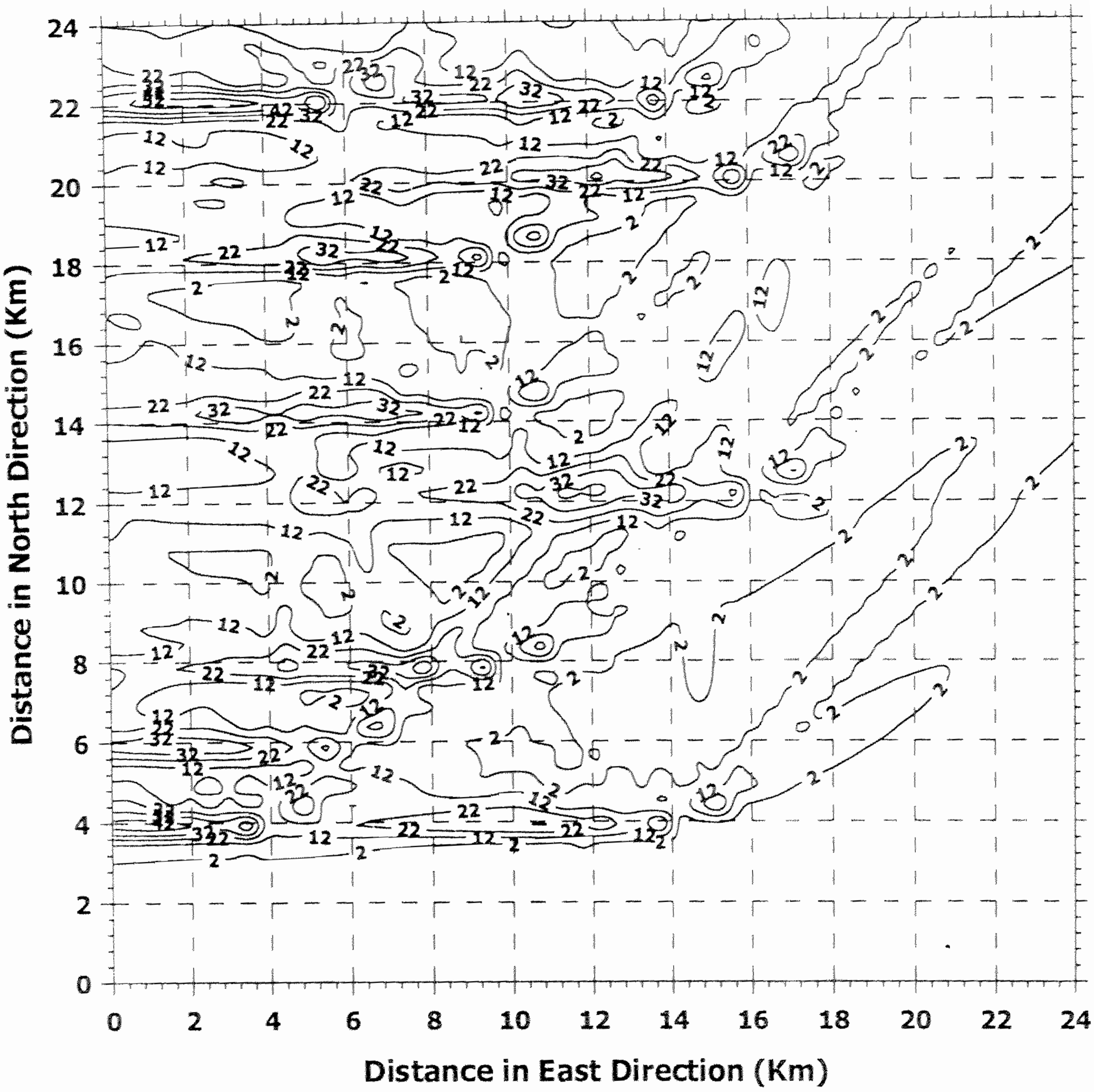


Fig. 6.1.1.7 : Predicted SO_2 Isopleths : Post Monsoon - Kalamassery (Ernakulam) [Emission Load : 6912 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	62	5.5	22.0	Alengad
2nd	56	3.0	22.0	Parur
3rd	56	2.5	22.0	Parur
4th	55	1.5	22.0	Parur
5th	55	2.0	22.0	Parur

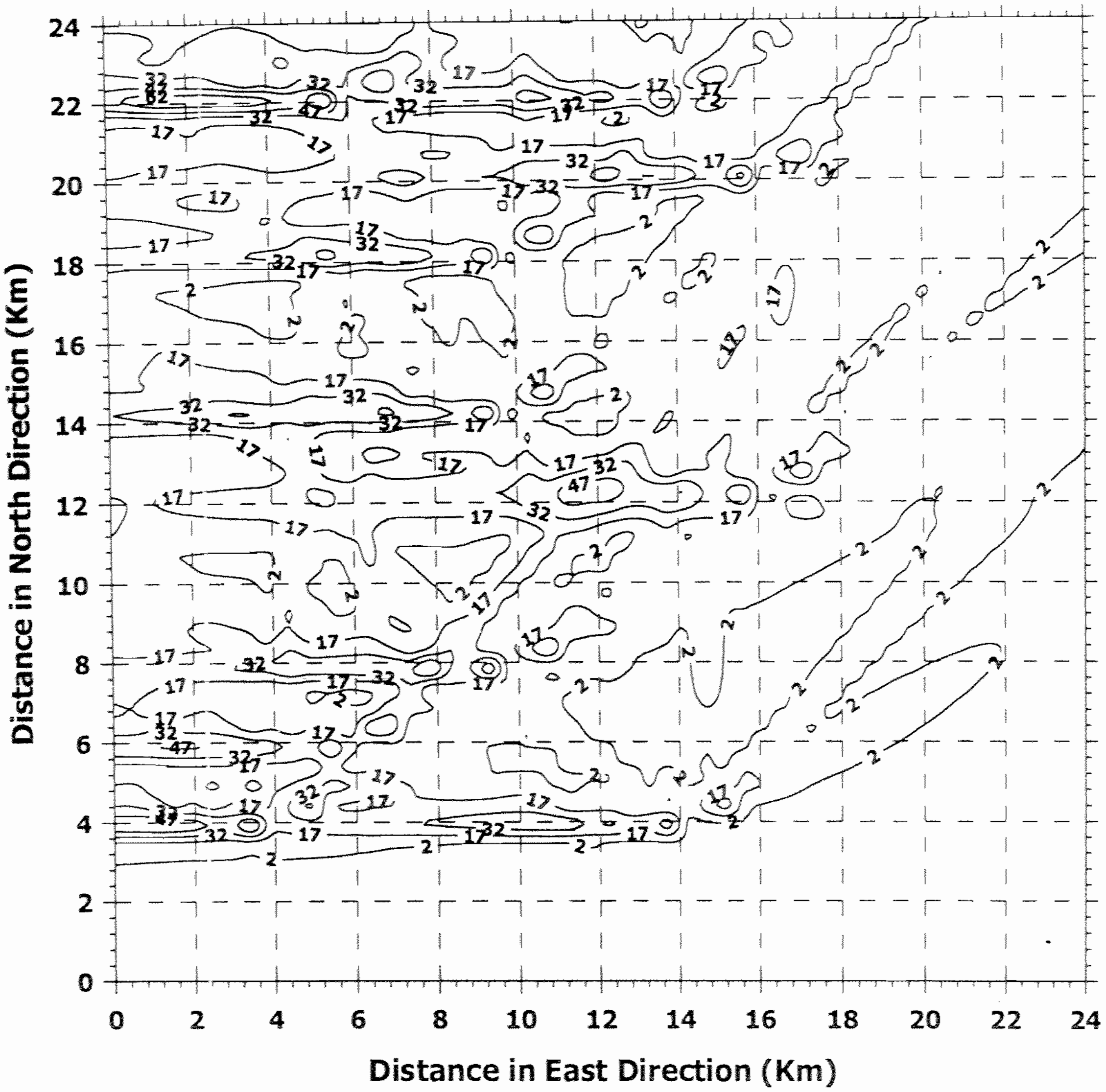


Fig. 6.1.1.8 : Predicted SPM Isopleths : Post Monsoon - Kalamassery (Ernakulam) [Emission Load : 8640 kg/day]

Highest Value	24 hrly Average Conc. (μg/m^3)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	78	5.5	22.0	Alengad
2nd	70	3.0	22.0	Parur
3rd	70	2.5	22.0	Parur
4th	69	1.5	22.0	Parur
5th	69	2.0	22.0	Parur

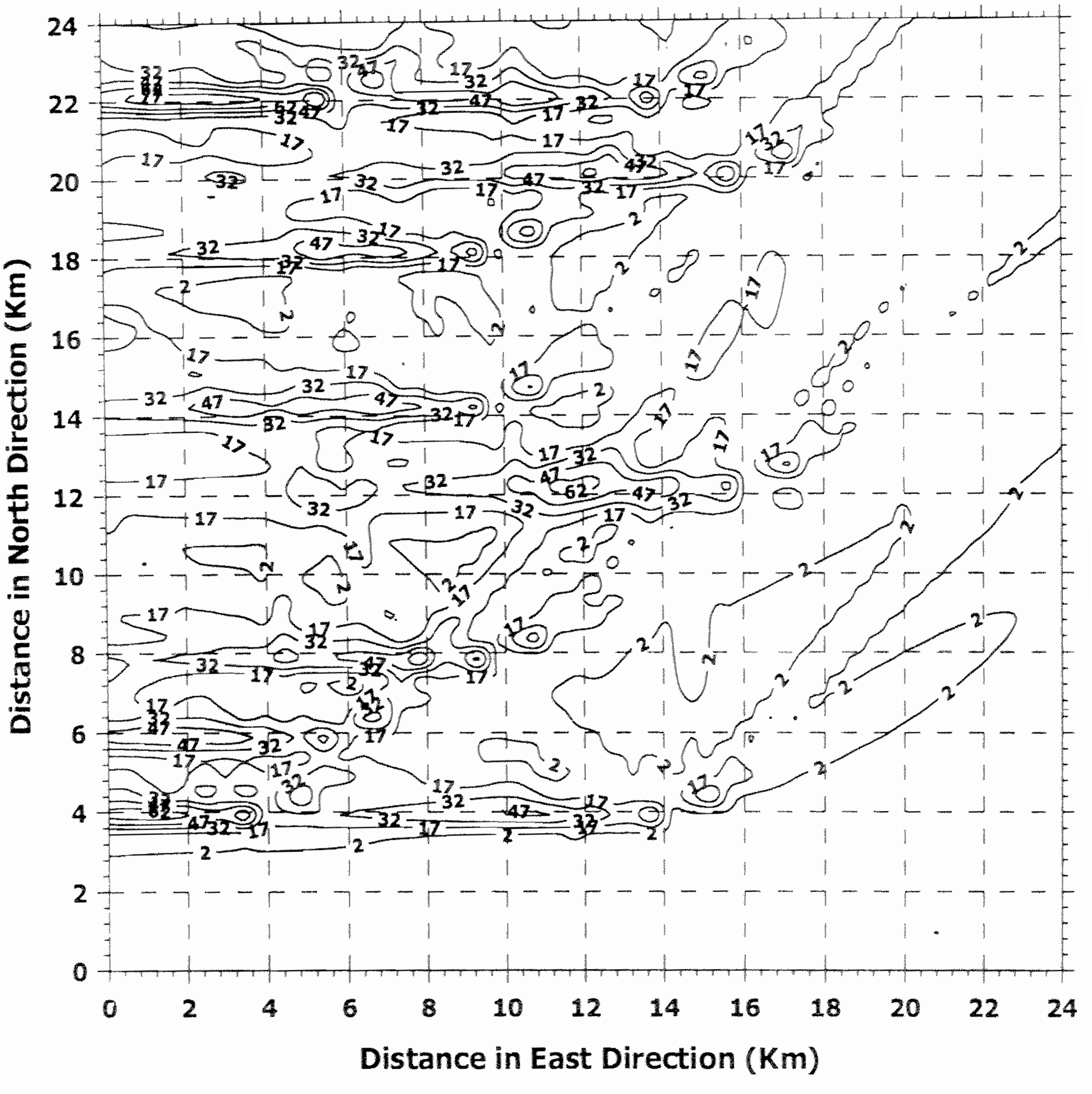


Fig. 6.1.1.9 : Predicted SO_2 Isopleths : Post Monsoon - Kalamassery (Ernakulam) [Emission Load : 10368 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	94	5.5	22.0	Alengad
2nd	84	3.0	22.0	Parur
3rd	83	2.5	22.0	Parur
4th	83	1.5	22.0	Parur
5th	82	2.0	22.0	Parur

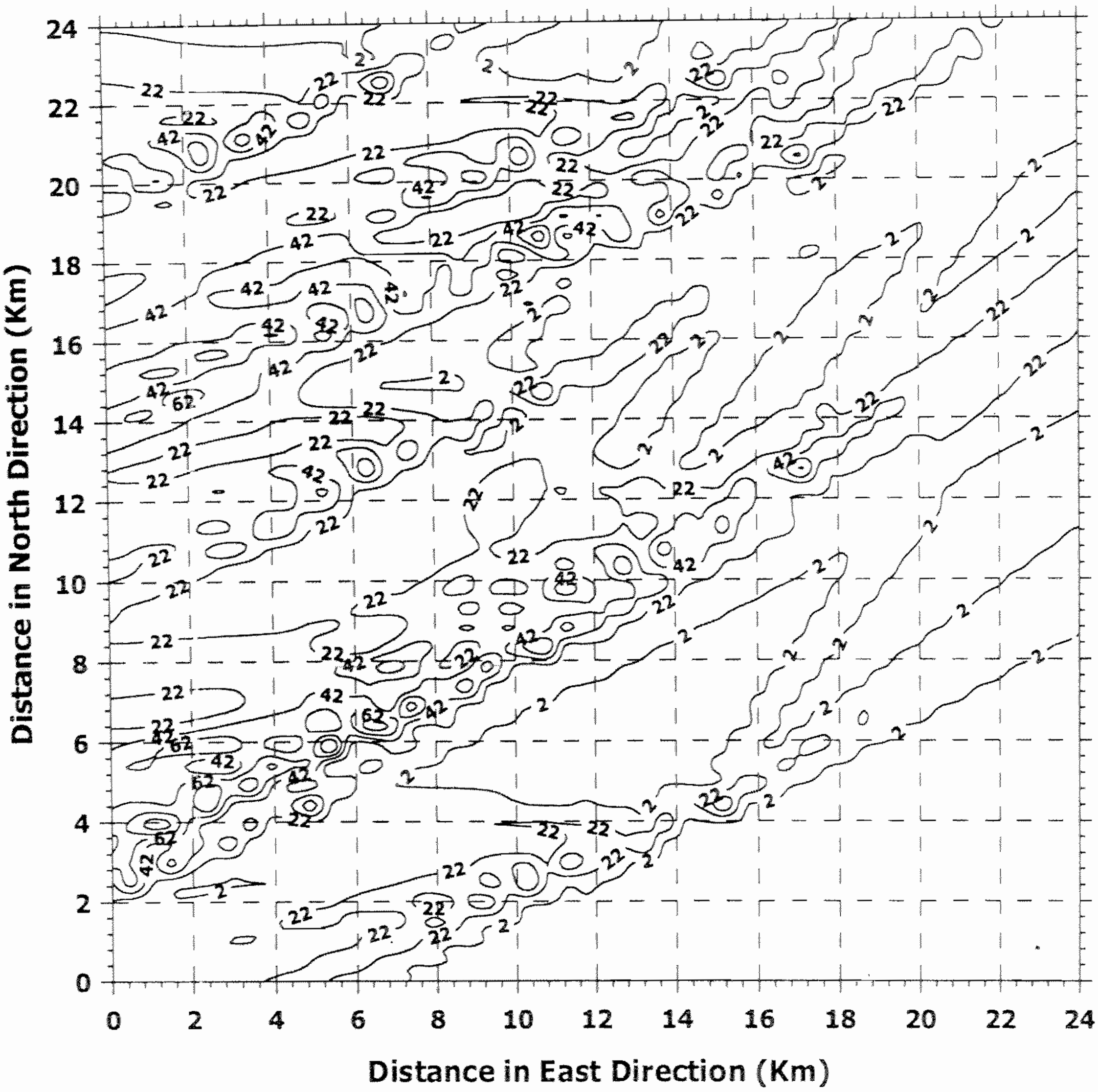


Fig. 6.1.1.10 : Predicted SPM Isopleths : Winter - Kalamassery (Ernakulam) [Emission Load : 17280 kg/day]

Highest Value	24 hrly Average Conc. (μg/m^3)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	109	1.0	4.0	Cochin
2nd	102	1.5	4.0	Cochin
3rd	101	5.5	6.0	Ernakulam
4th	95	2.5	4.5	Cochin
5th	93	3.5	5.0	Cochin

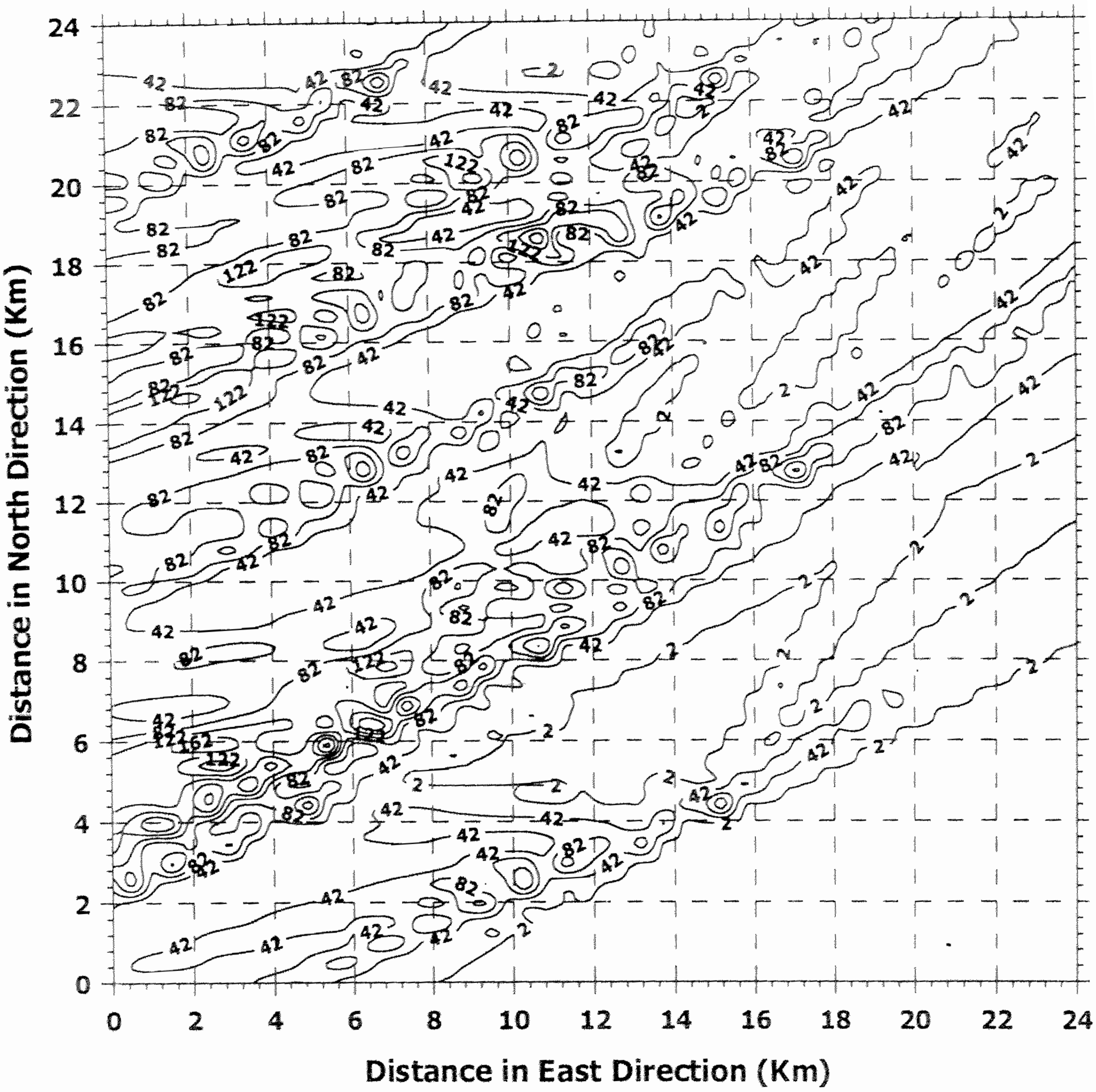


Fig. 6.1.1.11 : Predicted SPM Isopleths : Winter - Kalamassery (Ernakulam) [Emission Load : 43200 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	273	1.0	4.0	Cochin
2nd	254	1.5	4.0	Cochin
3rd	253	5.5	6.0	Ernakulam
4th	238	2.5	4.5	Cochin
5th	234	3.5	5.0	Cochin

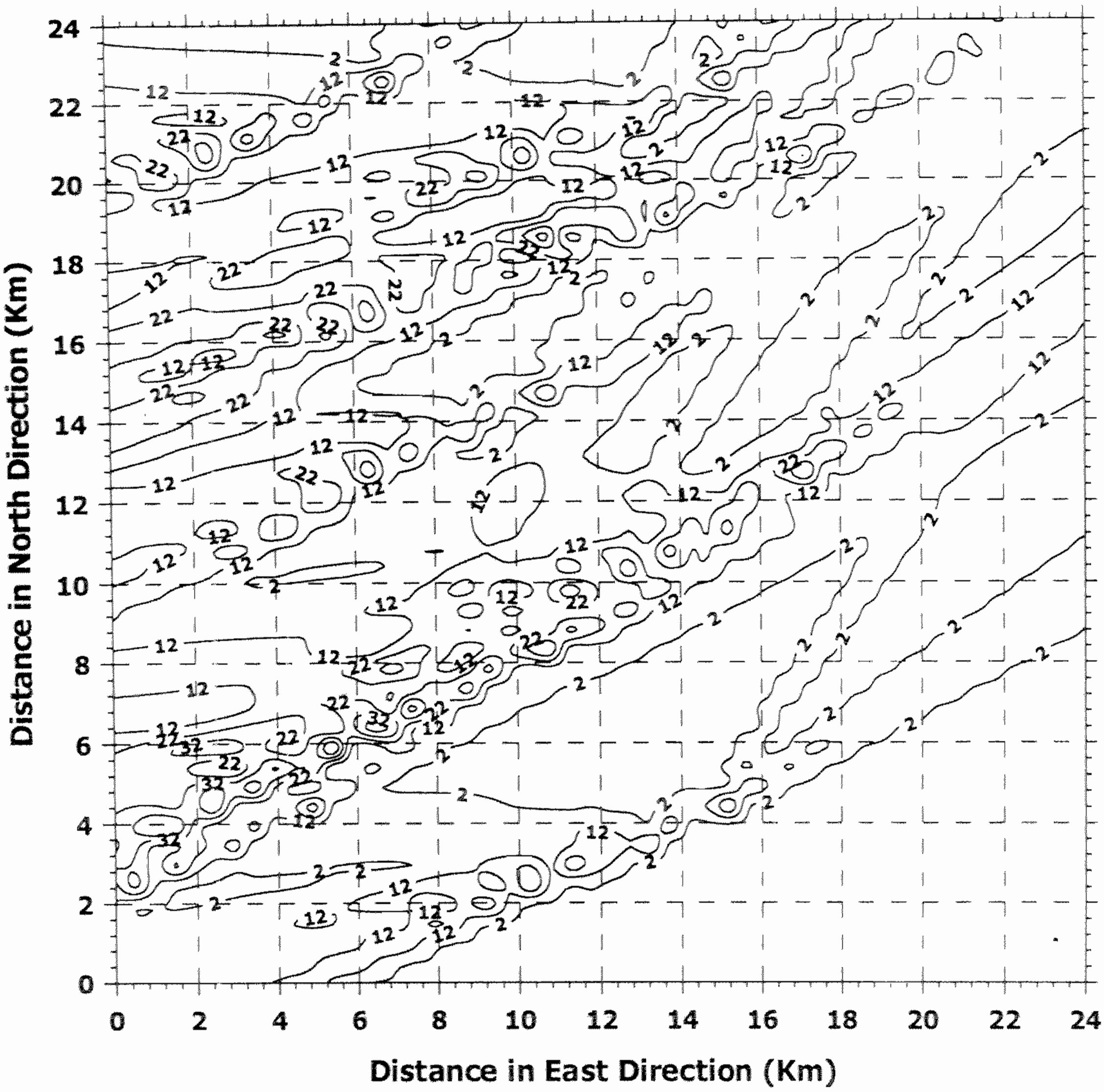


Fig. 6.1.1.12 : Predicted SPM Isopleths : Winter - Kalamassery (Ernakulam) [Emission Load : 8640 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	55	1.0	4.0	Cochin
2nd	51	1.5	4.0	Cochin
3rd	51	5.5	6.0	Ernakulam
4th	48	2.5	4.5	Cochin
5th	47	3.5	5.0	Cochin

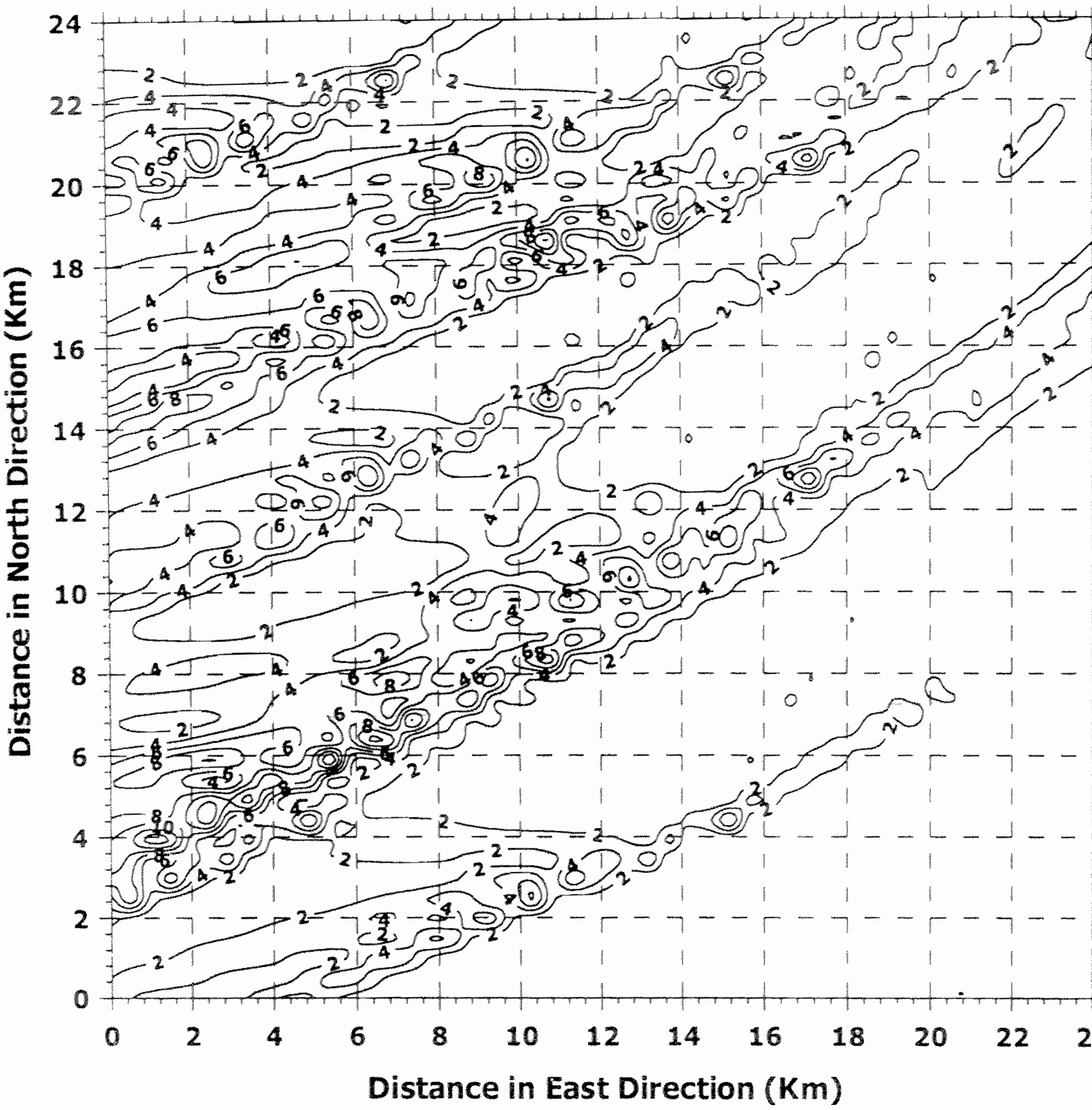


Fig. 6.1.1.13 : Predicted SO_2 Isopleths : Winter - Kalamassery (Ernakulam) [Emission Load : 2332.8 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	15	1.0	4.0	Cochin
2nd	14	1.5	4.0	Cochin
3rd	14	5.5	6.0	Ernakulam
4th	13	2.5	4.5	Cochin
5th	13	3.5	5.0	Cochin

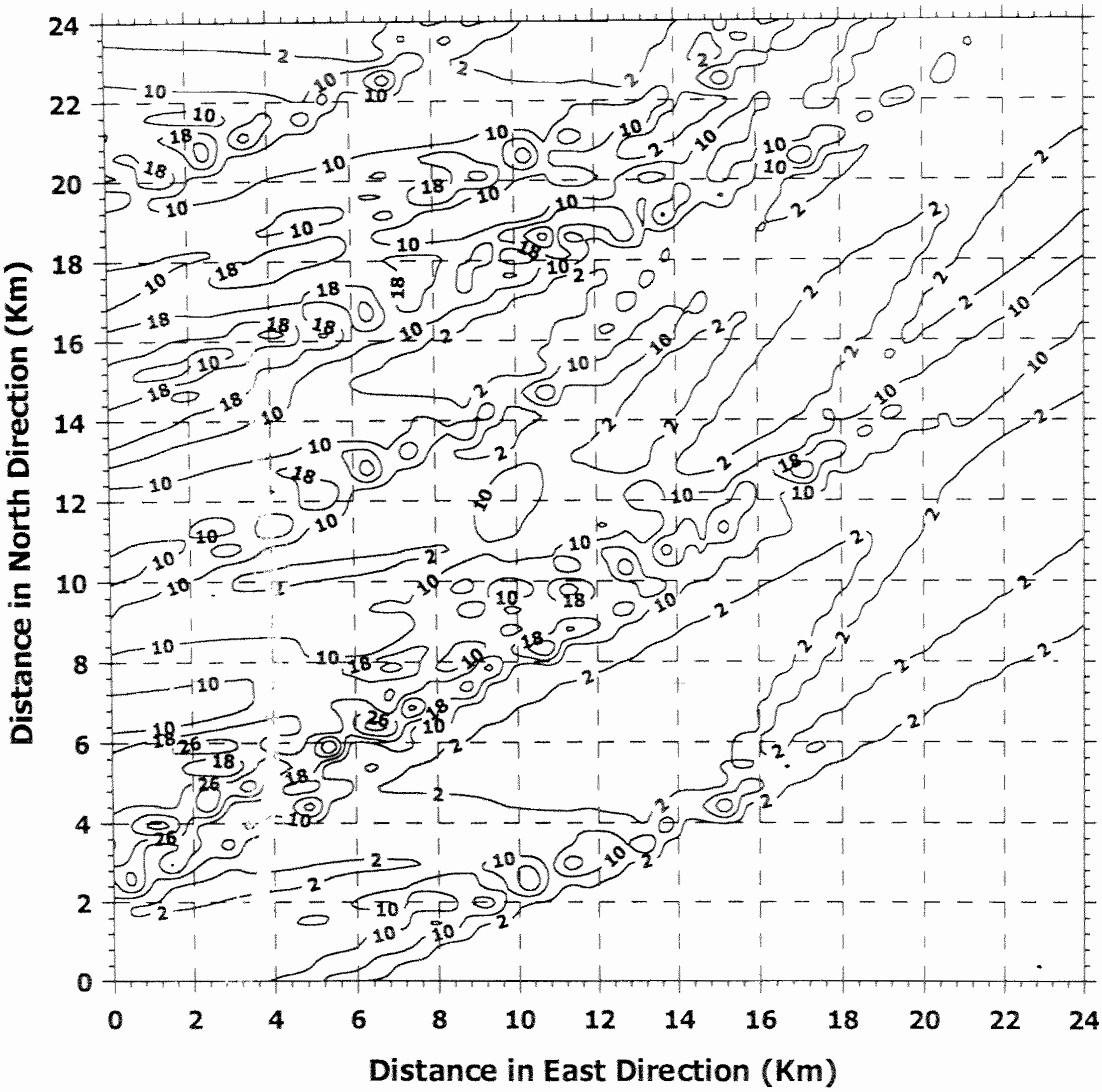


Fig 6.1.1.14 : Predicted SO_2 Isopleths : Winter - Kalamassery (Ernakulam) [Emission Load : 6912 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	44	1.0	4.0	Cochin
2nd	41	1.5	4.0	Cochin
3rd	41	5.5	6.0	Ernakulam
4th	38	2.5	4.5	Cochin
5th	37	3.5	5.0	Cochin

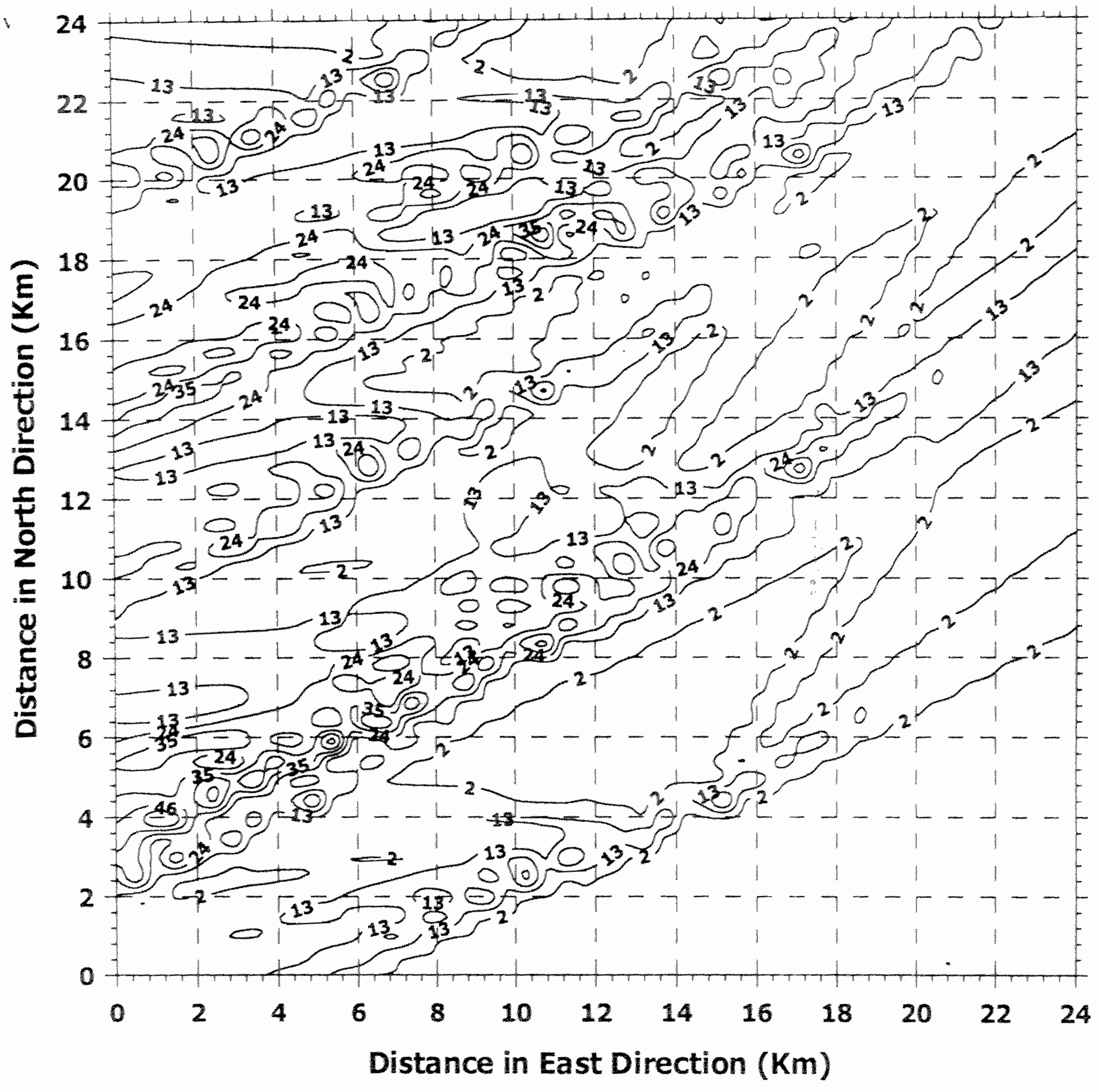


Fig 6.1.1.15 : Predicted SO_2 Isopleths : Winter - Kalamassery (Ernakulam) [Emission Load : 10368 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	66	1.0	4.0	Cochin
2nd	61	1.5	4.0	Cochin
3rd	61	5.5	6.0	Ernakulam
4th	57	2.5	4.5	Cochin
5th	56	3.5	5.0	Cochin

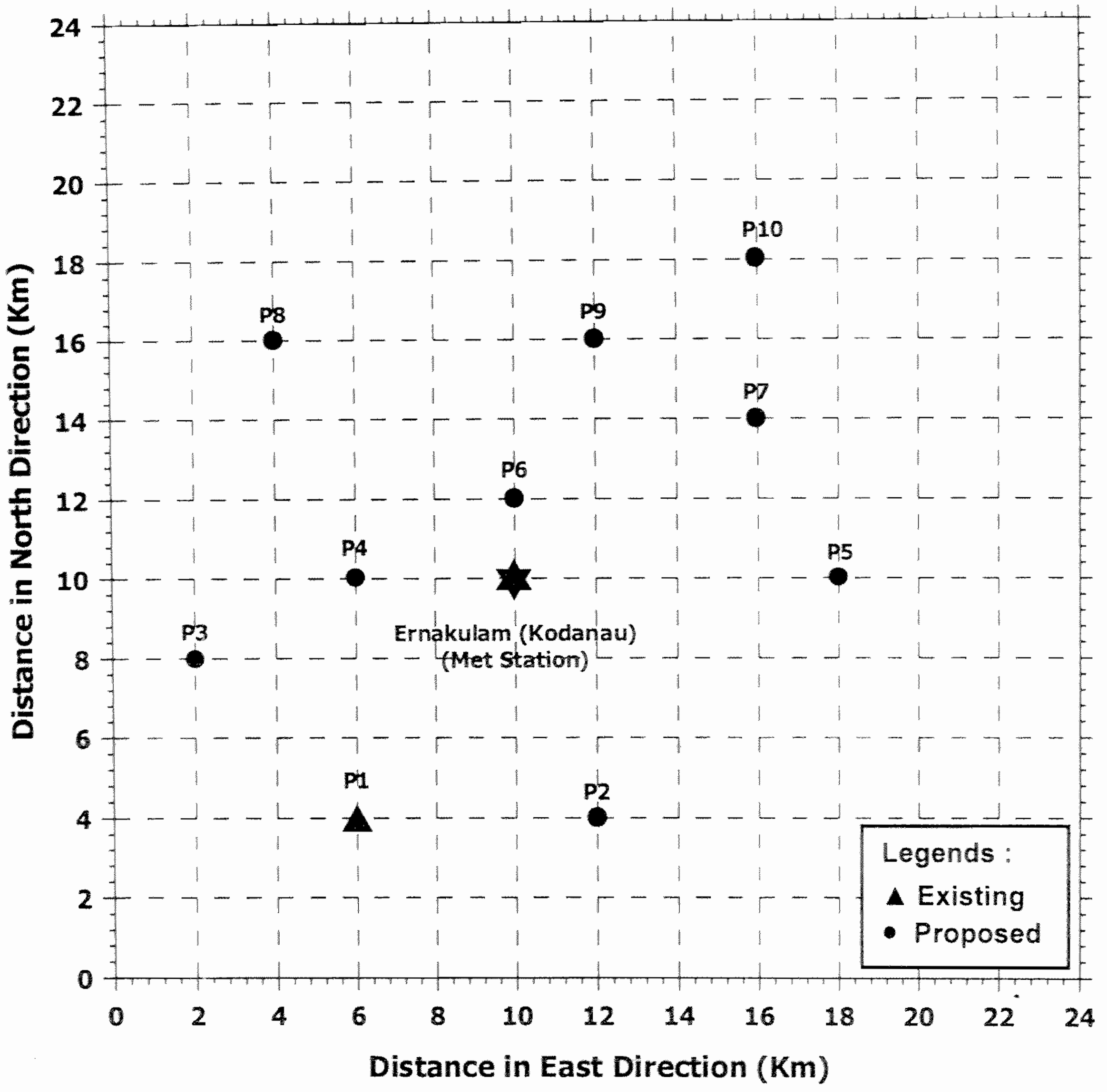


Fig. 6.1.1.16 : Existing and Proposed Point Sources in Kodanadu, Ernakulam District

Source	X	Y	Location	
			Place	Block
P1	6000	4000	Perumbavoor	
P2	12000	4000	kammanur	Koovapady
P3	2000	8000	Koovapady	Kovappady
P4	6000	10000	Koovapdy	Kovappady
P5	18000	10000	Vengoor	Kovappady
P6	10000	12000	Malayattor – Nileswaram	Angamali
P7	16000	14000	vengur	Kovappady
P8	4000	16000	Manjapra	Angamali
P9	12000	16000	Vengoor	Kovappady
P10	16000	18000	Vengoor	Kovappady

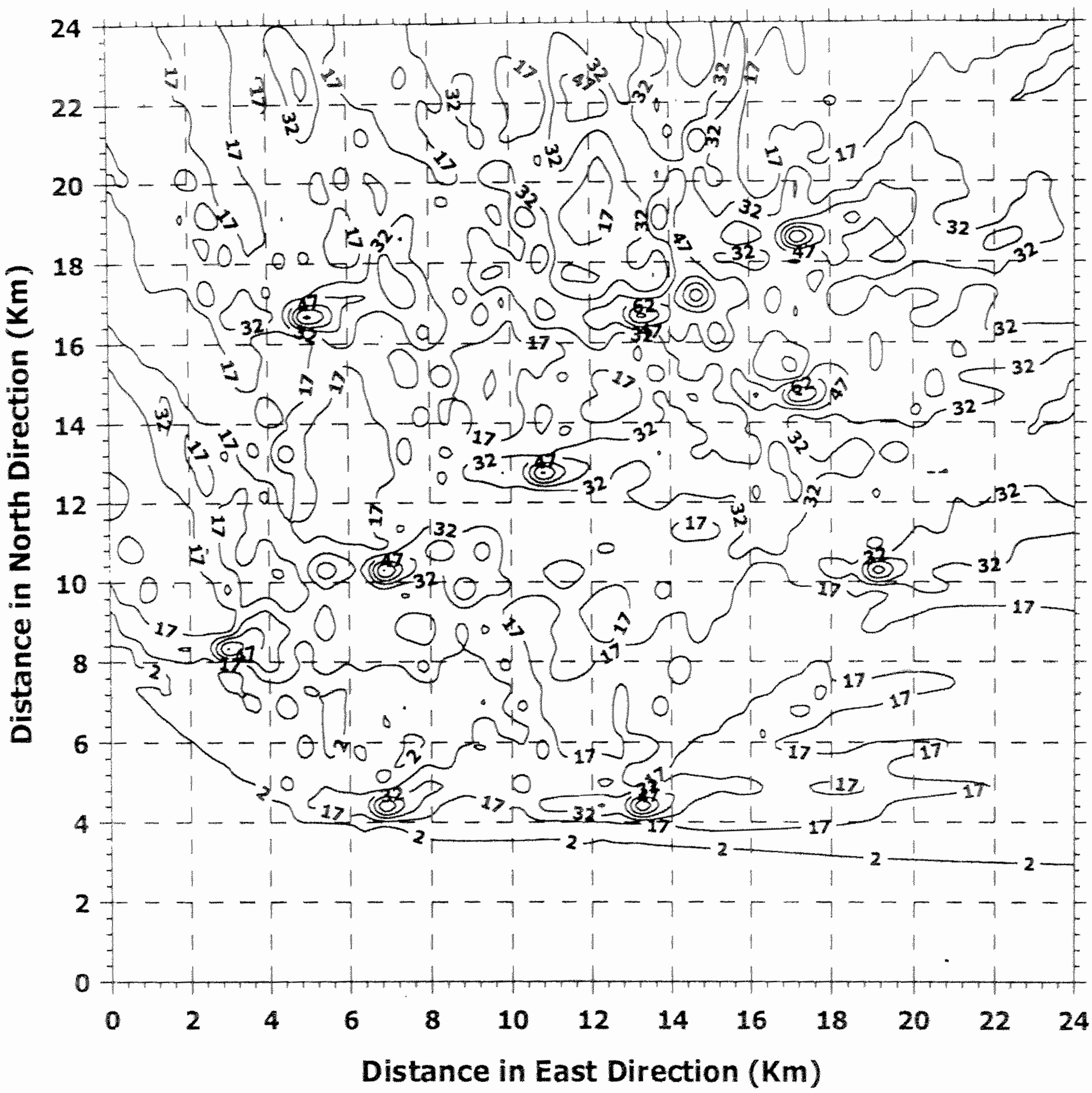


Fig. 6.1.1.17 : Predicted SPM Isopleths : Post Monsoon - Kodanadu (Ernakulam) [Emission Load : 12960 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	105	17.0	18.5	Koovapady
2nd	100	14.5	17.0	Koovapady
3rd	94	13.0	16.5	Angamali
4th	93	11.0	12.5	Koovapady
5th	93	7.0	10.5	Koovapady

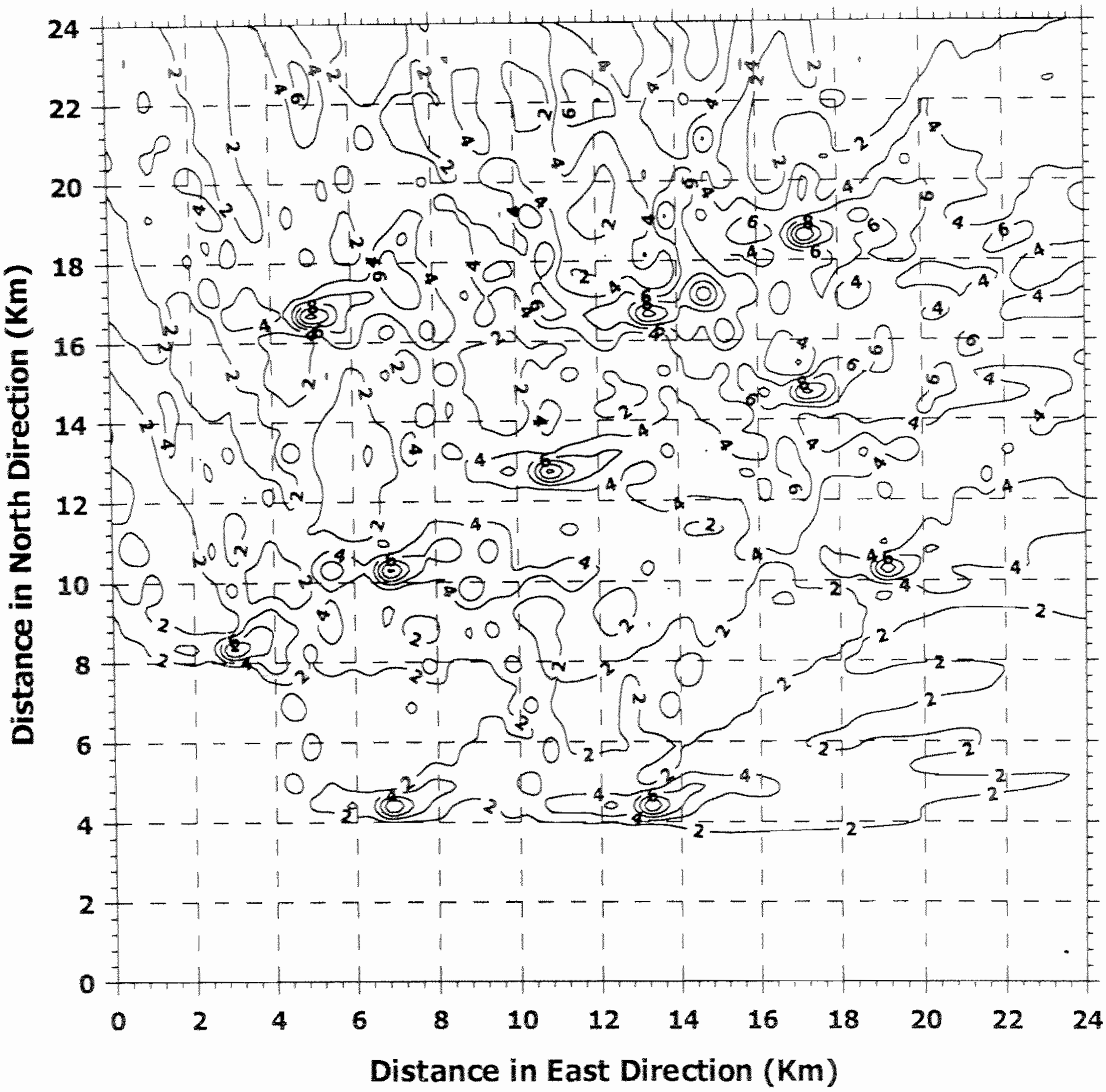


Fig. 6.1.1.18 : Predicted SO_2 Isopleths : Post Monsoon - Kodanadu (Ernakulam) [Emission Load : 1728 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	14	17.0	18.5	Koovapady
2nd	13	14.5	17.0	Koovapady
3rd	13	13.0	16.5	Angamali
4th	12	11.0	12.5	Koovapady
5th	12	7.0	10.5	Koovapady

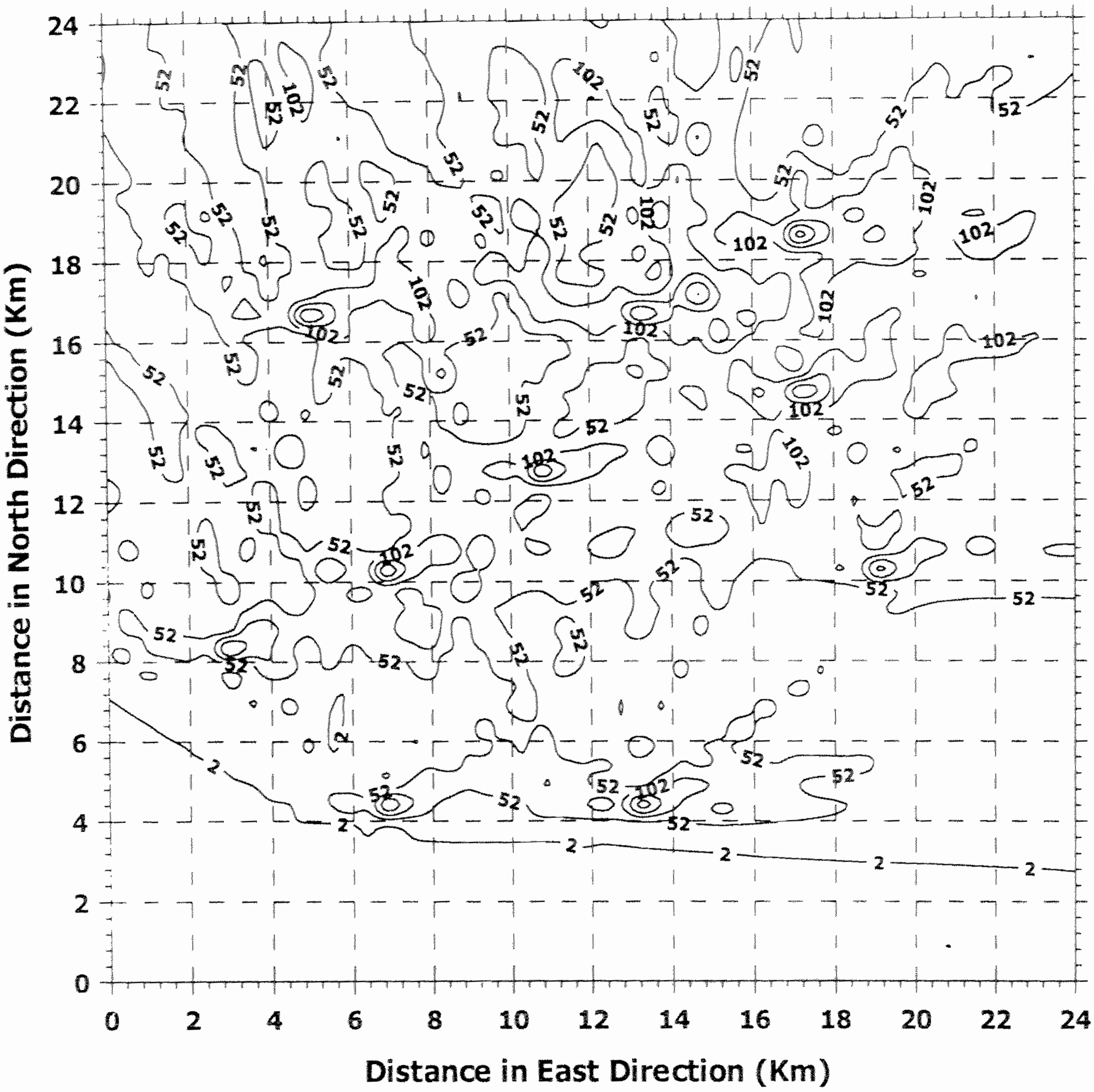


Fig. 6.1.1.19 : Predicted SPM Isopleths : Post Monsoon - Kodanadu (Ernakulam) [Emission Load : 32832 kg/day]

Highest Value	24 hrly Average Conc. (μg/m^3)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	265	17.0	18.5	Koovapady
2nd	252	14.5	17.0	Koovapady
3rd	239	13.0	16.5	Angamali
4th	236	11.0	12.5	Koovapady
5th	235	7.0	10.5	Koovapady

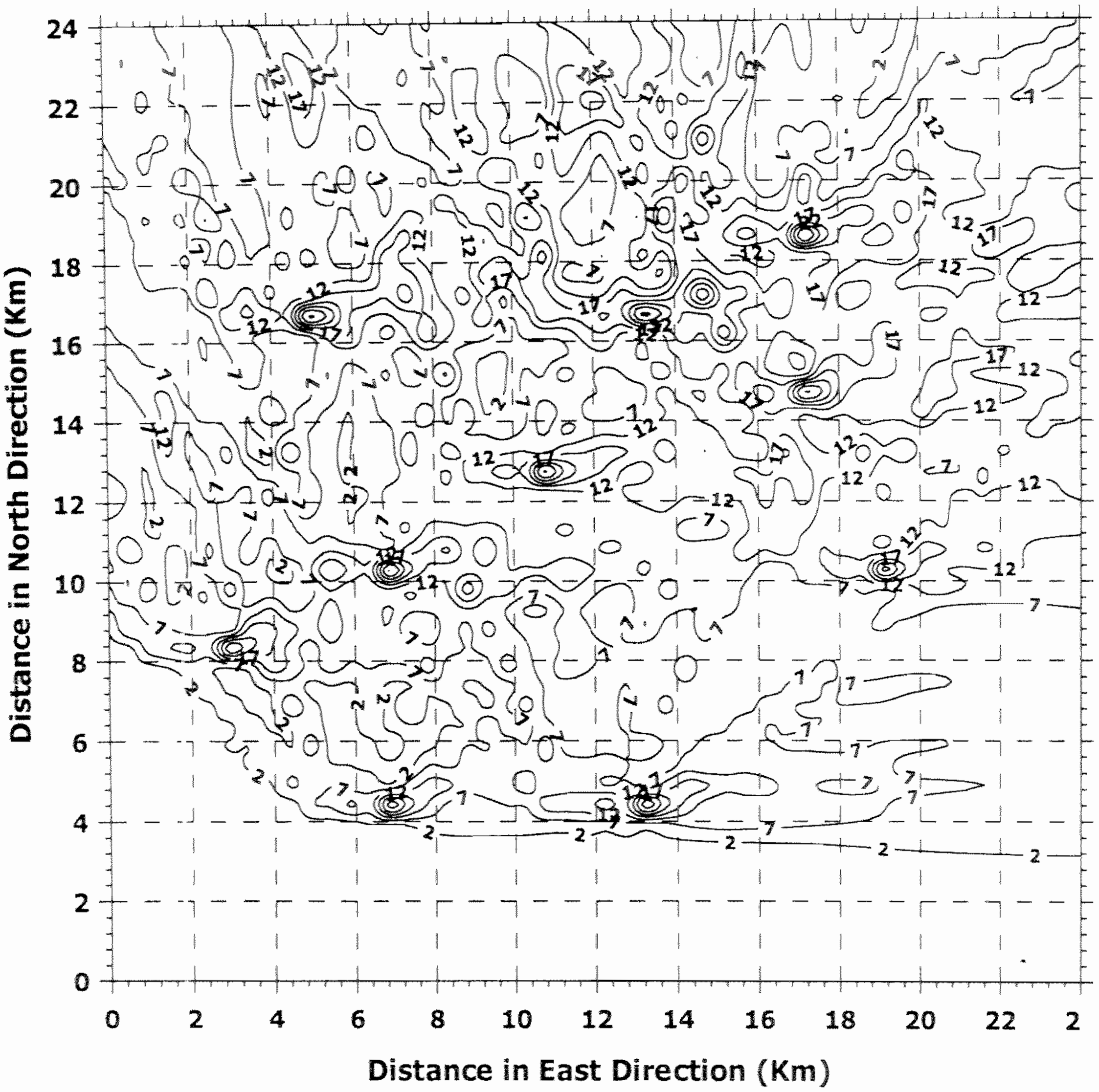


Fig. 6.1.1.20 : Predicted SO_2 Isopleths : Post Monsoon - Kodanadu (Ernakulam) [Emission Load : 5184 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	42	17.0	18.5	Koovapady
2nd	40	14.5	17.0	Koovapady
3rd	38	13.0	16.5	Angamali
4th	37	11.0	12.5	Koovapady
5th	37	7.0	10.5	Koovapady

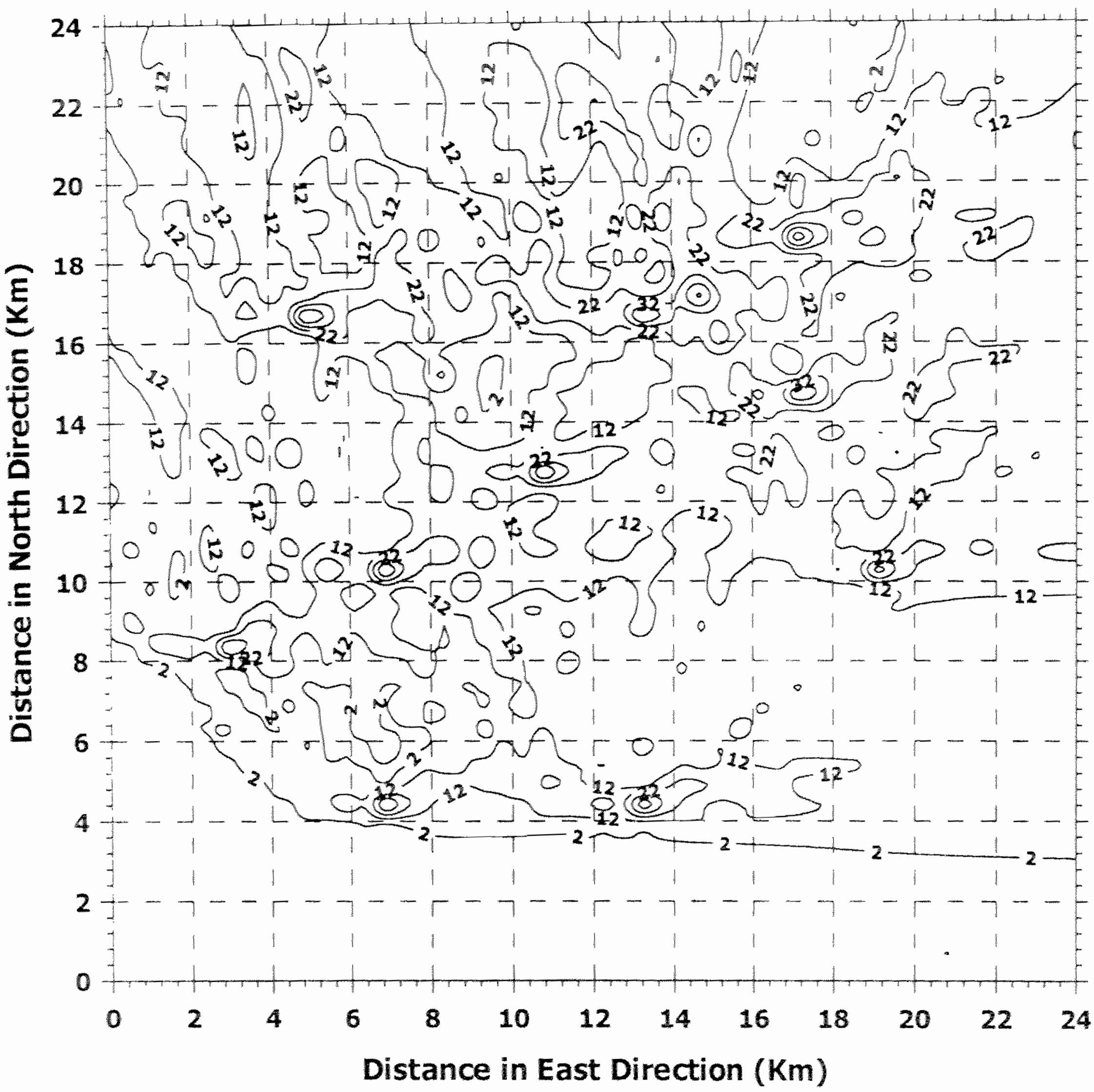


Fig. 6.1.1.21 : Predicted SPM Isopleths : Post Monsoon - Kodanadu (Ernakulam) [Emission Load : 6912 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	56	17.0	18.5	Koovapady
2nd	53	14.5	17.0	Koovapady
3rd	50	13.0	16.5	Angamali
4th	50	11.0	12.5	Koovapady
5th	50	7.0	10.5	Koovapady

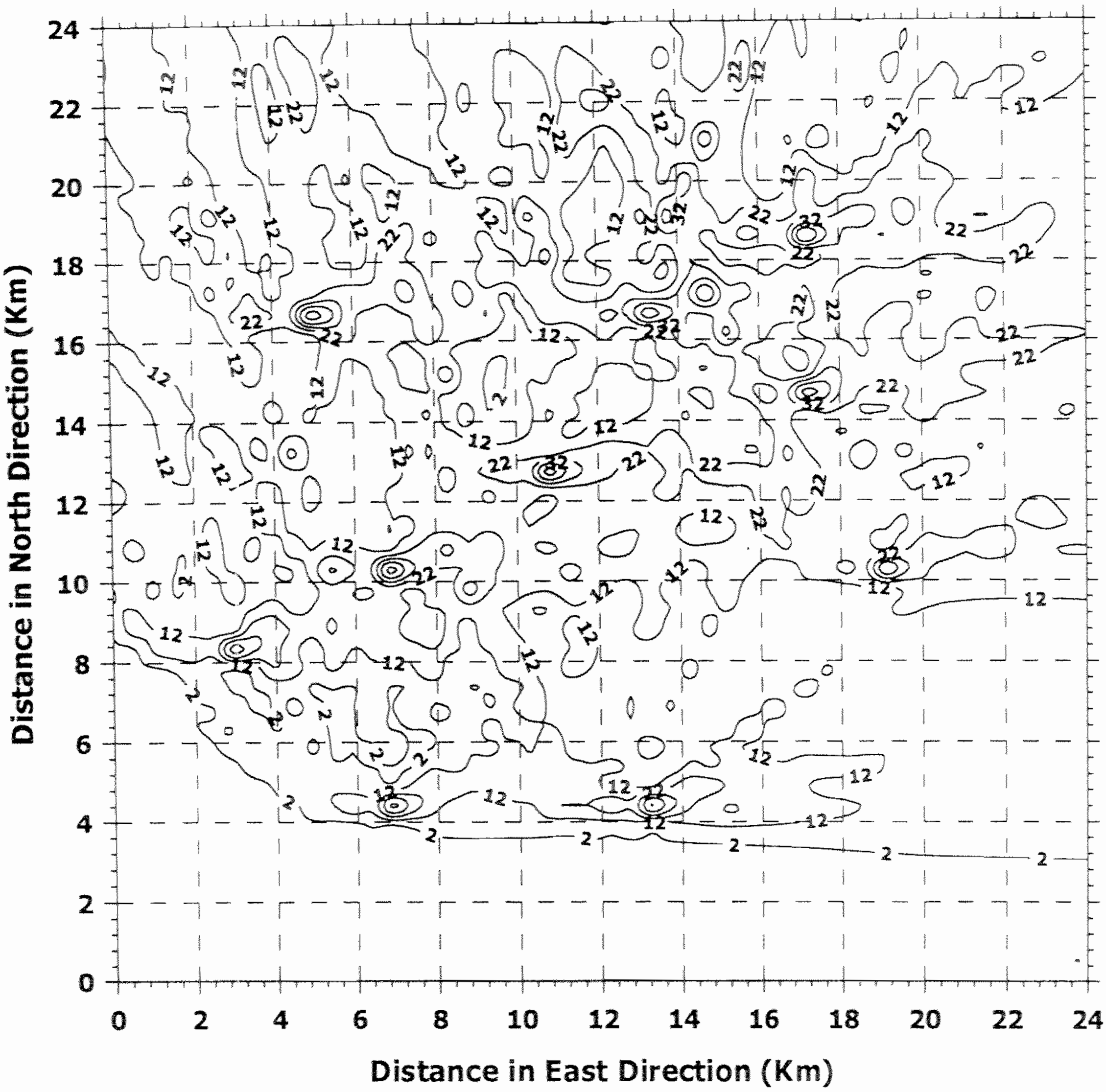


Fig. 6.1.1.22 : Predicted SO_2 Isopleths : Post Monsoon - Kodanadu (Ernakulam) [Emission Load : 7776 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	63	17.0	18.5	Koovapady
2nd	60	14.5	17.0	Koovapady
3rd	57	13.0	16.5	Angamali
4th	56	11.0	12.5	Koovapady
5th	56	7.0	10.5	Koovapady

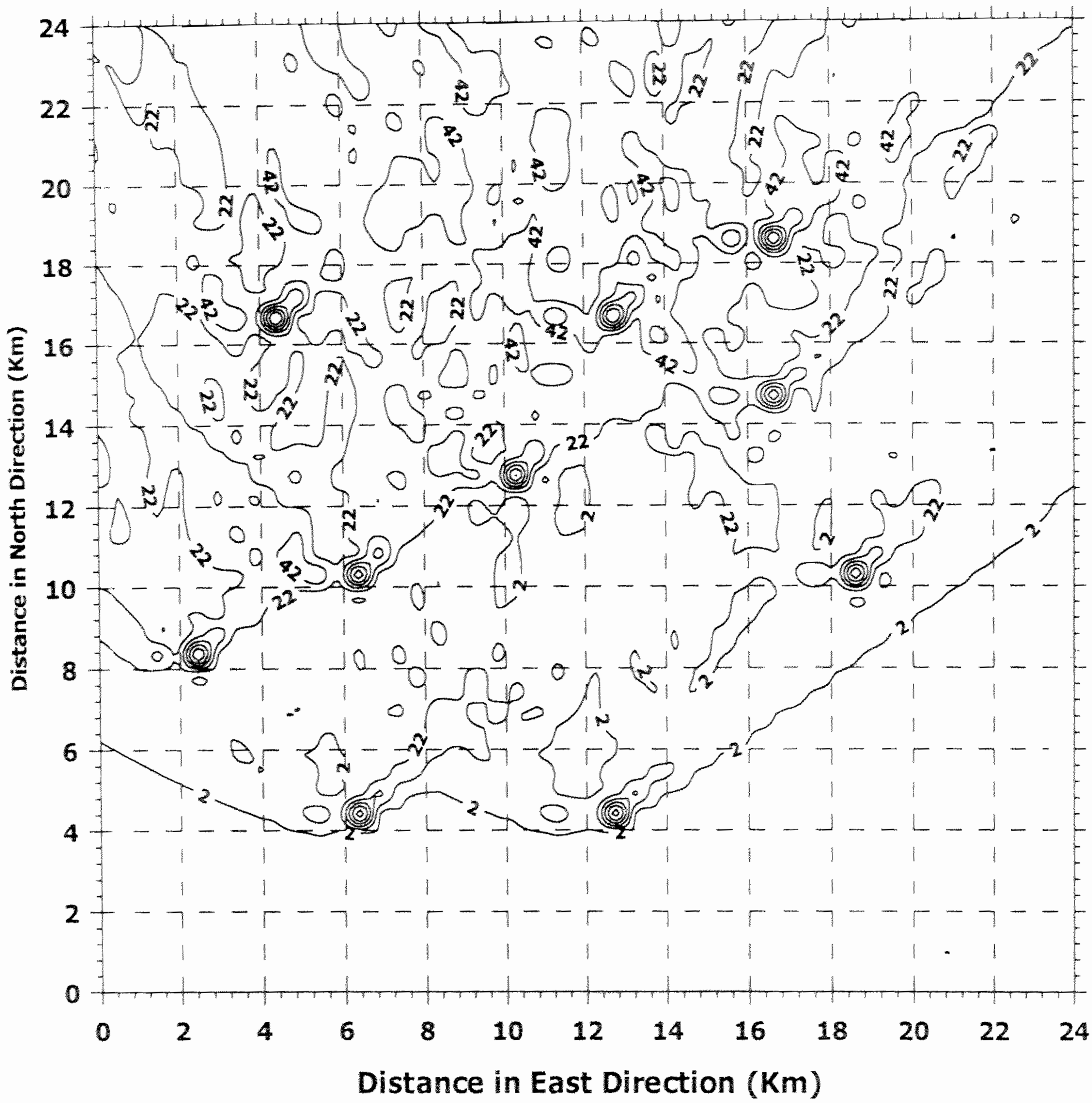


Fig. 6.1.1.23 : Predicted SPM Isopleths : Winter - Kodanadu (Ernakulam) [Emission Load : 12960 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	146	12.5	16.5	Koovapady
2nd	145	4.5	16.5	Angamali
3rd	141	16.5	18.5	Koovapady
4th	123	10.5	12.5	Koovapady
5th	121	2.5	8.5	Koovapady

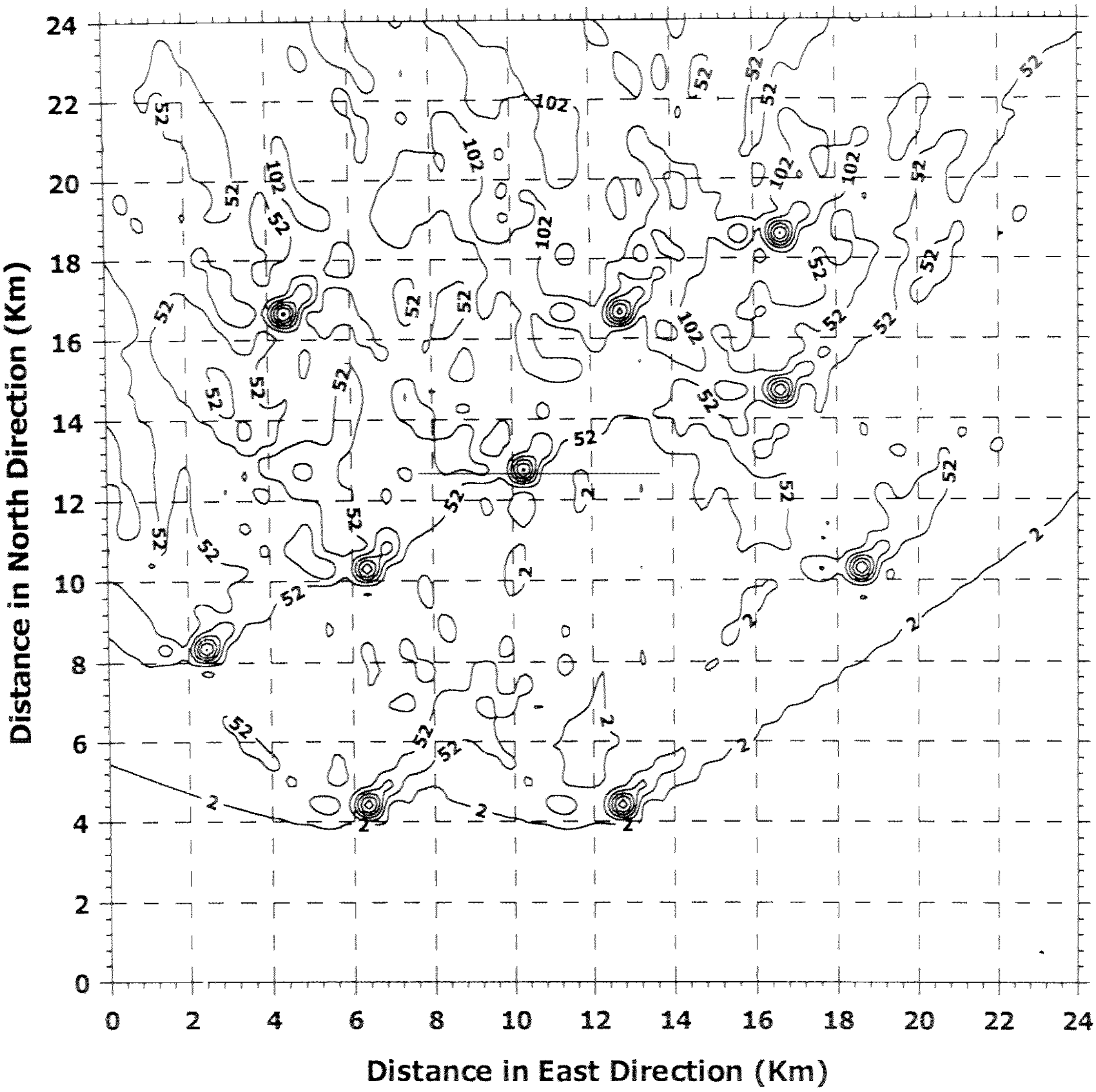


Fig. 6.1.1.24 : Predicted SPM Isopleths : Winter - Kodanadu (Ernakulam) [Emission Load : 32832 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	371	12.5	16.5	Koovapady
2nd	367	4.5	16.5	Angamali
3rd	358	16.5	18.5	Koovapady
4th	311	10.5	12.5	Koovapady
5th	306	2.5	8.5	Koovapady

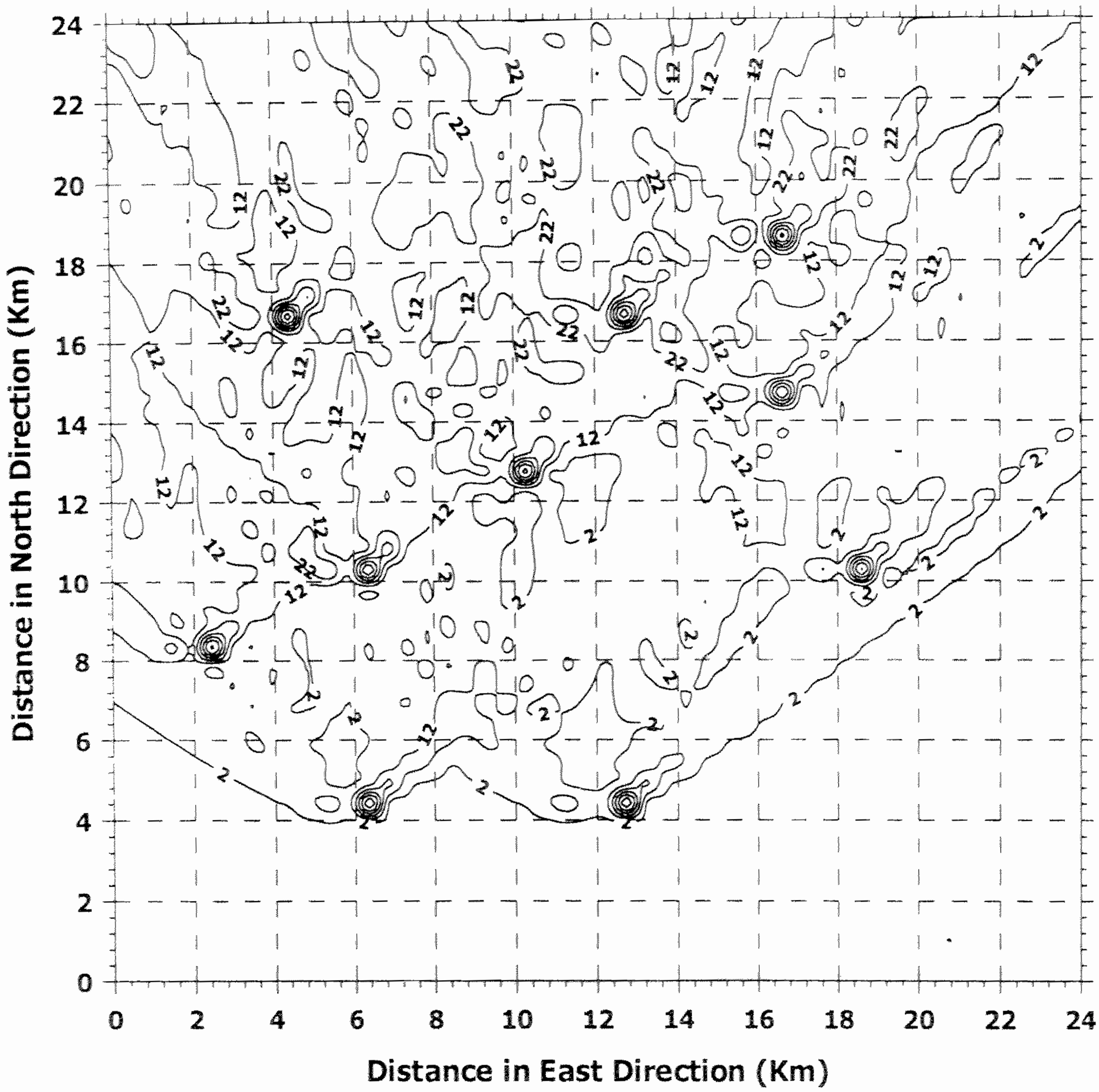


Fig. 6.1.1.25 : Predicted SPM Isopleths : Winter - Kodanadu (Ernakulam) [Emission Load : 6912 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	78	12.5	16.5	Koovapady
2nd	77	4.5	16.5	Angamali
3rd	75	16.5	18.5	Koovapady
4th	65	10.5	12.5	Koovapady
5th	64	2.5	8.5	Koovapady

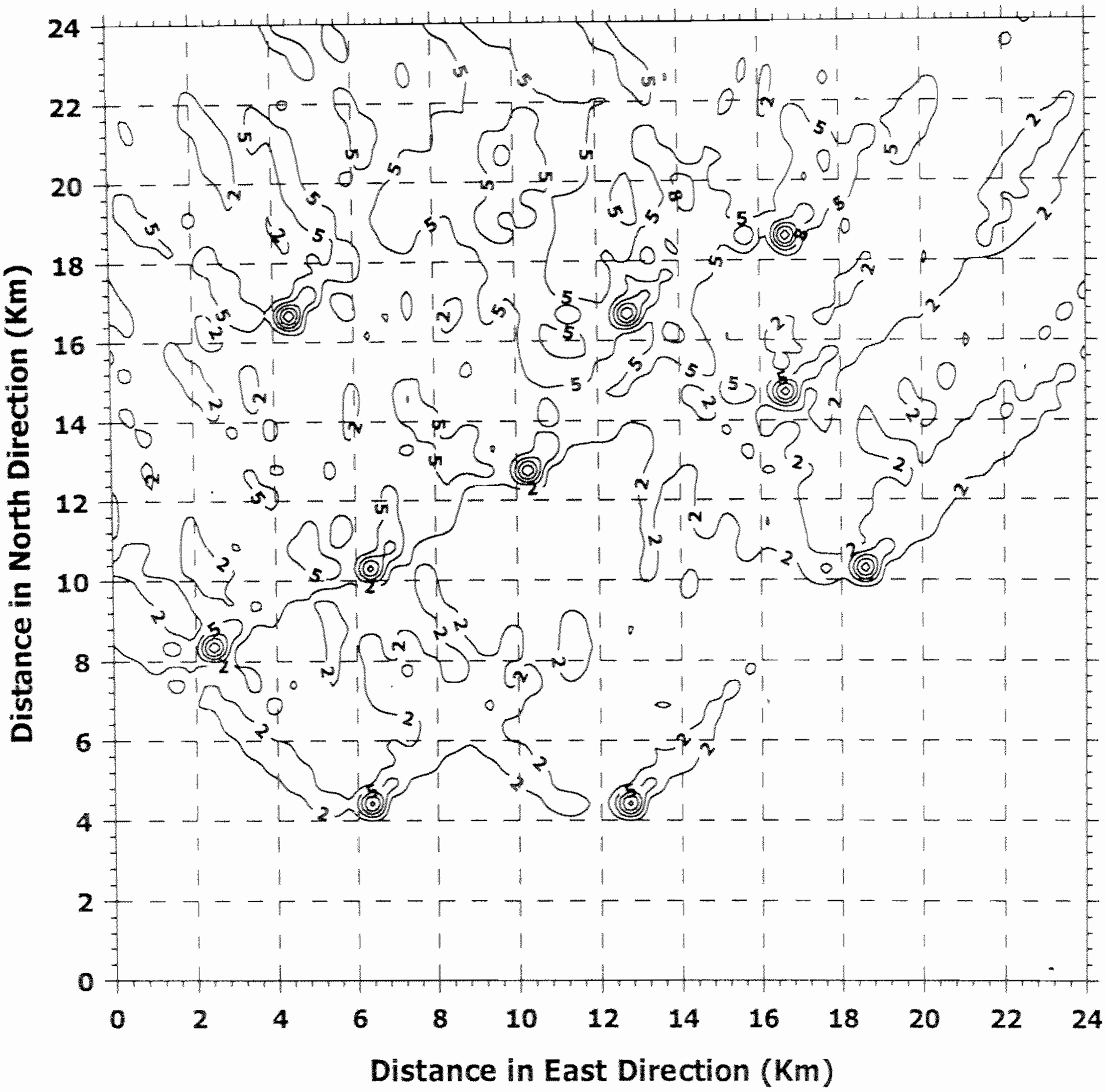


Fig. 6.1.1.26 : Predicted SO_2 Isopleths : Winter - Kodanadu (Ernakulam) [Emission Load : 1728 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	20	12.5	16.5	Koovapady
2nd	19	4.5	16.5	Angamali
3rd	19	16.5	18.5	Koovapady
4th	16	10.5	12.5	Koovapady
5th	16	2.5	8.5	Koovapady

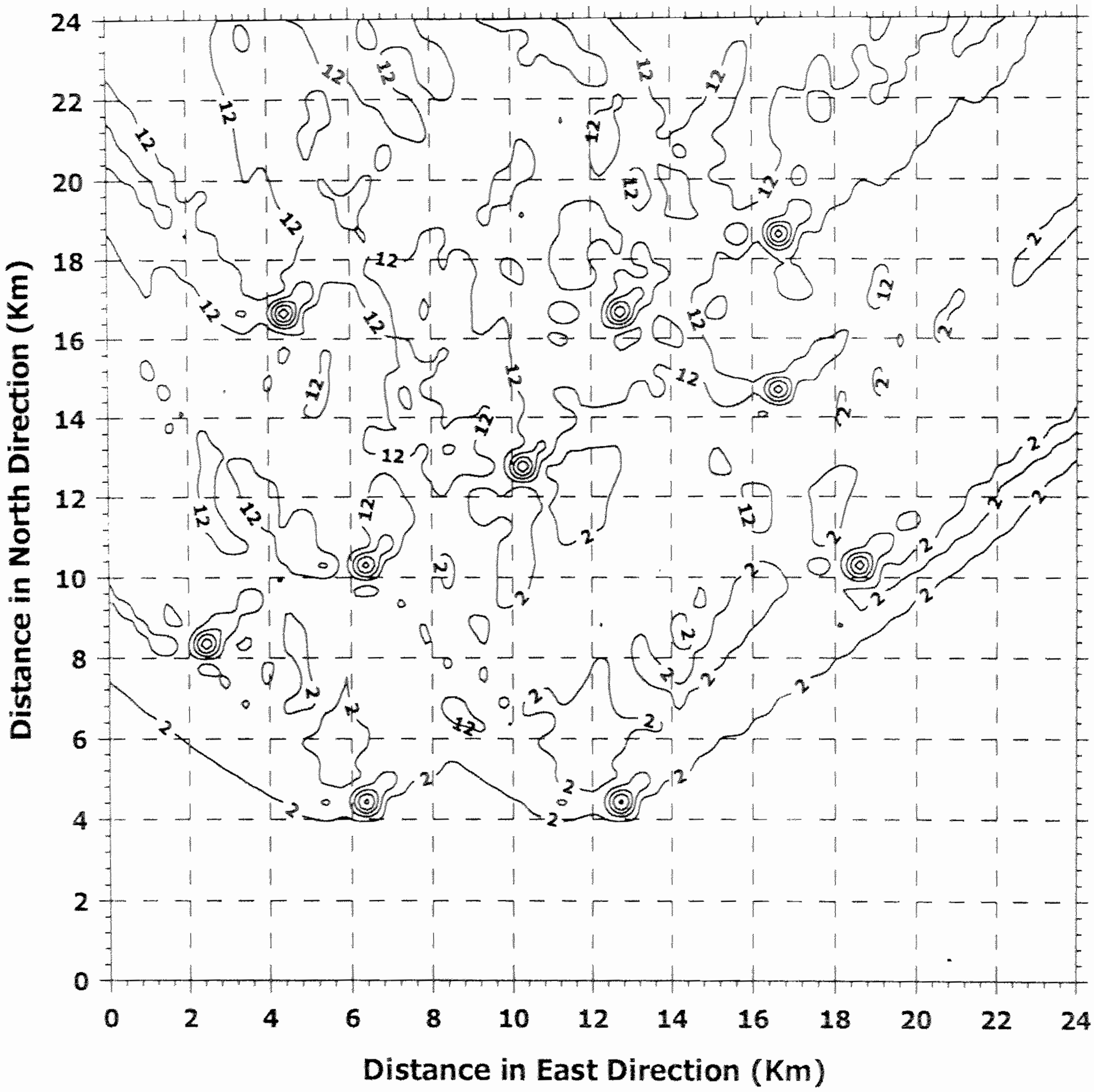


Fig. 6.1.1.27 : Predicted SO_2 Isopleths : Winter - Kodanadu (Ernakulam) [Emission Load : 5184 kg/day]

Highest Value	24 hrly Average Conc. (µg/m³)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	59	12.5	16.5	Koovapady
2nd	58	4.5	16.5	Angamali
3rd	56	16.5	18.5	Koovapady
4th	49	10.5	12.5	Koovapady
5th	48	2.5	8.5	Koovapady

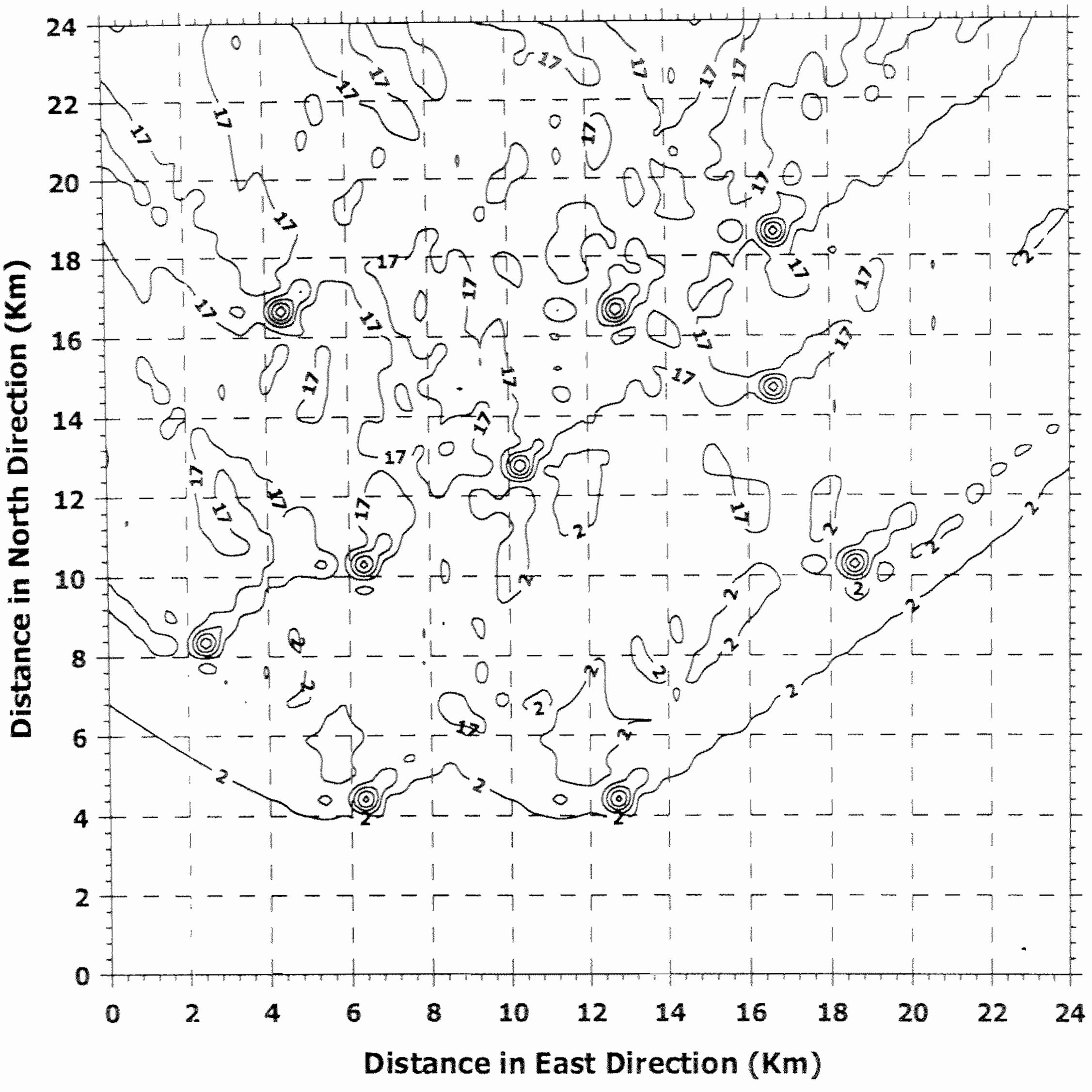


Fig. 6.1.1.28 : Predicted SO_2 Isopleths : Winter - Kodanadu (Ernakulam) [Emission Load : 7776 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	88	12.5	16.5	Koovapady
2nd	87	4.5	16.5	Angamali
3rd	85	16.5	18.5	Koovapady
4th	74	10.5	12.5	Koovapady
5th	72	2.5	8.5	Koovapady

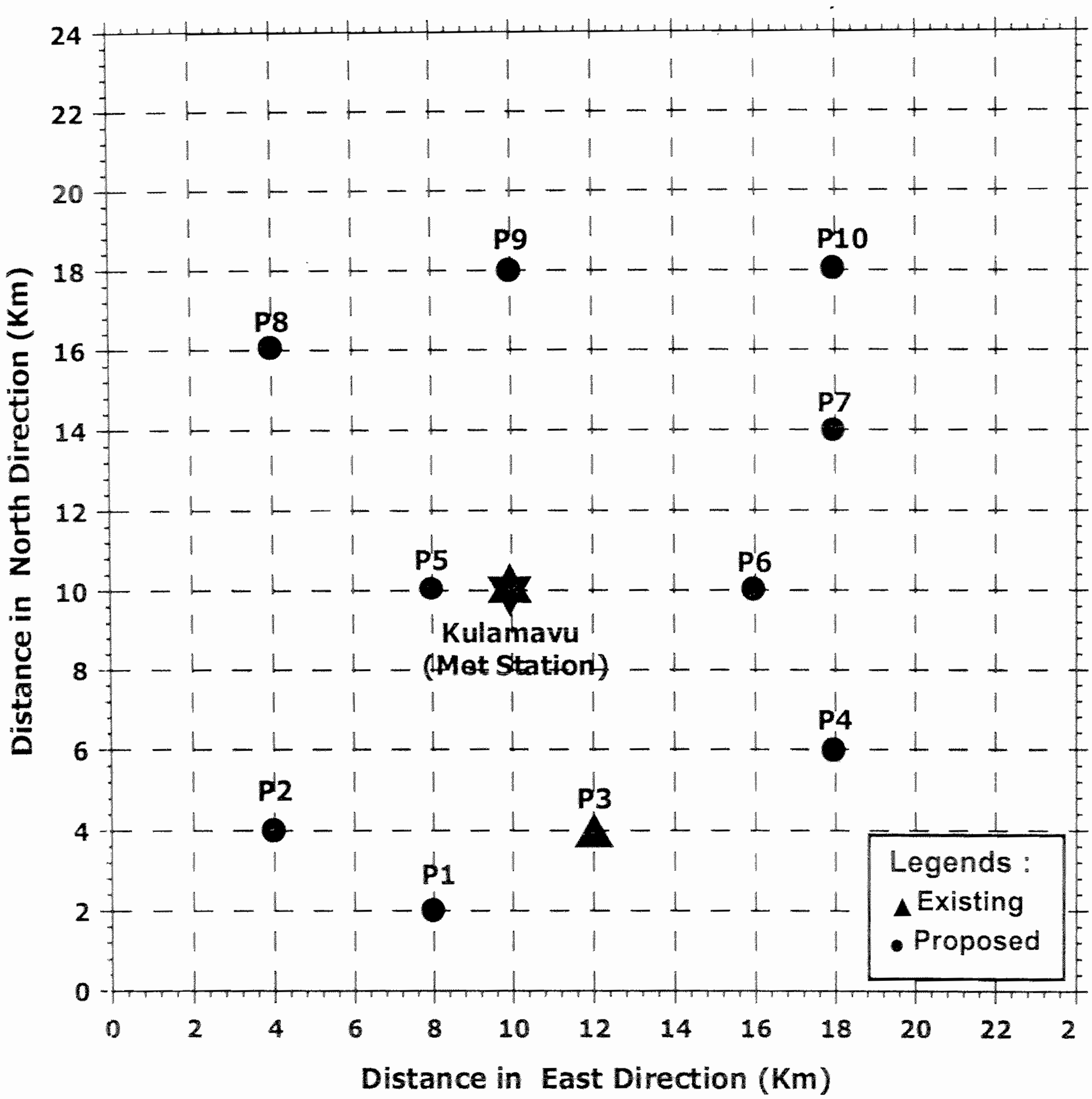


Fig. 6.1.1.29 : Existing and Proposed Point Sources in Idukki District

Source	X	Y	Location	
			Place	Block
P1	8000	2000	Poonjar Thekekkara	Erattupetta
P2	4000	4000	Teekay	Erattupetta
P3	12000	4000	Elappara	Arudai
P4	18000	6000	----	----
P5	8000	10000	Arakkulam	Idukki
P6	16000	10000	Vazhathope	Idukki
P7	18000	14000	Idukki	----
P8	4000	16000	Arakkulam	Idukki
P9	10000	18000	Idukki - Kanjikuzhi	Idukki
P10	18000	18000	Idukki - Kanjikuzhi	Idukki

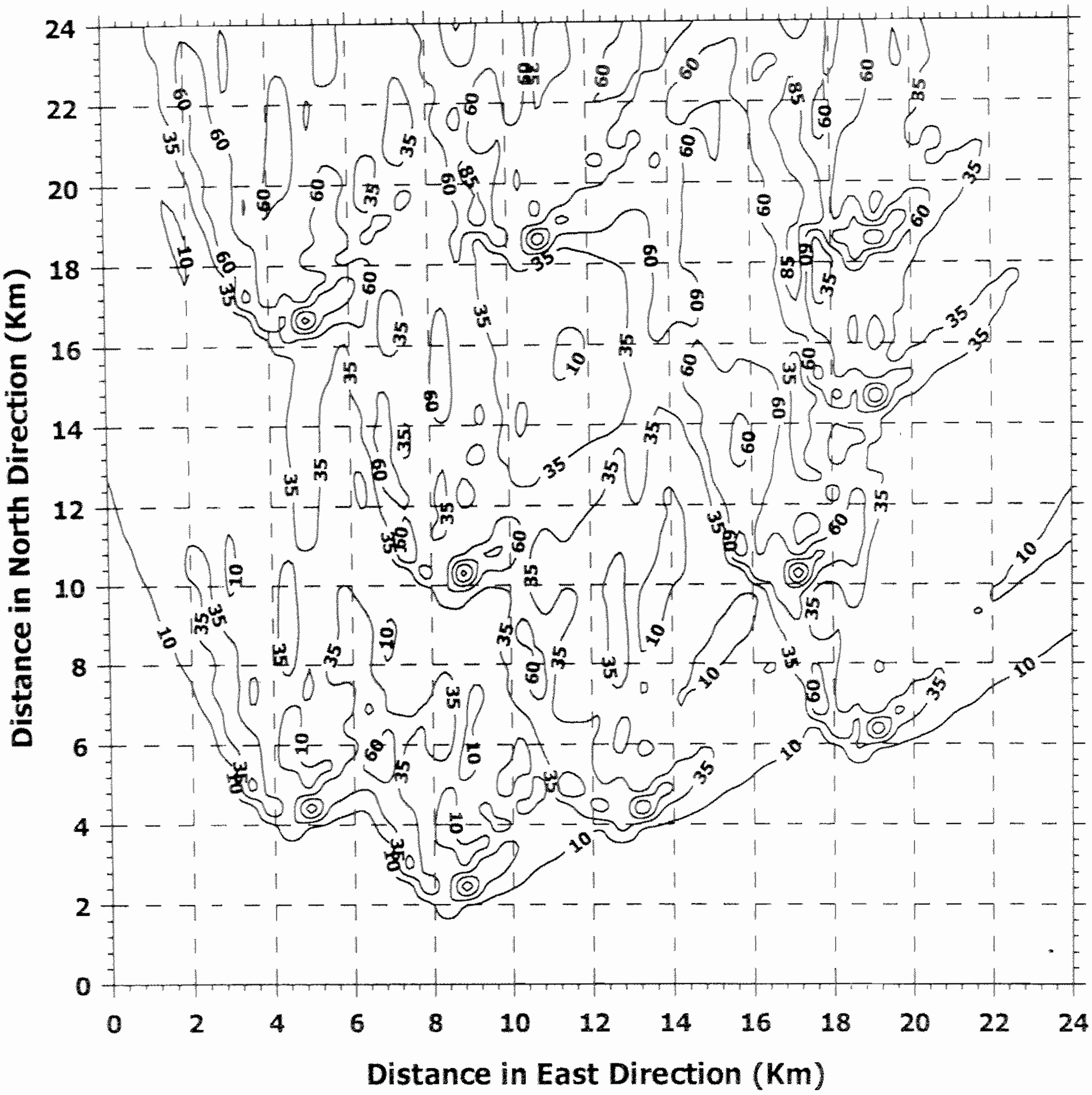


Fig. 6.1.1.30 : Predicted SPM Isopleths : Post Monsoon - Idukki [Emission Load : 21600 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	148	17.0	10.5	Idukki
2nd	142	9.0	10.5	Idukki
3rd	142	5.0	16.5	Idukki
4th	132	19.0	14.5	Vazhathope
5th	132	19.0	18.5	Idukki- Kanjikuzhy

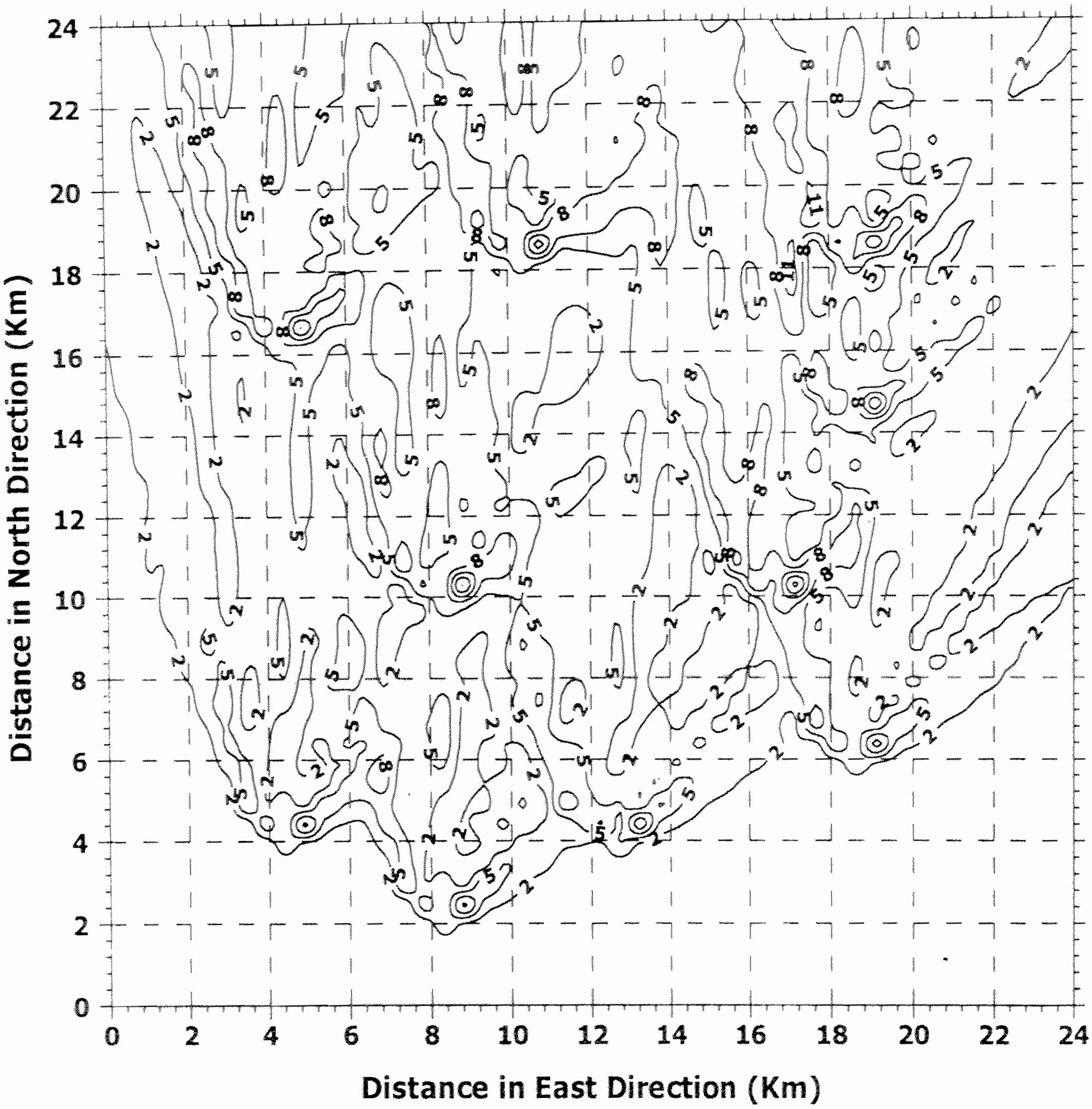


Fig. 6.1.1.31 : Predicted SO_2 Isopleths : Post Monsoon - Idukki
[Emission Load : 2592 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	18	17.0	10.5	Idukki
2nd	17	9.0	10.5	Idukki
3rd	17	5.0	16.5	Idukki
4th	16	19.0	14.5	Vazhathope
5th	16	19.0	18.5	Idukki- Kanjikuzhy

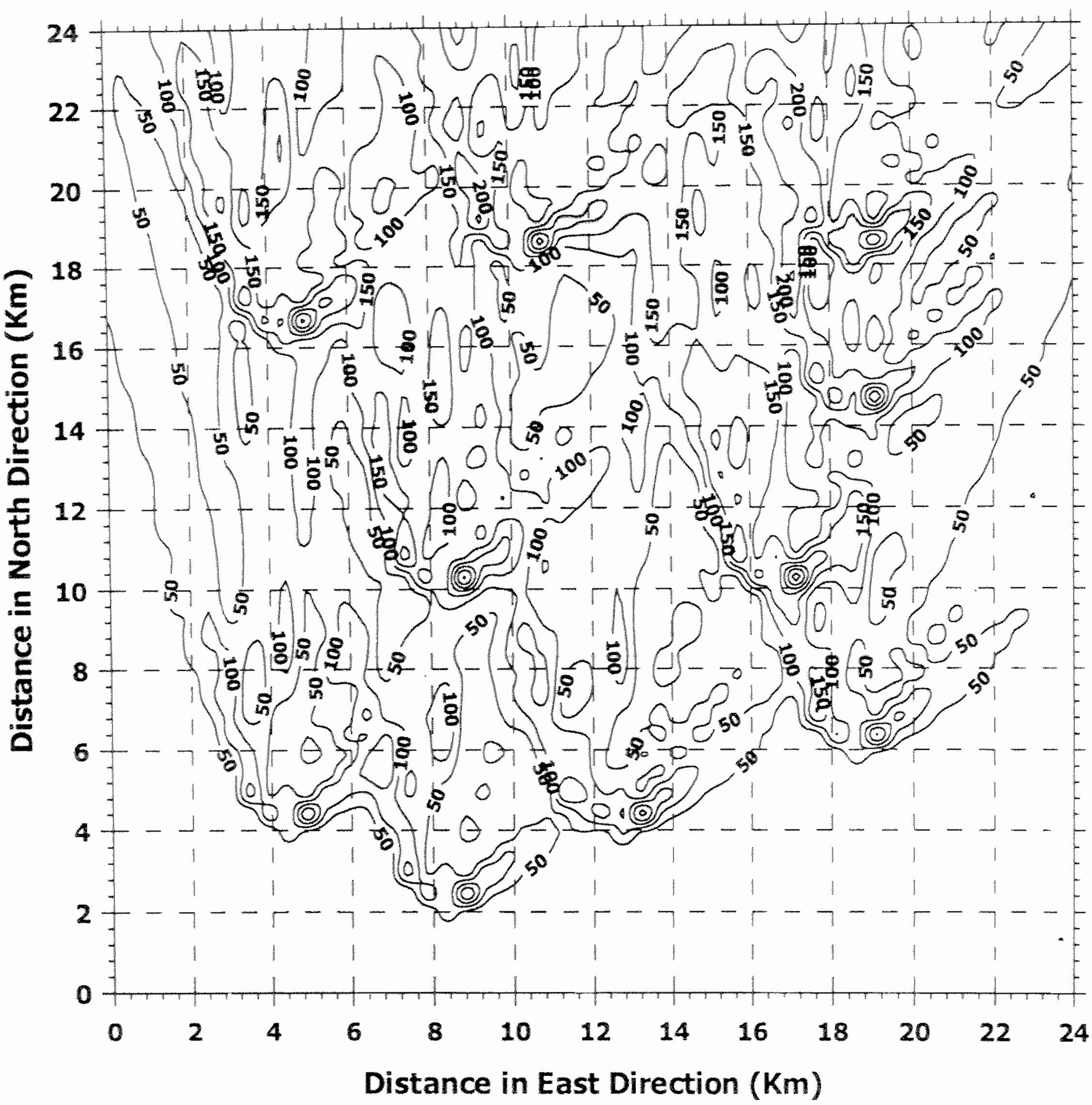


Fig. 6.1.1.32 : Predicted SPM Isopleths : Post Monsoon - Idukki
[Emission Load : 54432 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	374	17.0	10.5	Idukki
2nd	359	9.0	10.5	Idukki
3rd	358	5.0	16.5	Idukki
4th	334	19.0	14.5	Vazhathope
5th	333	19.0	18.5	Idukki-Kanjikuzhy

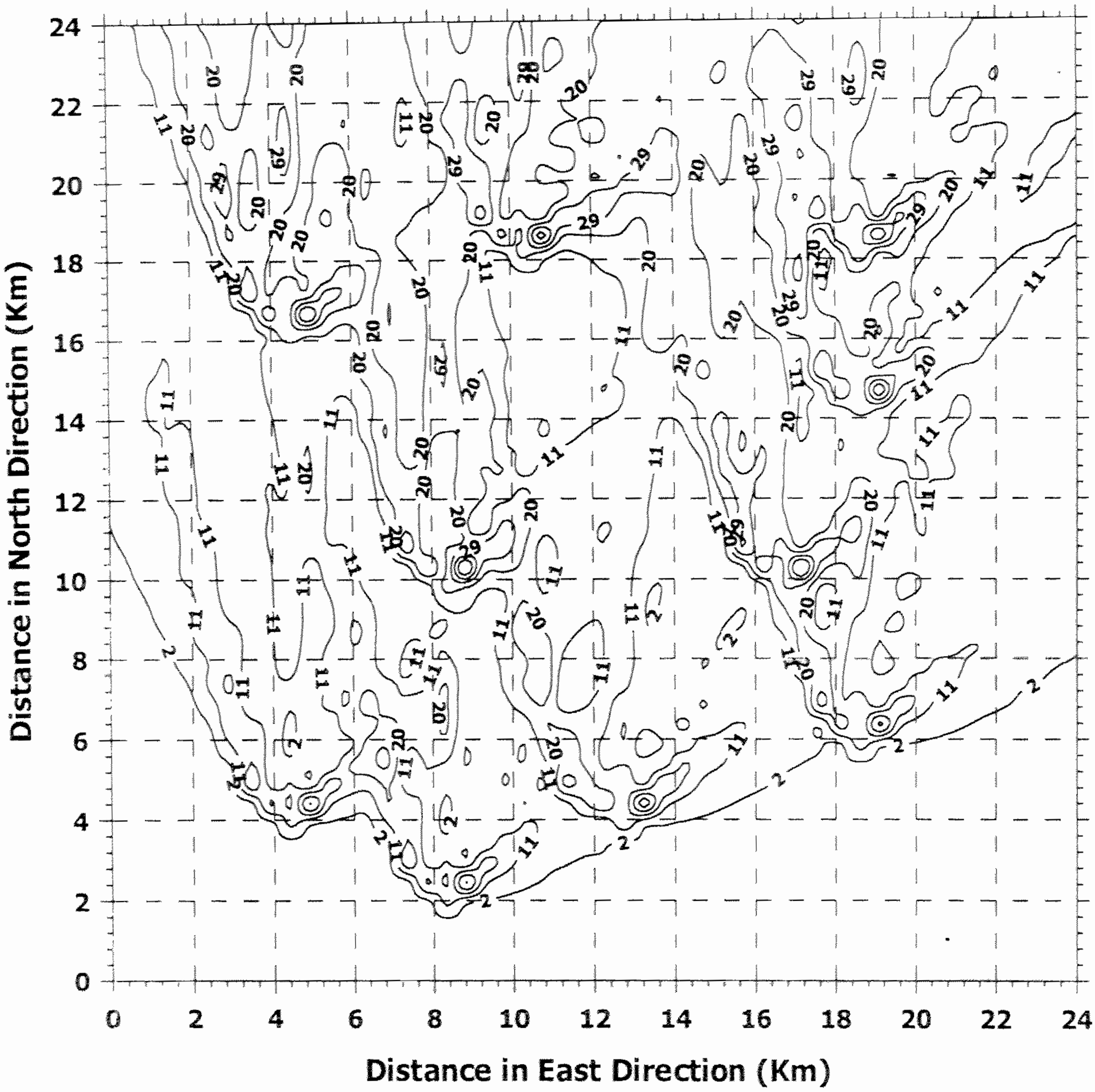


Fig. 6.1.1.33 : Predicted SO_2 Isopleths : Post Monsoon - Idukki
[Emission Load : 8640 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	59	17.0	10.5	Idukki
2nd	57	9.0	10.5	Idukki
3rd	57	5.0	16.5	Idukki
4th	53	19.0	14.5	Vazhathope
5th	53	19.0	18.5	Idukki- Kanjikuzhy

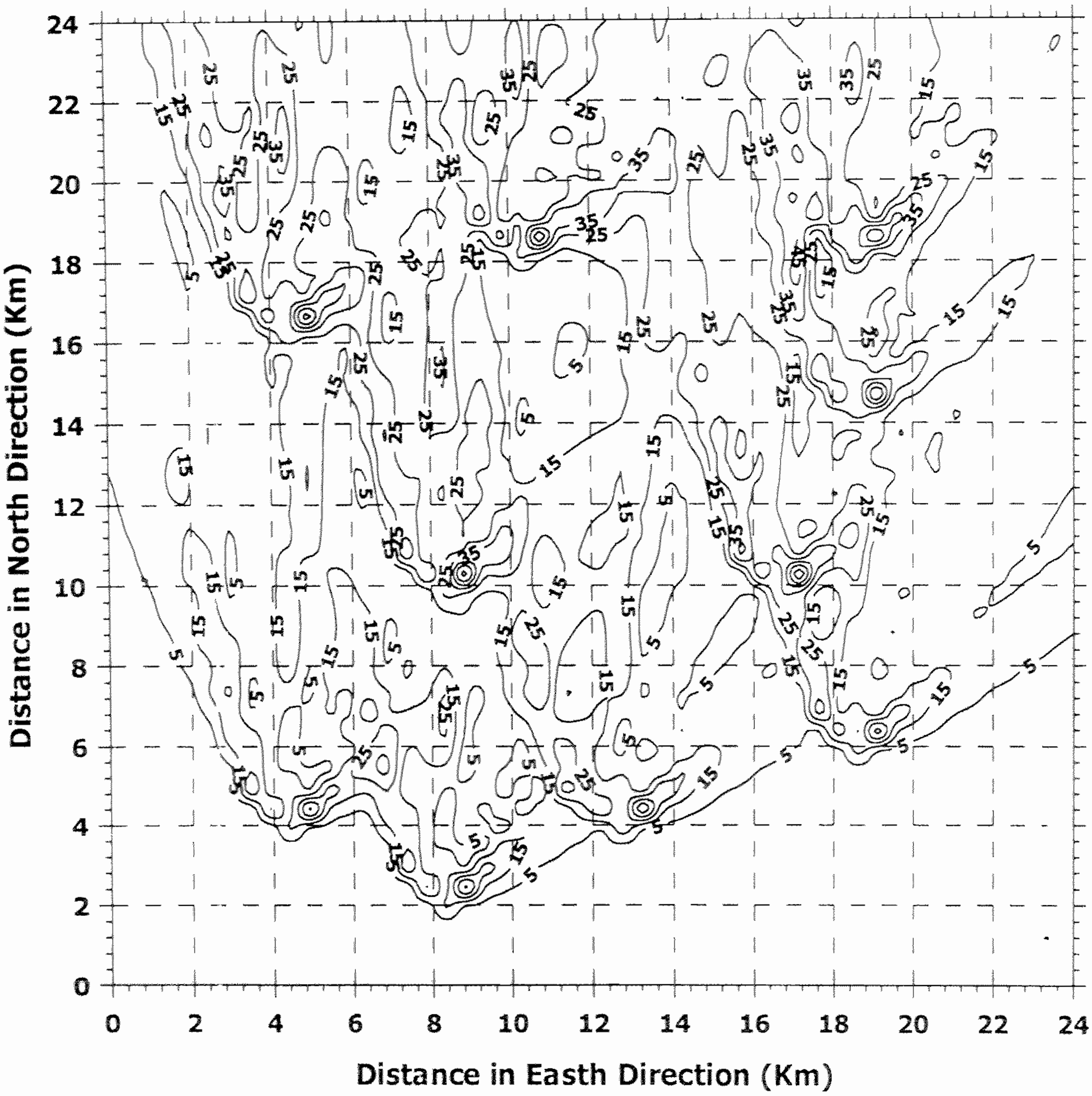


Fig. 6.1.1.34 : Predicted SPM Isopleths : Post Monsoon - Idukki
[Emission Load : 10368 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	71	17.0	10.5	Idukki
2nd	68	19.0	14.5	Idukki
3rd	68	19.0	18.5	Idukki
4th	64	9.0	10.5	Vazhathope
5th	64	11.0	18.5	Idukki- Kanjikuzhy

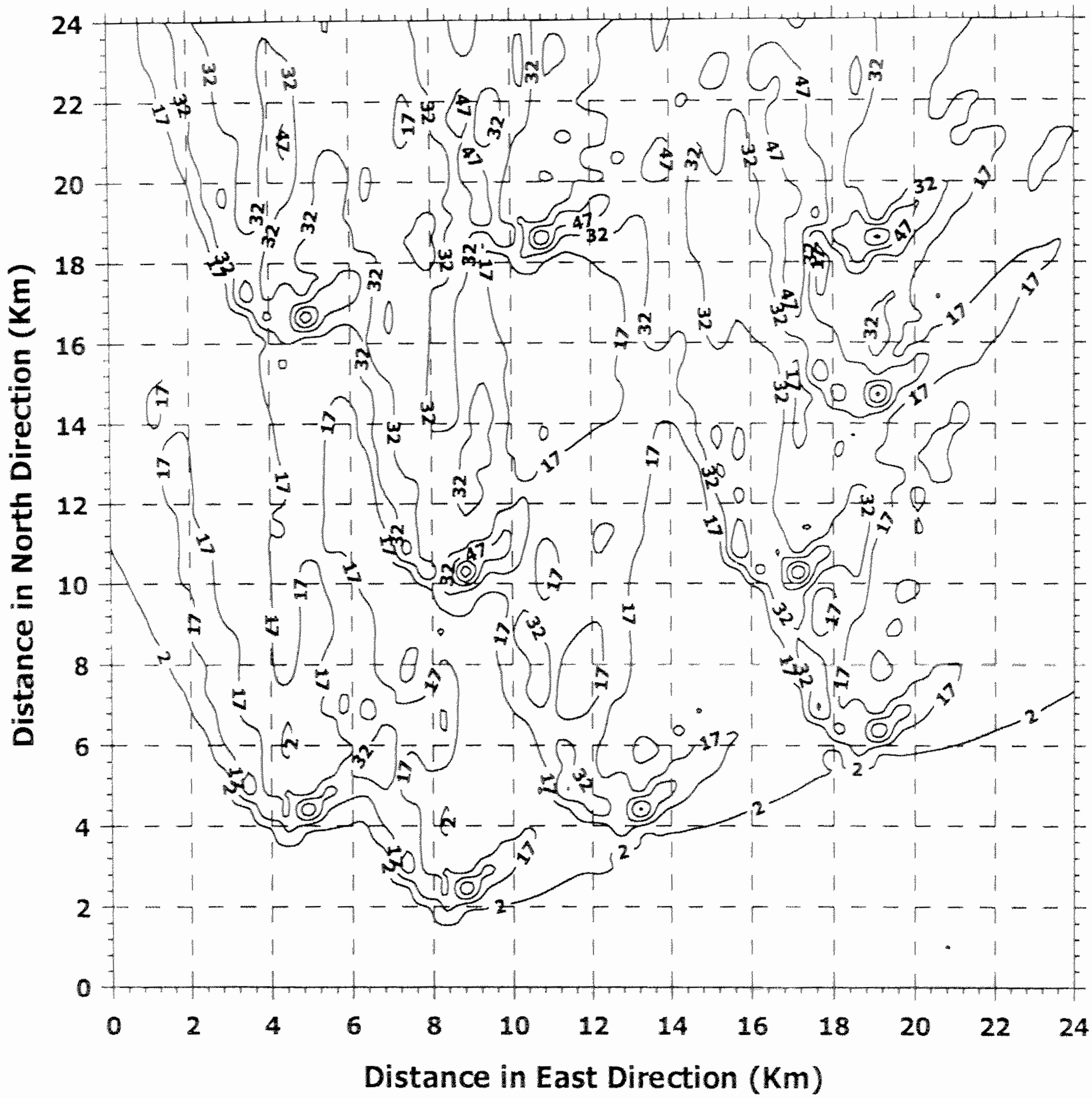


Fig. 6.1.1.35 : Predicted SO_2 Isopleths : Post Monsoon - Idukki
[Emission Load : 12960 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	89	17.0	10.5	Idukki
2nd	85	19.0	14.5	Idukki
3rd	85	19.0	18.5	Idukki
4th	79	9.0	10.5	Vazhathope
5th	79	11.0	18.5	Idukki- Kanjikuzhy

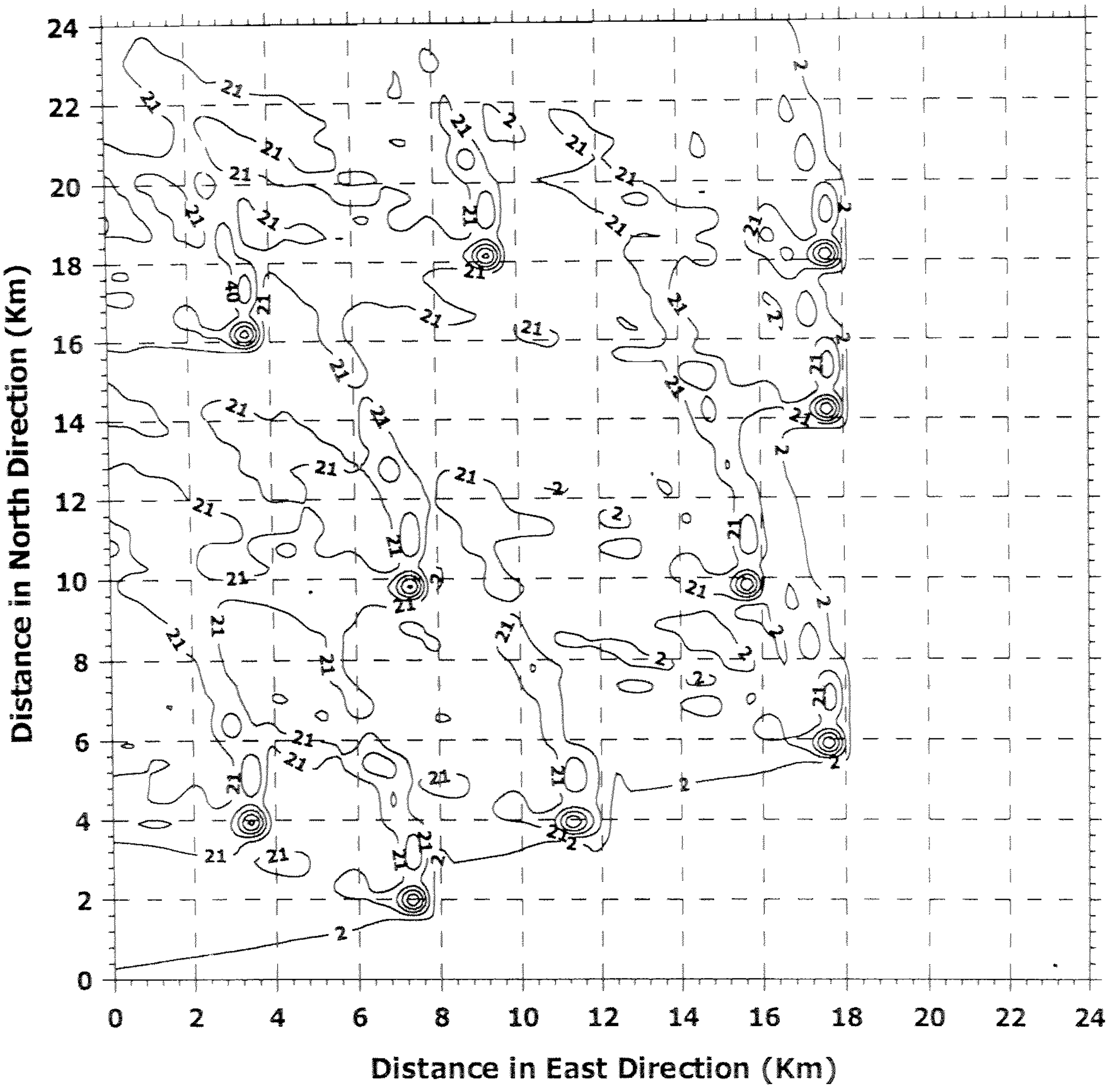


Fig. 6.1.1.36 : Predicted SPM Isopleths : Winter - Idukki
[Emission Load : 21600 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	105	3.5	16.0	Arakkulam
2nd	102	3.5	4.0	Arakkulam
3rd	102	9.5	18.0	Vettimattom
4th	100	7.5	10.0	Idukki
5th	94	15.5	10.0	Idukki

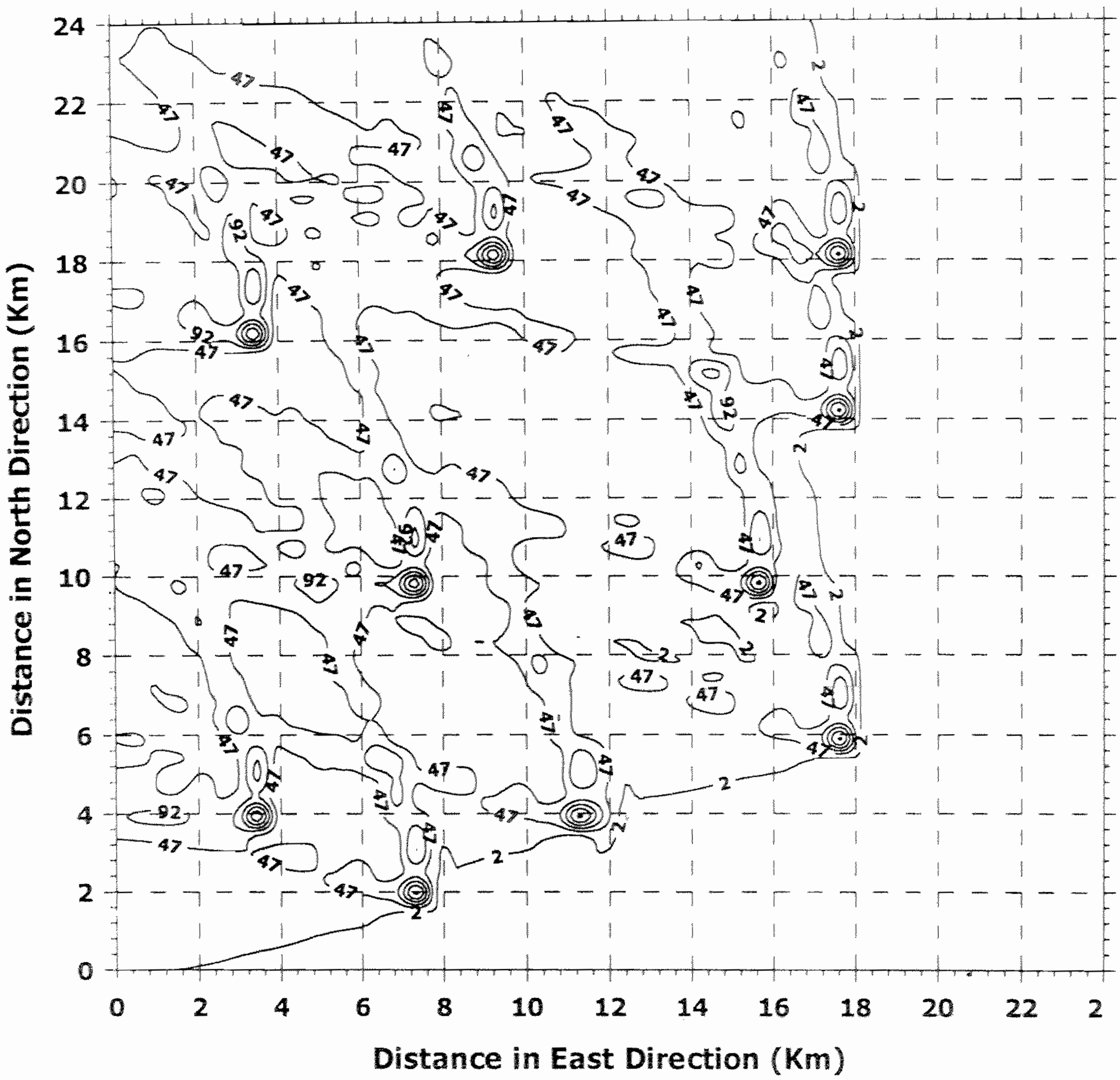


Fig. 6.1.1.37 : Predicted SPM Isopleths : Winter - Idukki
[Emission Load : 54432 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	265	3.5	16.0	Arakkulam
2nd	258	3.5	4.0	Arakkulam
3rd	258	9.5	18.0	Vettimattom
4th	253	7.5	10.0	Idukki
5th	238	15.5	10.0	Idukki

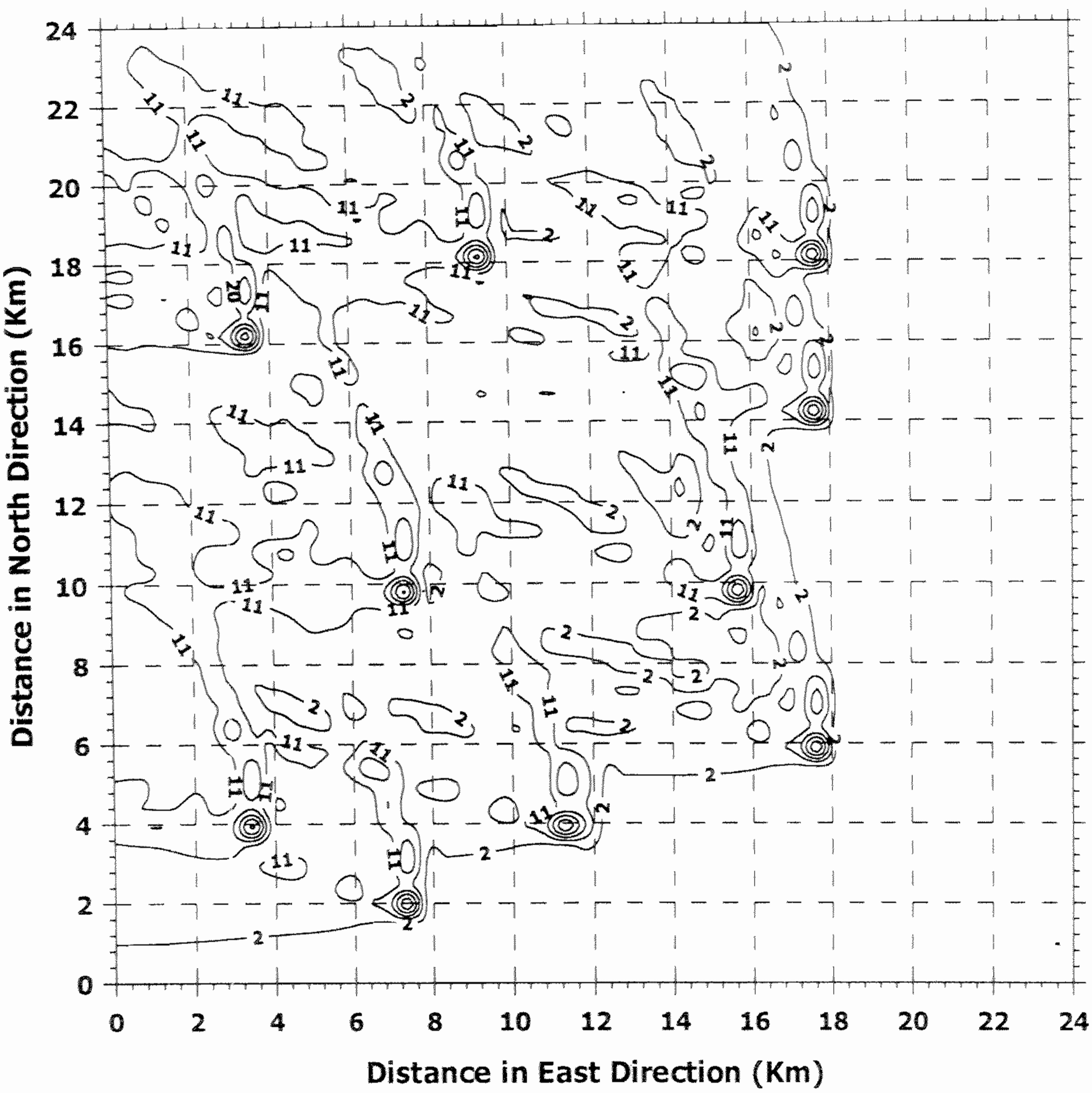


Fig. 6.1.1.38 : Predicted SPM Isopleths : Winter - Idukki
[Emission Load : 10368 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	51	3.5	16.0	Arakkulam
2nd	49	3.5	4.0	Arakkulam
3rd	49	9.5	18.0	Vettimattom
4th	48	7.5	10.0	Idukki
5th	45	15.5	10.0	Idukki

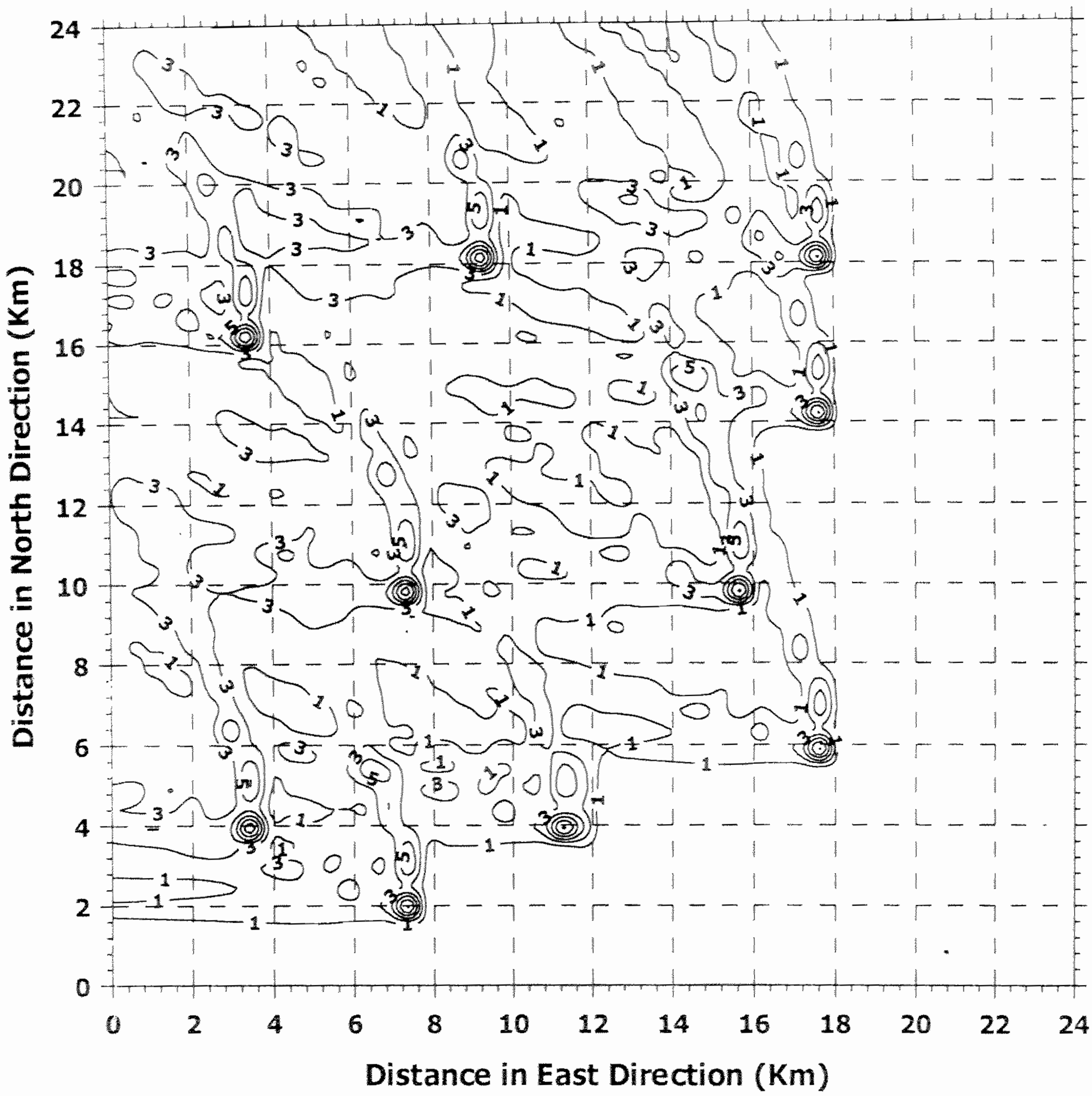


Fig. 6.1.1.39 : Predicted SO_2 Isopleths : Winter - Idukki
[Emission Load : 2592 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	13	3.5	16.0	Arakkulam
2nd	12	3.5	4.0	Arakkulam
3rd	12	9.5	18.0	Vettimattom
4th	12	7.5	10.0	Idukki
5th	11	15.5	10.0	Idukki

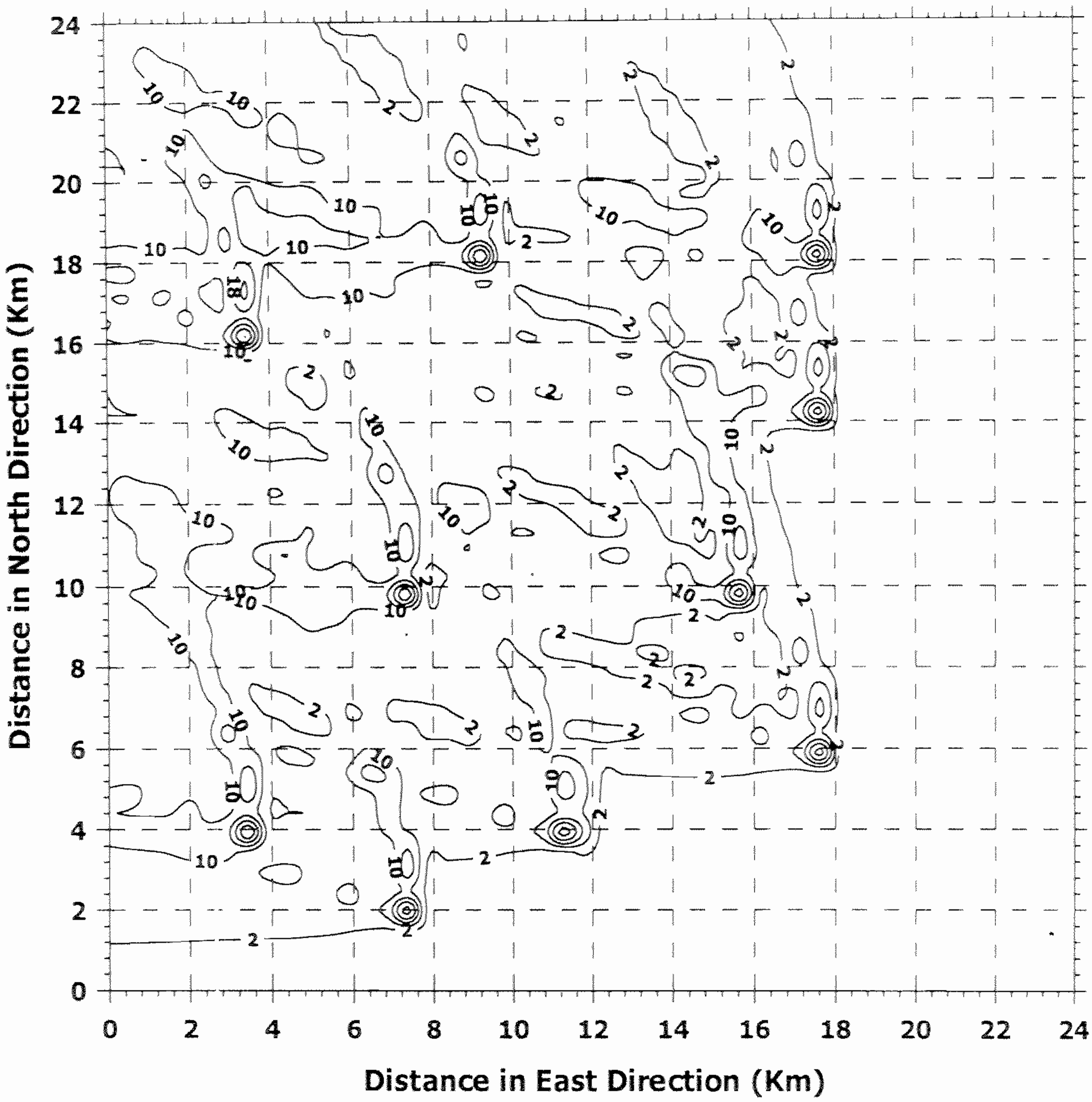


Fig. 6.1.1.40 : Predicted SO_2 Isopleths : Winter - Idukki
[Emission Load : 8640 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	42	3.5	16.0	Arakkulam
2nd	41	3.5	4.0	Arakkulam
3rd	41	9.5	18.0	Vettimattom
4th	40	7.5	10.0	Idukki
5th	38	15.5	10.0	Idukki

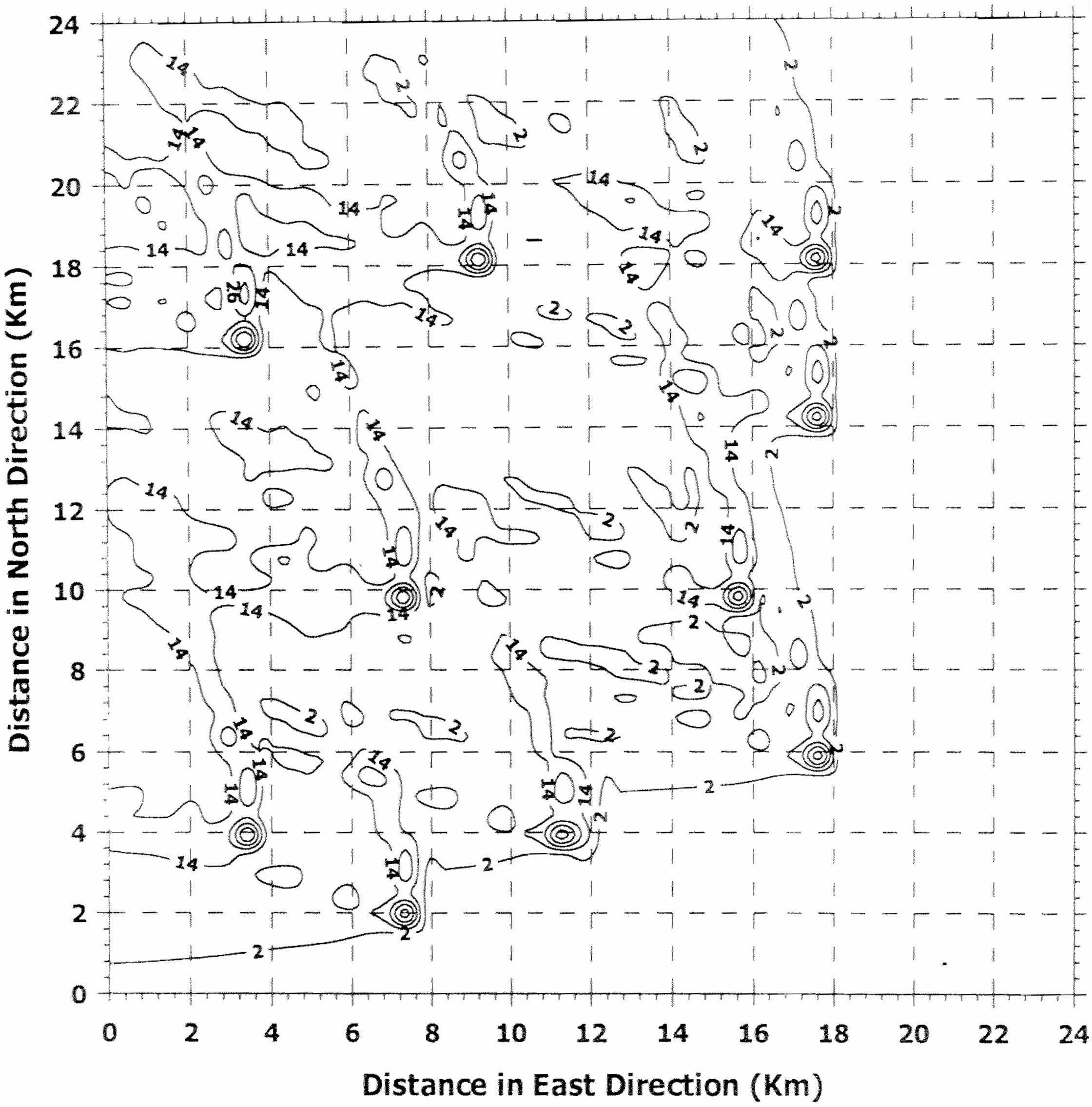


Fig. 6.1.1.41 : Predicted SO_2 Isopleths : Winter - Idukki
[Emission Load : 12960 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	63	3.5	16.0	Arakkulam
2nd	61	3.5	4.0	Arakkulam
3rd	61	9.5	18.0	Vettimattom
4th	60	7.5	10.0	Idukki
5th	57	15.5	10.0	Idukki

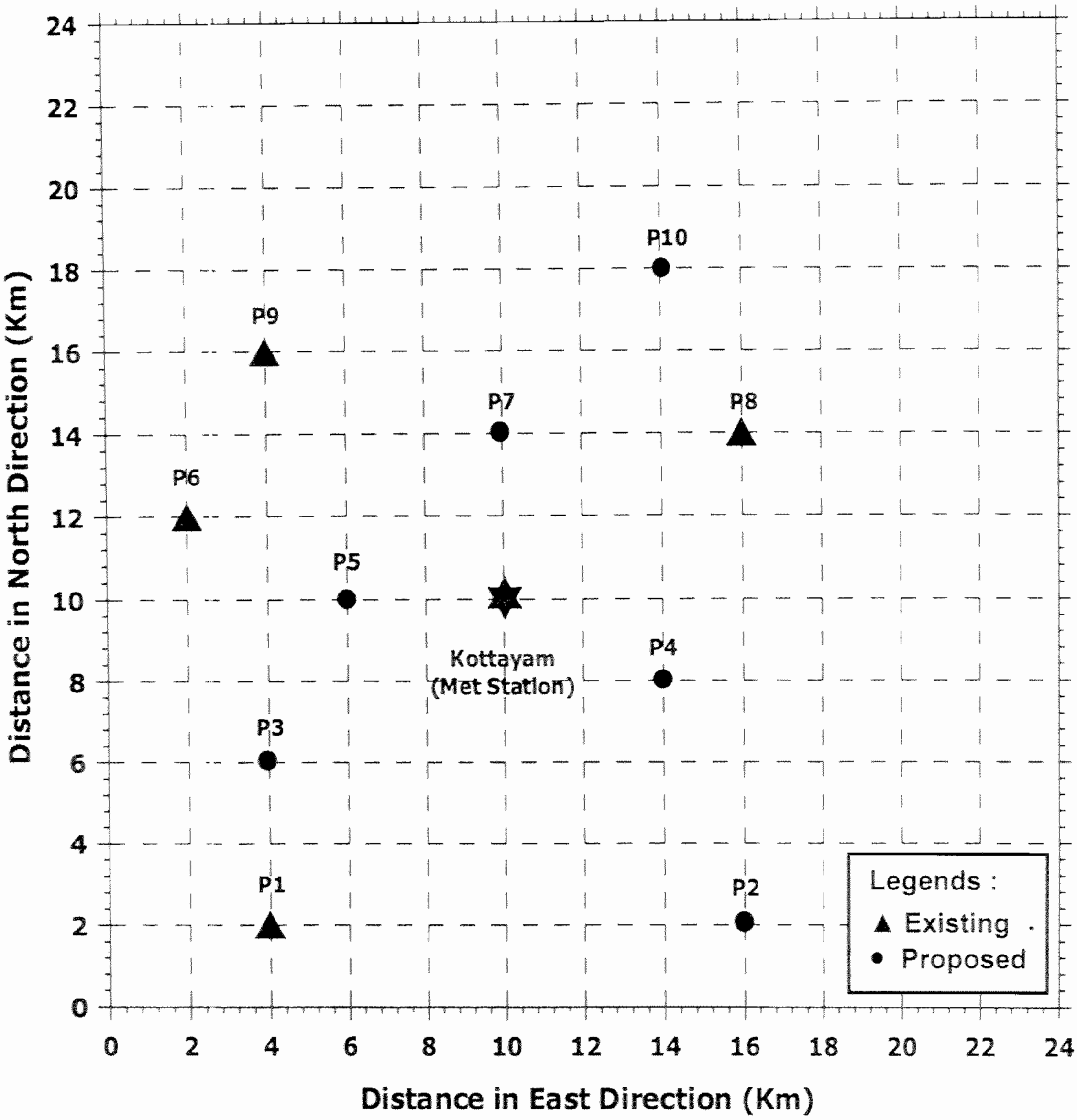


Fig. 6.1.1.42 : Existing and Proposed Point Sources in Kottayam District

Source	X	Y	Location	
			Place	Block
P1	4000	2000	Changanacherry	
P2	16000	2000	Mallapalli	Mallapalli
P3	4000	6000	Kuruchi	Madappally
P4	14000	8000	Karnkachal	Madappally
P5	6000	10000	Panachikkad	Pallom
P6	2000	12000	Nattakom	Pallom
P7	5000	14000	Pambadi	Pambadi
P8	16000	14000	Kooapada	Pambadi
P9	4000	16000	Kottayam	------
P10	14000	18000	Kooapada	Pambadi

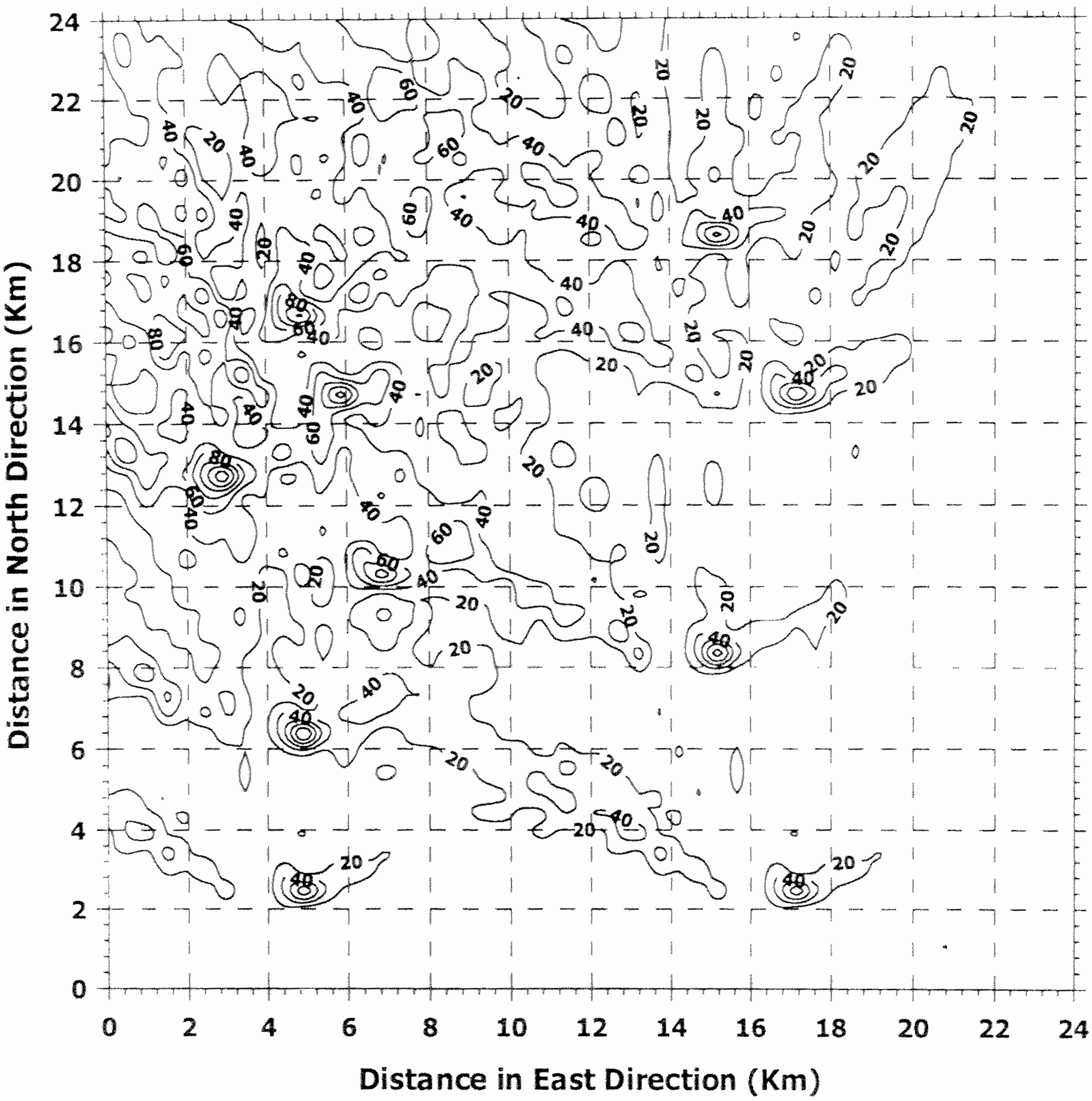


Fig. 6.1.1.43 : Predicted SPM Isopleths : Post Monsoon - Kottayam [Emission Load : 19008 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	151	3.0	12.5	Kottayam
2nd	126	6.0	14.5	Kottayam
3rd	122	5.0	16.5	Kottayam
4th	119	5.0	6.5	Madapally
5th	111	2.5	12.5	Nattakom

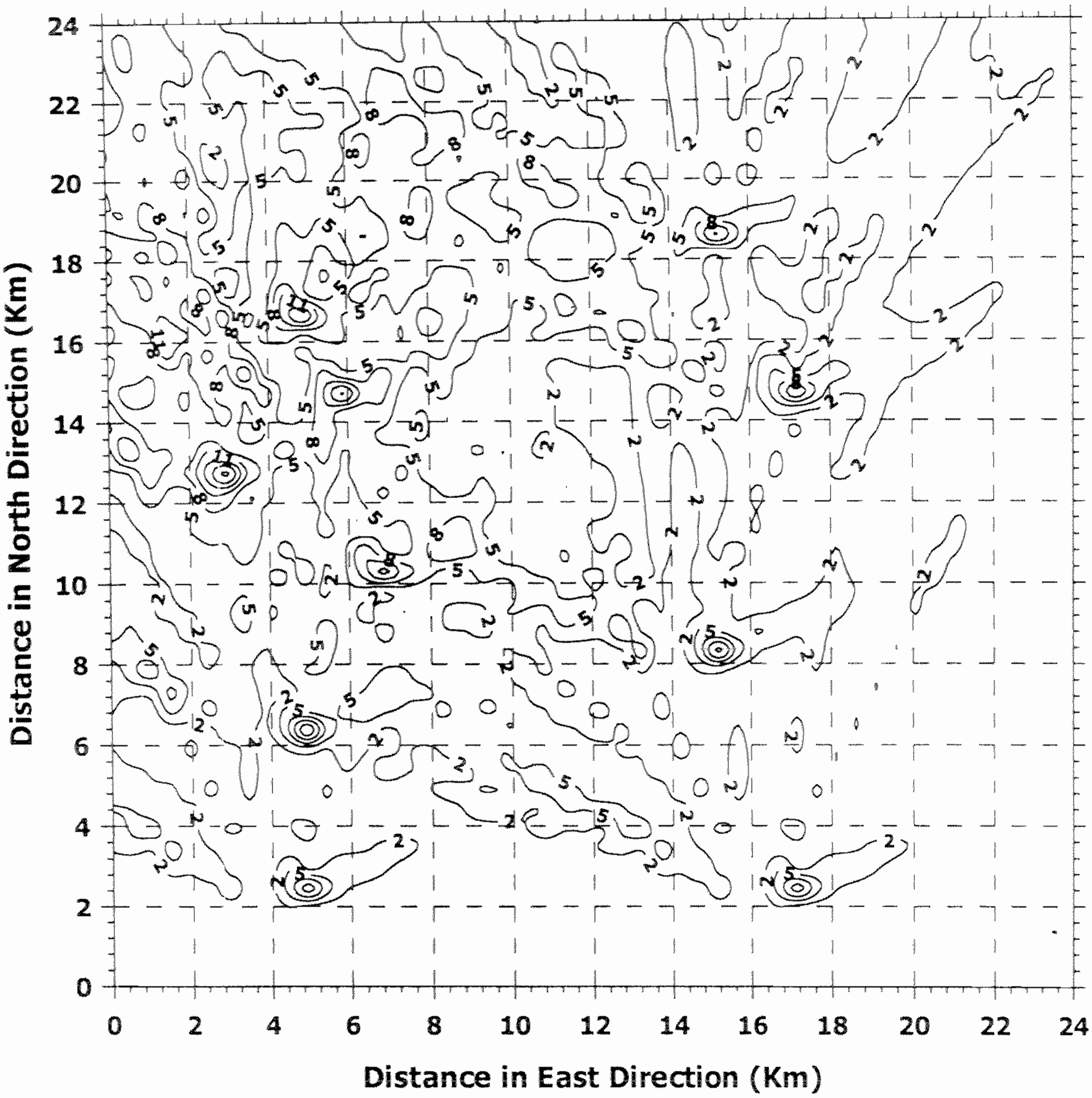


Fig. 6.1.1.44 : Predicted SO_2 Isopleths : Post Monsoon - Kottayam
[Emission Load : 2592 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	21	3.0	12.5	Kottayam
2nd	17	6.0	14.5	Kottayam
3rd	17	5.0	16.5	Kottayam
4th	16	5.0	6.5	Madapally
5th	15	2.5	12.5	Nattakom

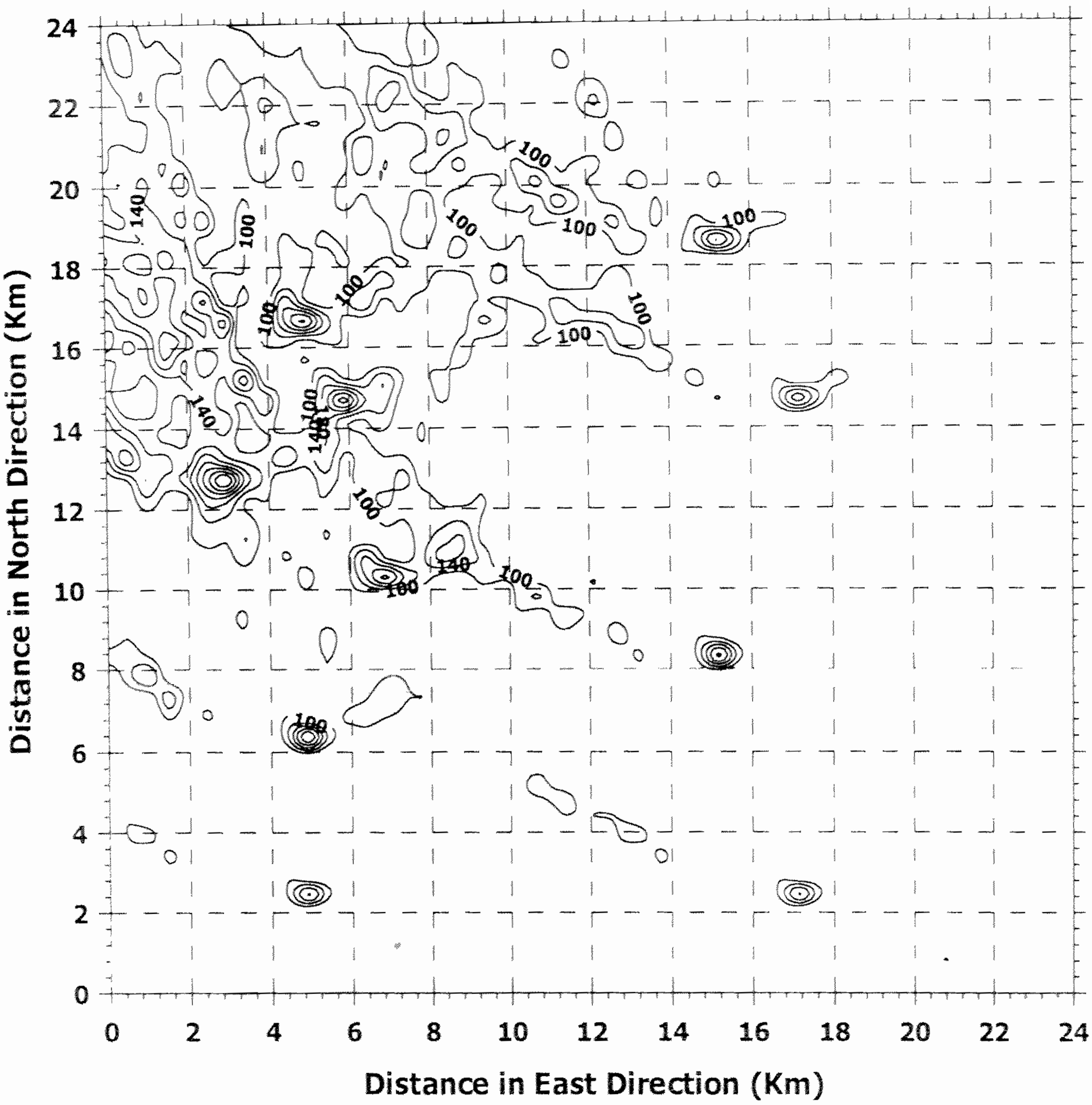


Fig. 6.1.1.45 : Predicted SPM Isopleths : Post Monsoon - Kottayam [Emission Load : 47520 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	377	3.0	12.5	Kottayam
2nd	315	6.0	14.5	Kottayam
3rd	305	5.0	16.5	Kottayam
4th	297	5.0	6.5	Madapally
5th	276	2.5	12.5	Nattakom

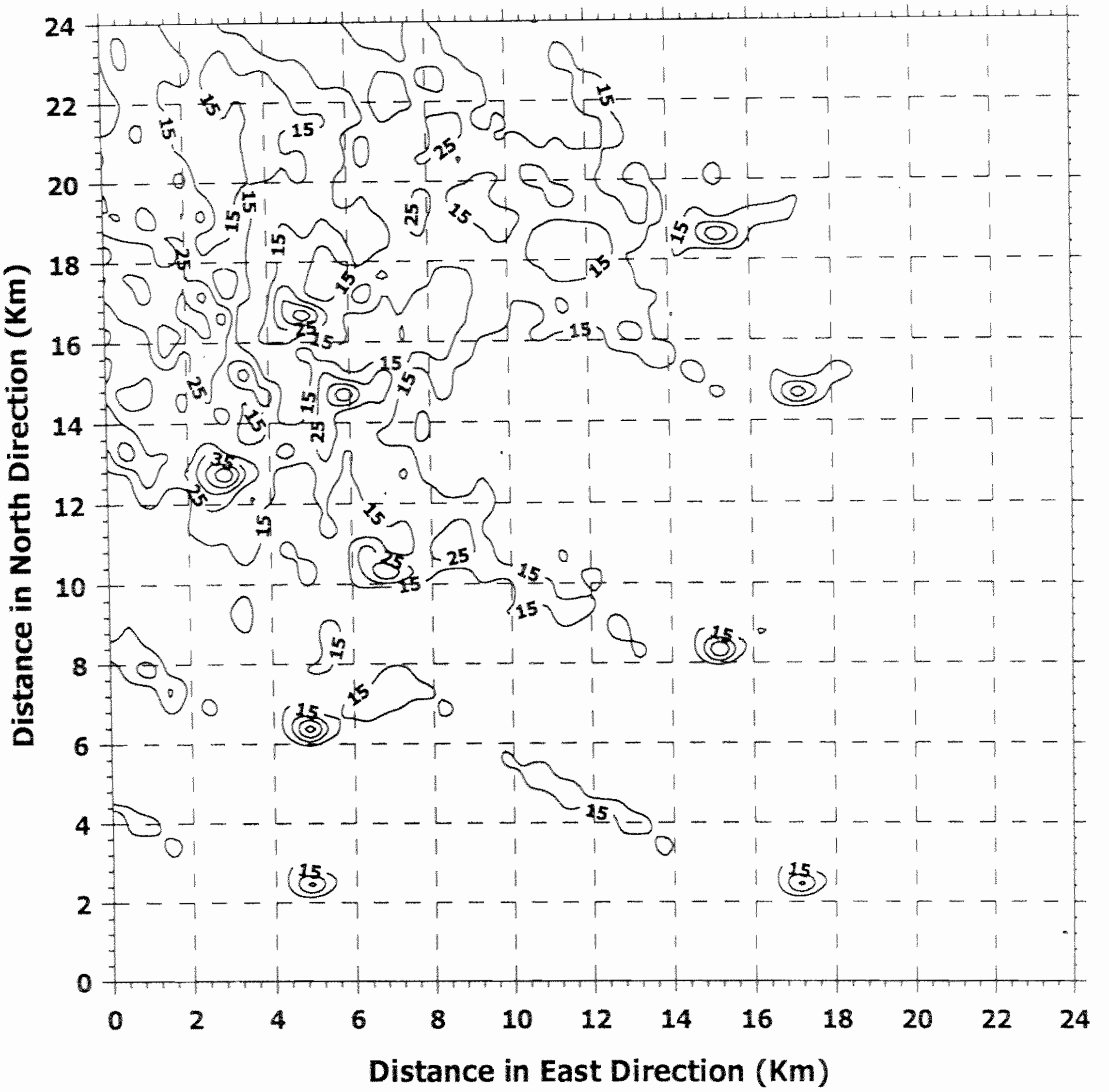


Fig. 6.1.1.46 : Predicted SO_2 Isopleths : Post Monsoon - Kottayam
[Emission Load : 7776 kg/day]

Highest Value	24 hrly Average Conc. (µg/m³)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	62	3.0	12.5	Kottayam
2nd	52	6.0	14.5	Kottayam
3rd	50	5.0	16.5	Kottayam
4th	49	5.0	6.5	Madapally
5th	45	2.5	12.5	Nattakom

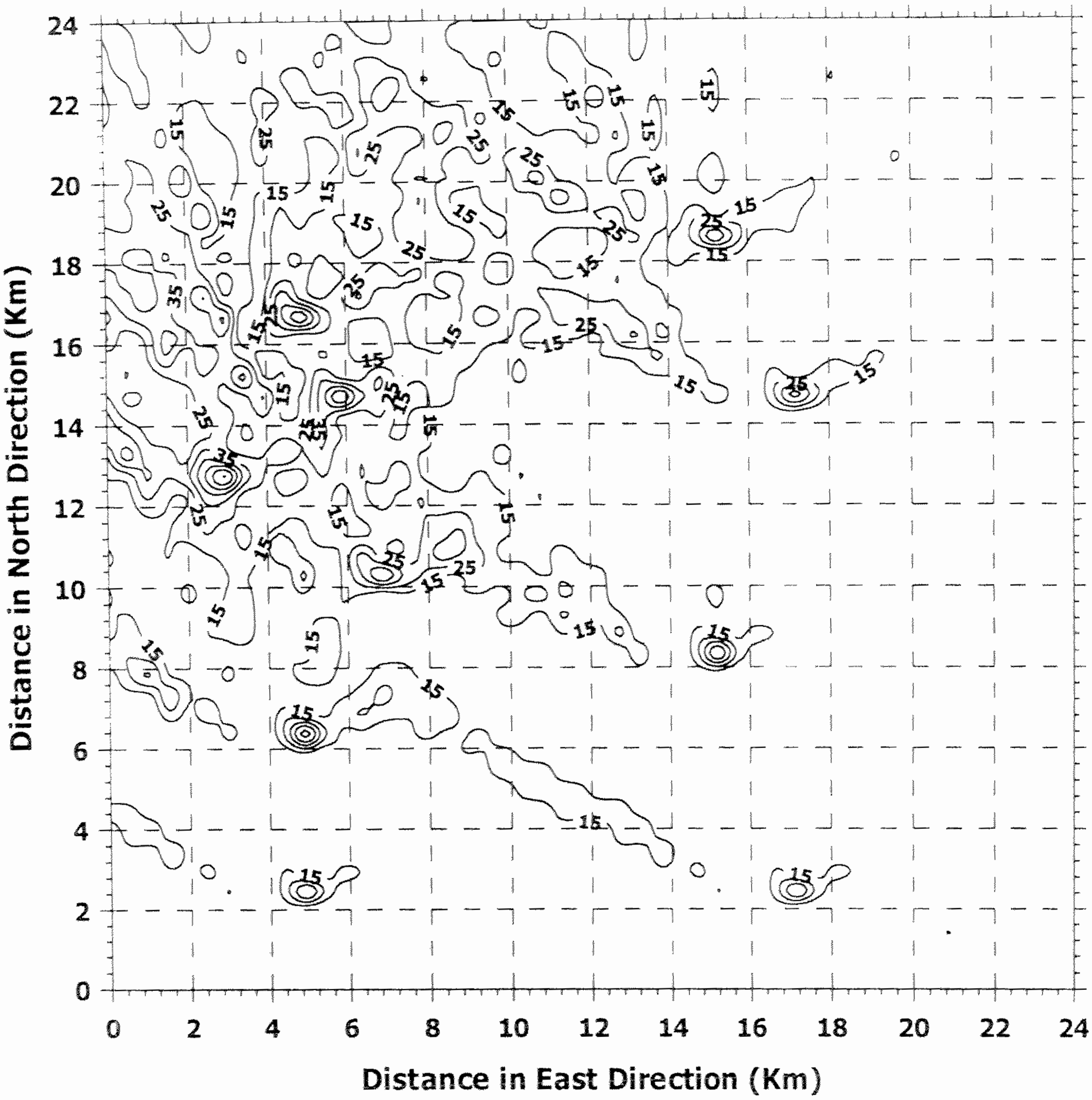


Fig. 6.1.1.47 : Predicted SO_2 Isopleths : Post Monsoon - Kottayam [Emission Load : 9504 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	75	3.0	12.5	Kottayam
2nd	63	6.0	14.5	Kottayam
3rd	61	5.0	16.5	Kottayam
4th	59	5.0	6.5	Madapally
5th	55	2.5	12.5	Nattakom

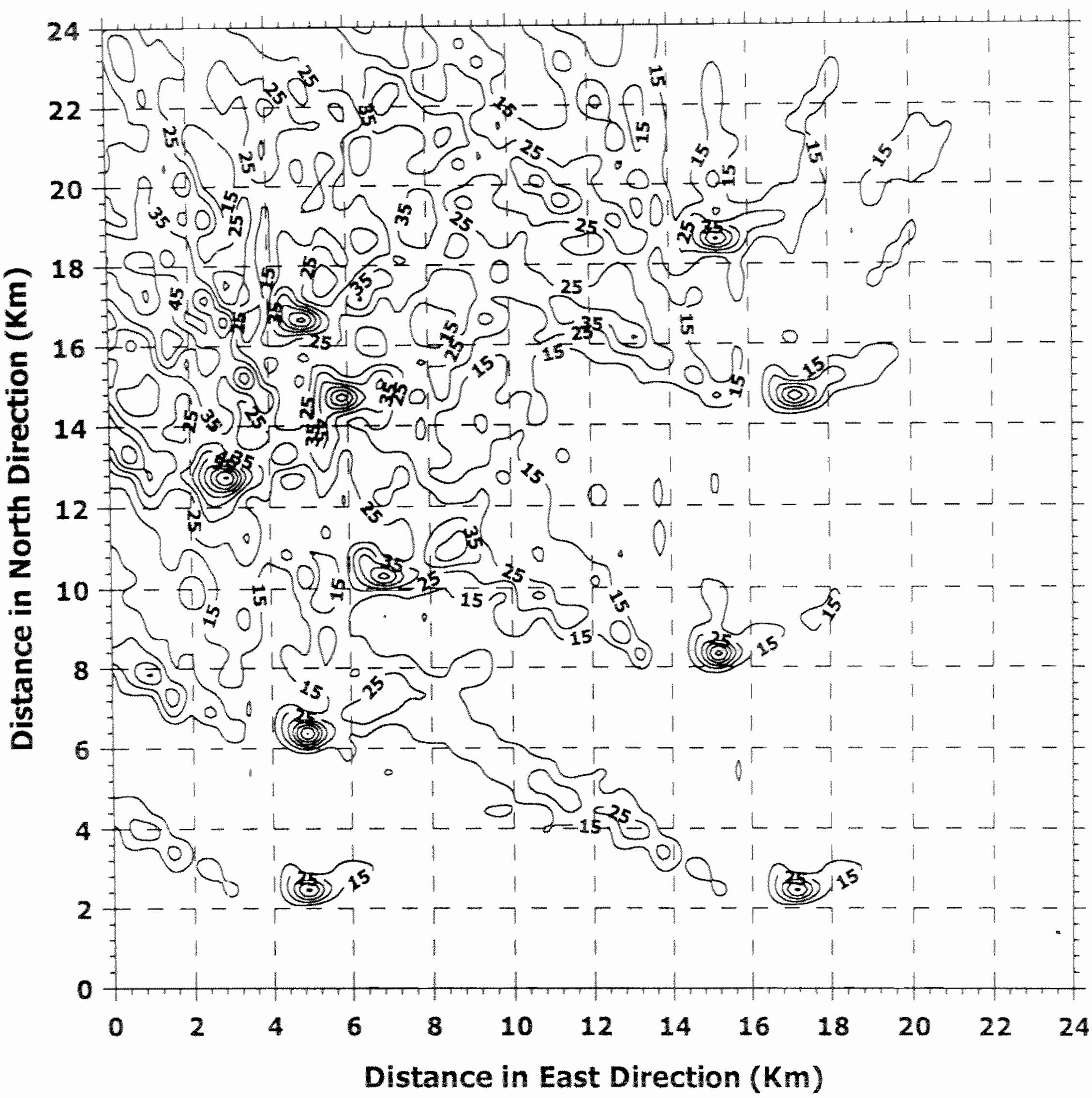


Fig. 6.1.1.48 : Predicted SO_2 Isopleths : Post Monsoon - Kottayam [Emission Load : 12096 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	96	3.0	12.5	Kottayam
2nd	80	6.0	14.5	Kottayam
3rd	78	5.0	16.5	Kottayam
4th	75	5.0	6.5	Madapally
5th	70	2.5	12.5	Nattakom

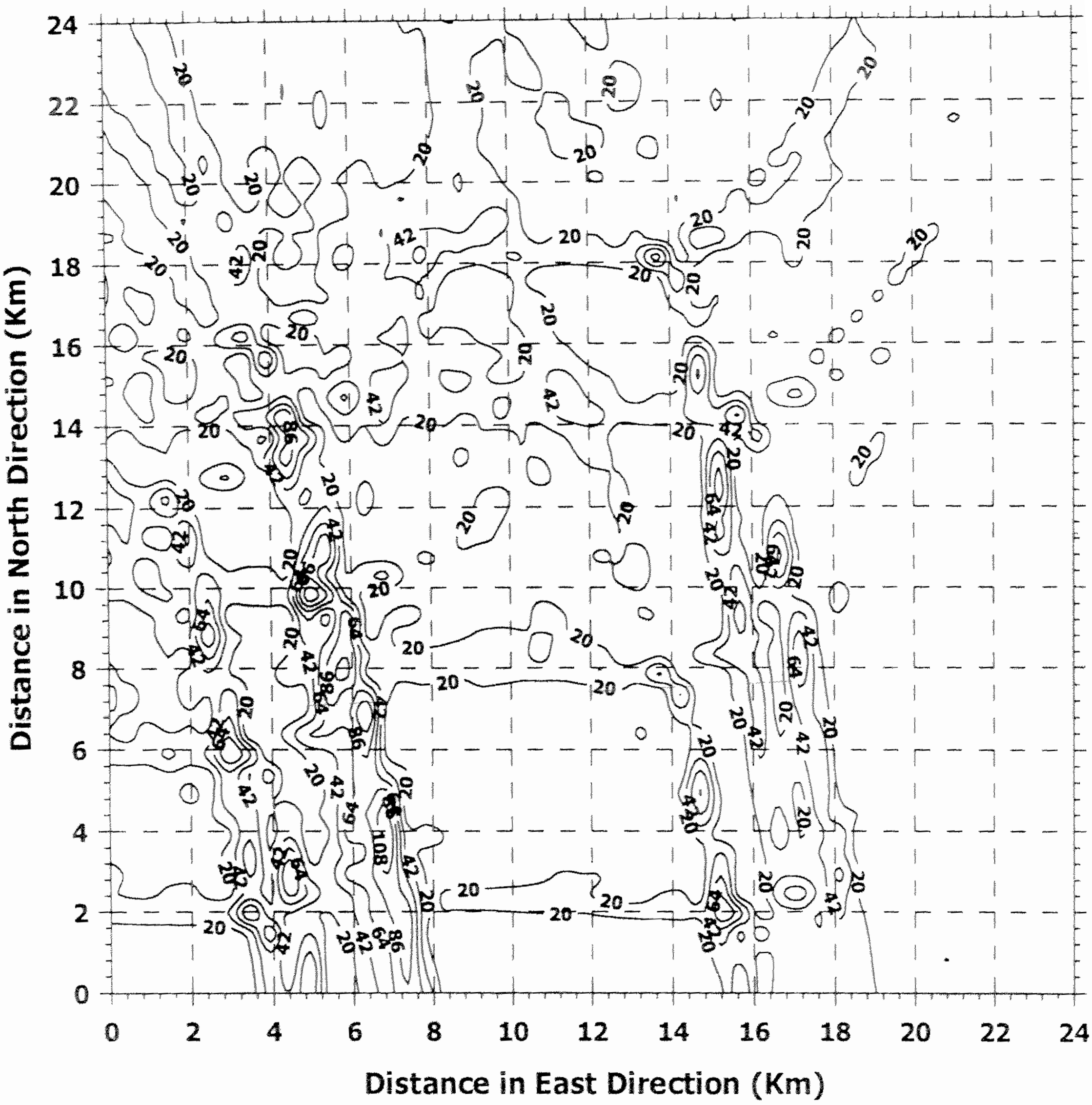


Fig. 6.1.1.49 : Predicted SPM Isopleths : Winter - Kottayam
[Emission Load : 19008 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	140	5.0	10.0	Pallom
2nd	128	6.5	7.0	Madapally
3rd	126	7.0	4.0	Chenganacherry
4th	121	7.0	3.5	Chenganacherry
5th	112	6.0	8.0	Pallom

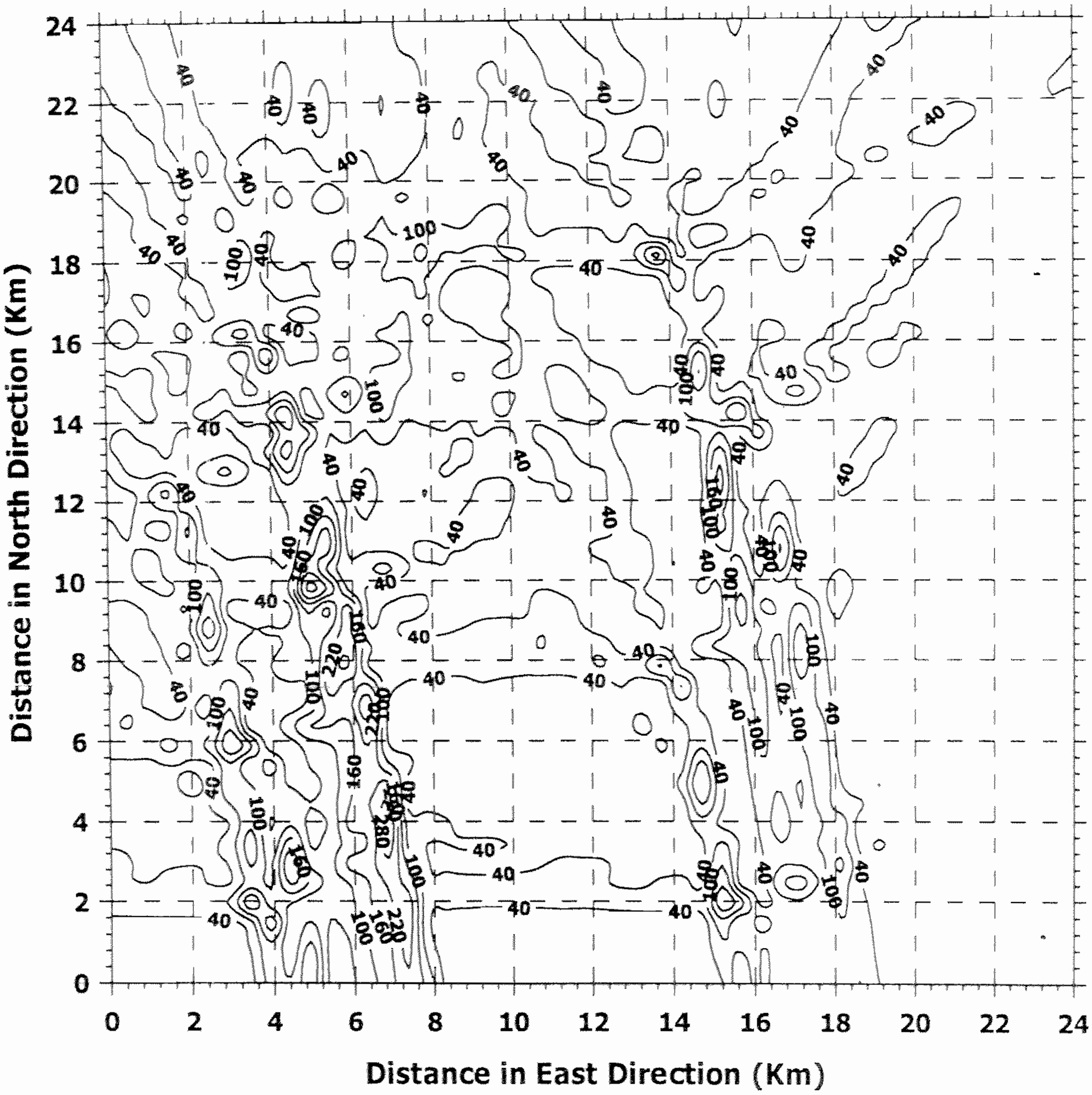


Fig. 6.1.1.50 : Predicted SPM Isopleths : Winter - Kottayam
[Emission Load : 47520 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	350	5.0	10.0	Pallom
2nd	320	6.5	7.0	Madapally
3rd	316	7.0	4.0	Chenganacherry
4th	303	7.0	3.5	Chenganacherry
5th	279	6.0	8.0	Pallom

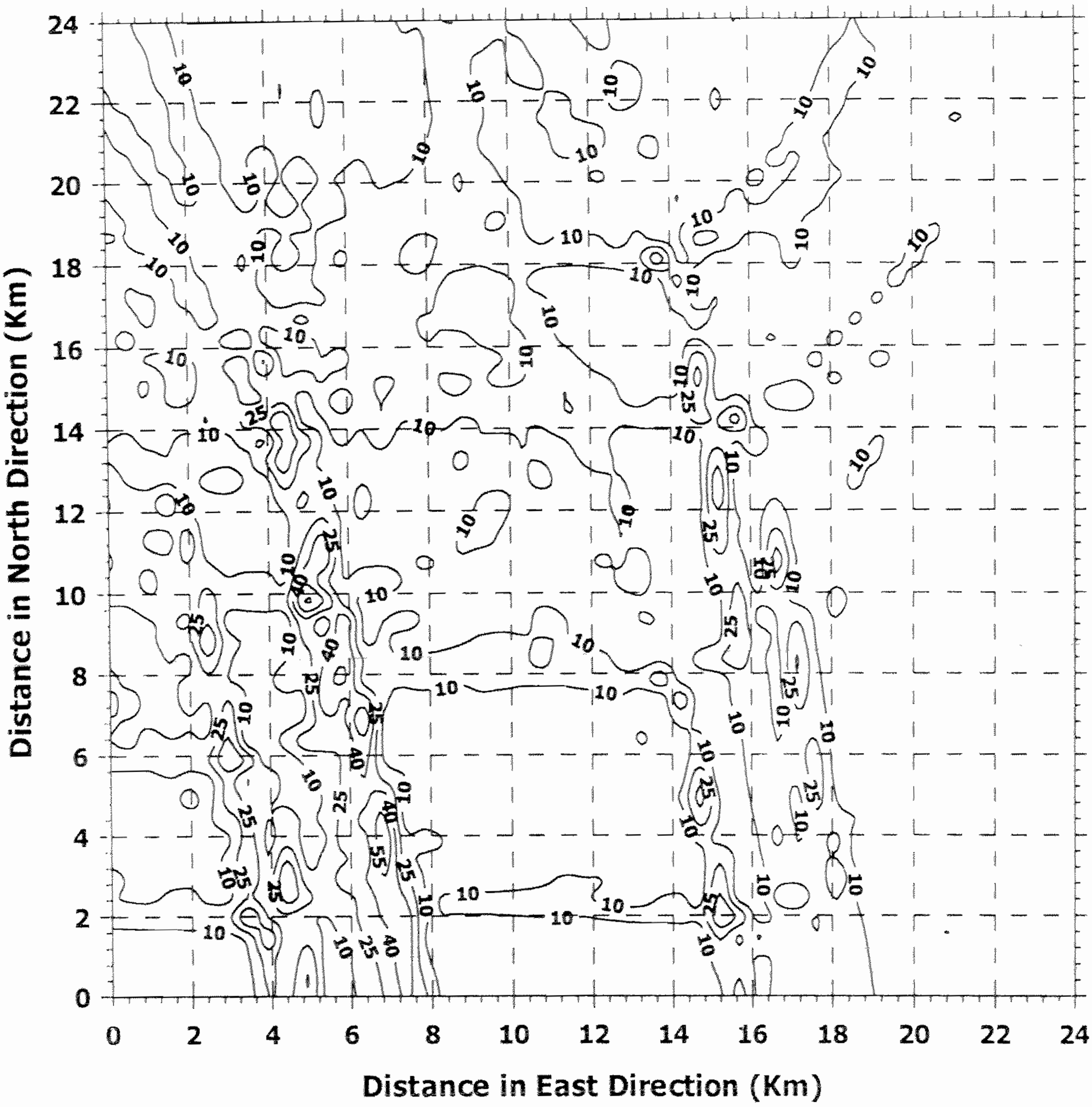


Fig. 6.1.1.51 : Predicted SPM Isopleths : Winter - Kottayam
[Emission Load : 9504 kg/day]

Highest Value	24 hrly Average Conc. (μg/m³)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	70	5.0	10.0	Pallom
2nd	64	6.5	7.0	Madapally
3rd	63	7.0	4.0	Chenganacherry
4th	61	7.0	3.5	Chenganacherry
5th	56	6.0	8.0	Pallom

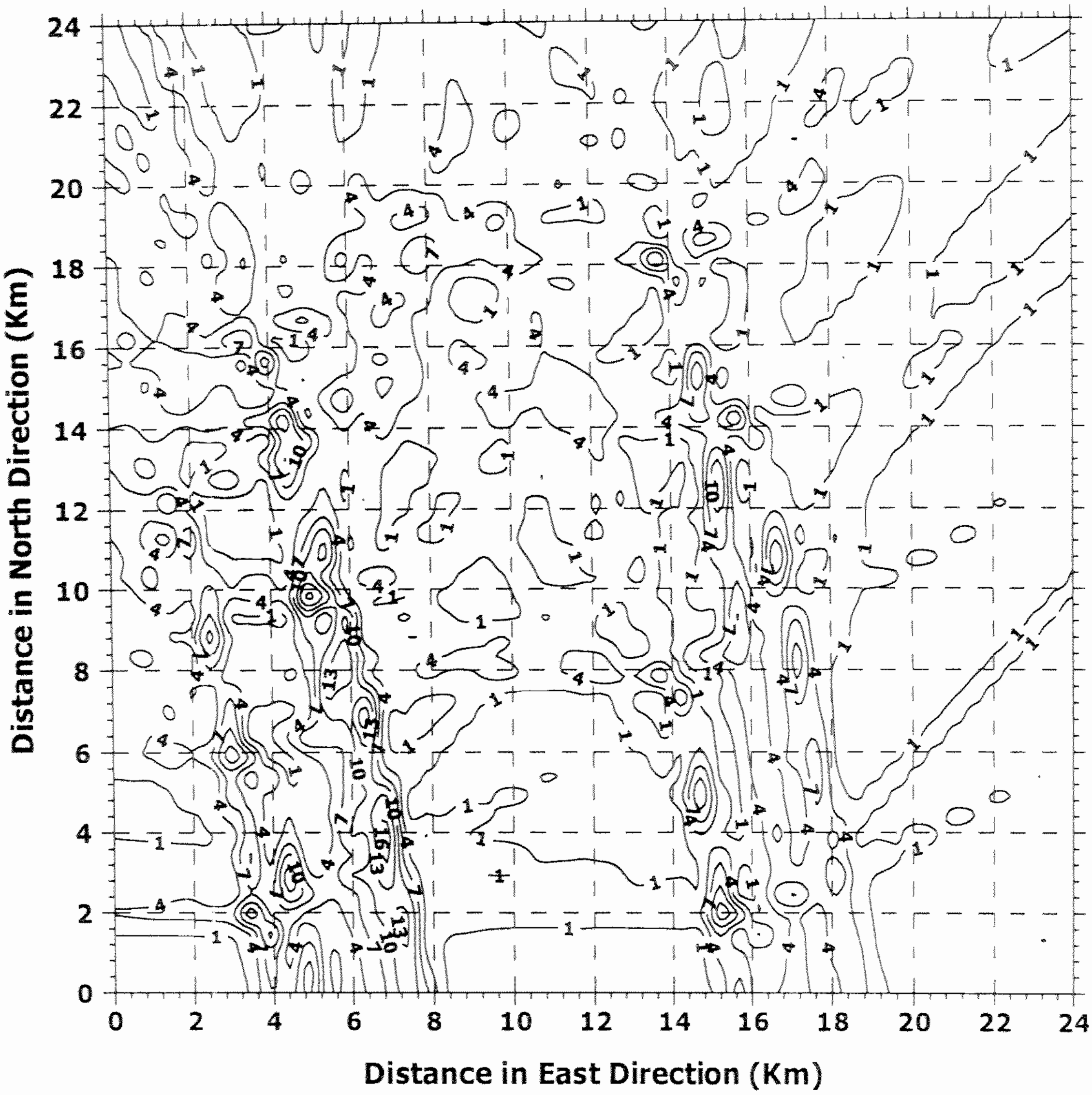


Fig. 6.1.1.52 : Predicted SO_2 Isopleths : Winter - Kottayam
[Emission Load : 2592 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	19	5.0	10.0	Pallom
2nd	17	6.5	7.0	Madapally
3rd	17	7.0	4.0	Chenganacherry
4th	17	7.0	3.5	Chenganacherry
5th	15	6.0	8.0	Pallom

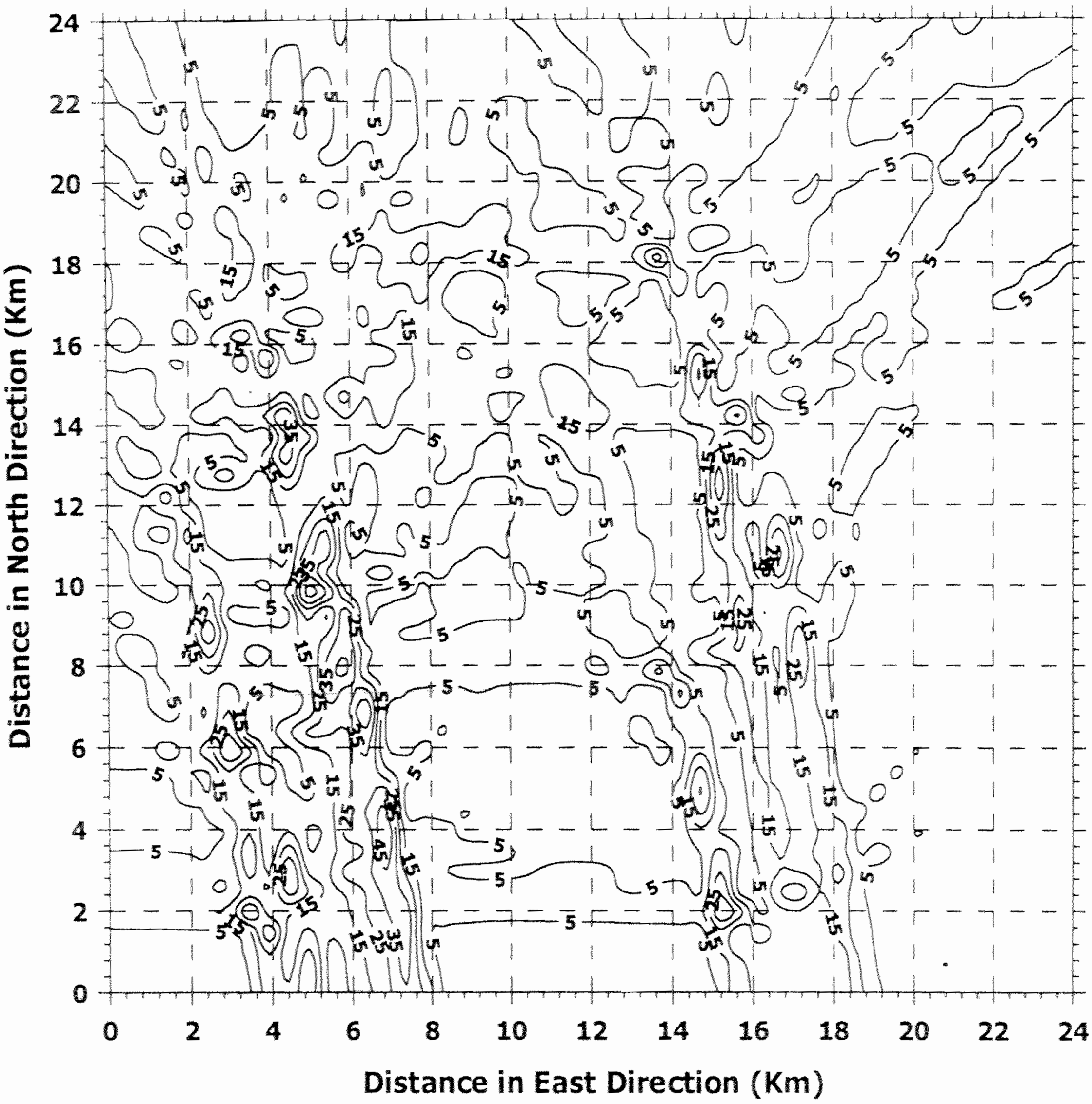


Fig. 6.1.1.53 : Predicted SO_2 Isopleths : Winter - Kottayam
[Emission Load : 7776 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	57	5.0	10.0	Pallom
2nd	52	6.5	7.0	Madapally
3rd	52	7.0	4.0	Chenganacherry
4th	50	7.0	3.5	Chenganacherry
5th	46	6.0	8.0	Pallom

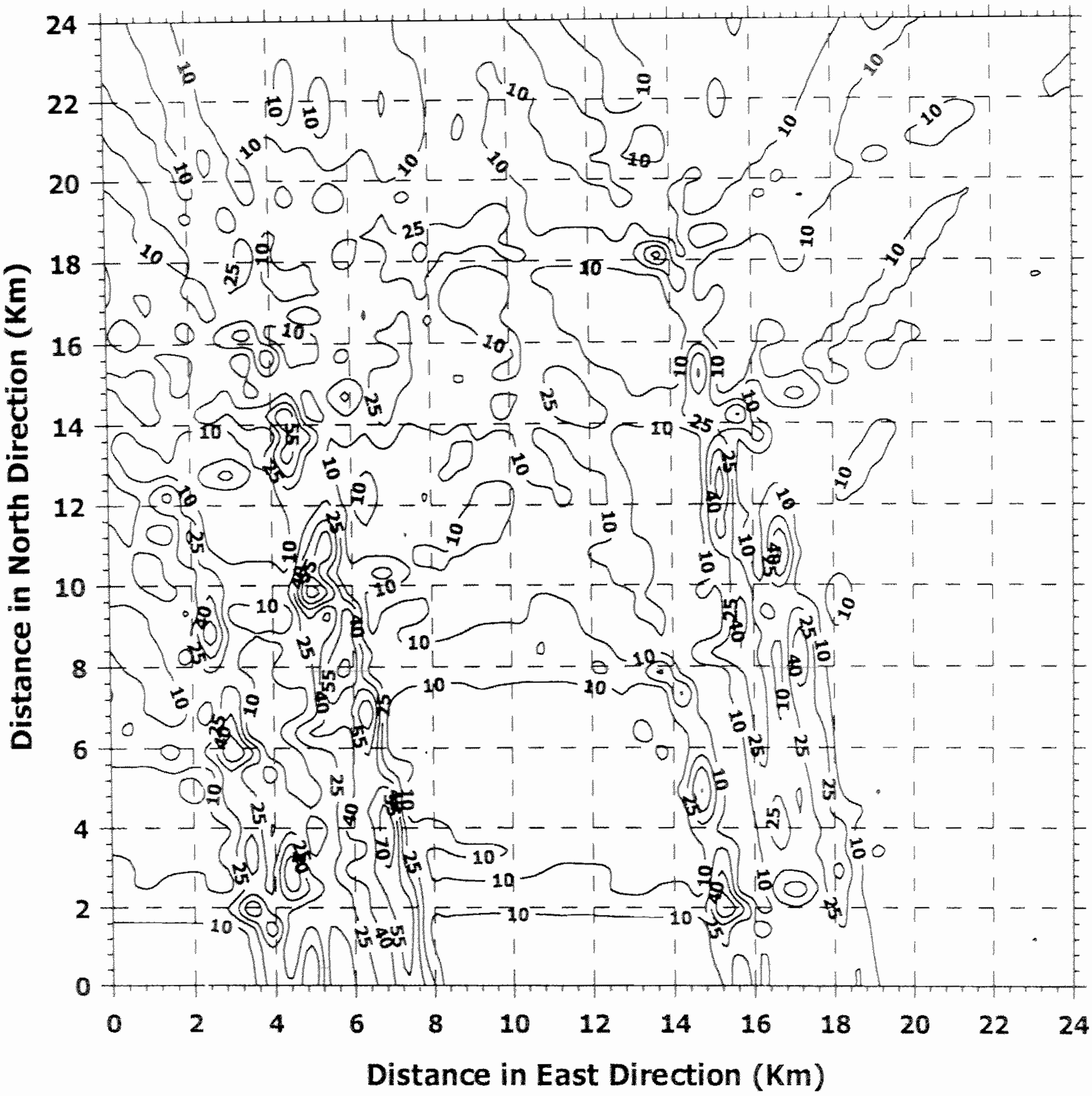


Fig. 6.1.1.54 : Predicted SO_2 Isopleths : Winter - Kottayam
[Emission Load : 12096 kg/day]

Highest Value	24 hrly Average Conc. (μg/m³)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	89	5.0	10.0	Pallom
2nd	82	6.5	7.0	Madapally
3rd	80	7.0	4.0	Chenganacherry
4th	77	7.0	3.5	Chenganacherry
5th	71	6.0	8.0	Pallom

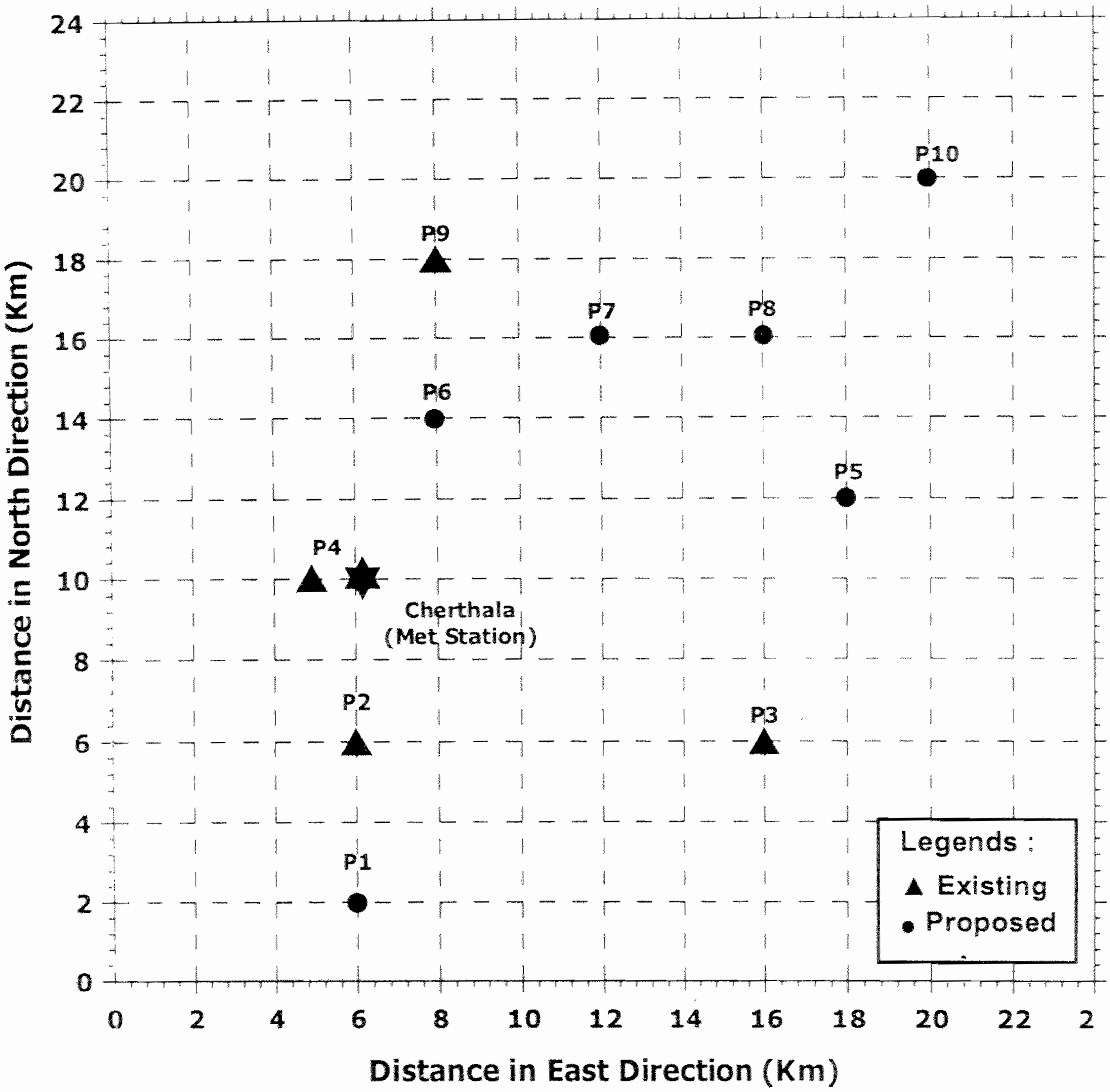


Fig. 6.1.1.55 : Existing and Proposed Point Sources in Alappuzha District

Source	X	Y	Location	
			Place	Block
P1	6000	2000	Aryad	Ariyad
P2	6000	6000	Maririkulam South	Ariyad
P3	16000	6000	Kumarakom	Pallom
P4	6000	10000	Mararikulam North	Kanjikuzhy
P5	18000	12000	------	------
P6	8000	14000	Kanjikuzhy	Kanjikuzhy
P7	12000	16000	Thannemukkom	Kanjikuzhy
P8	16000	16000	Vechur	Viakom
P9	8000	18000	Cherthala	------
P10	20000	20000	Kallara	Kaduthuruthy

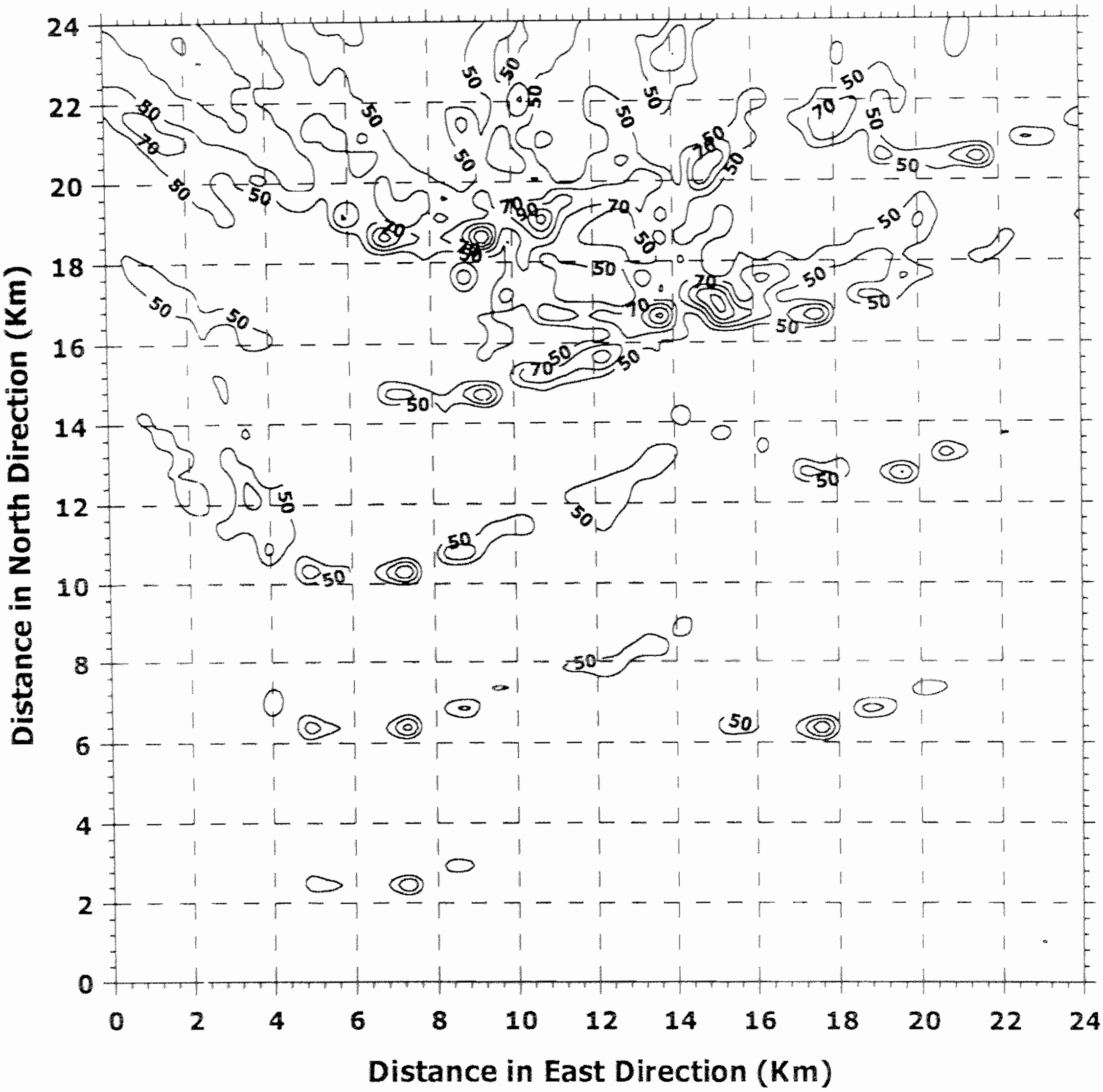


Fig. 6.1.1.56 : Predicted SPM Isopleths : Post Monsoon - Alappuzha [Emission Load : 21600 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	149	9.5	18.5	Cherthala
2nd	136	11.0	19.0	Kanjikuzhy
3rd	135	13.5	16.5	Kanjikuzhy
4th	127	15.0	17.0	Viakom
5th	125	15.0	16.5	Viakom

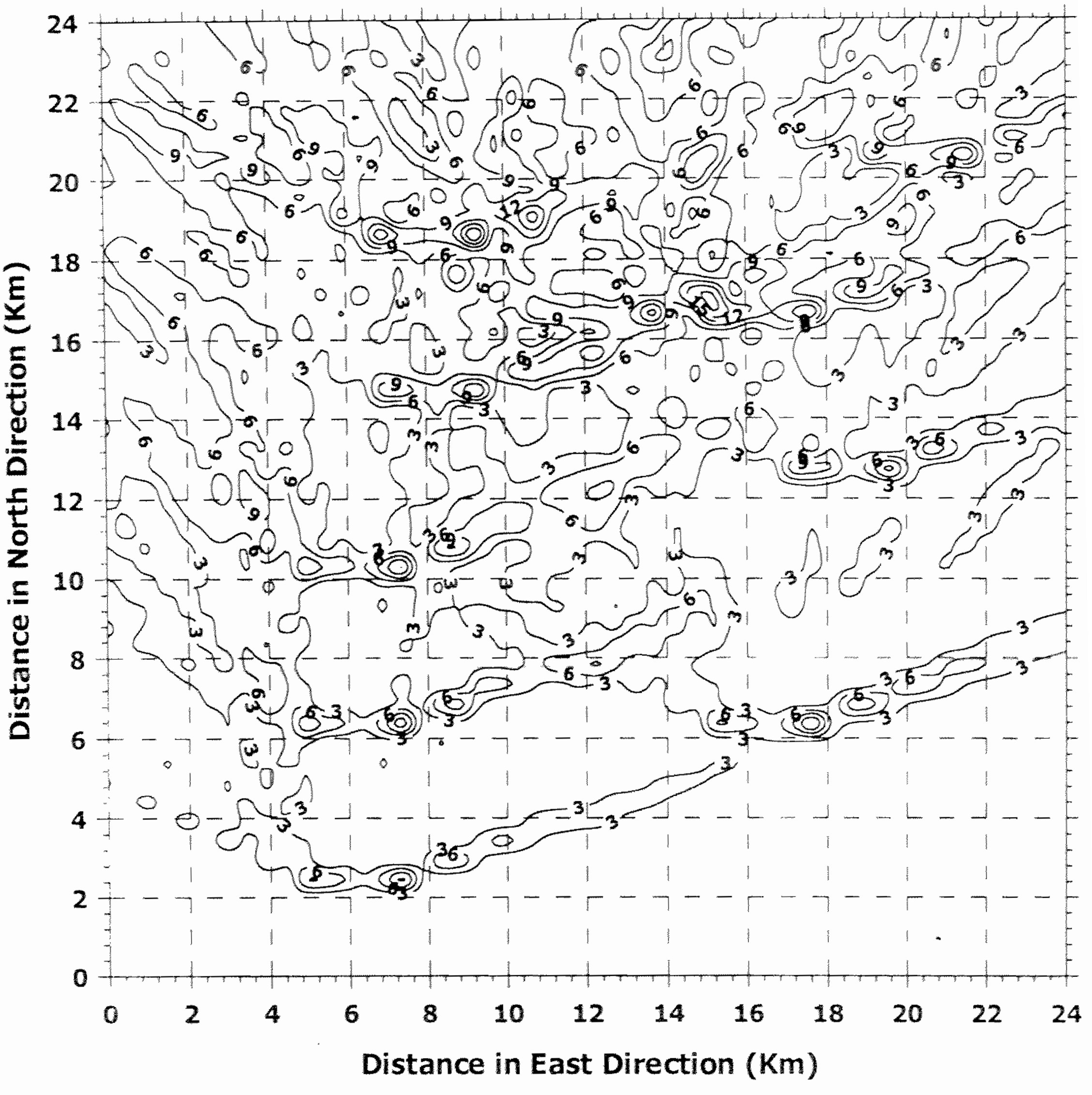


Fig. 6.1.1.57 : Predicted SO_2 Isopleths : Post Monsoon - Alappuzha
[Emission Load : 3024 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	21	9.5	18.5	Cherthala
2nd	19	11.0	19.0	Kanjikuzhy
3rd	19	13.5	16.5	Kanjikuzhy
4th	18	15.0	17.0	Viakom
5th	18	15.0	16.5	Viakom

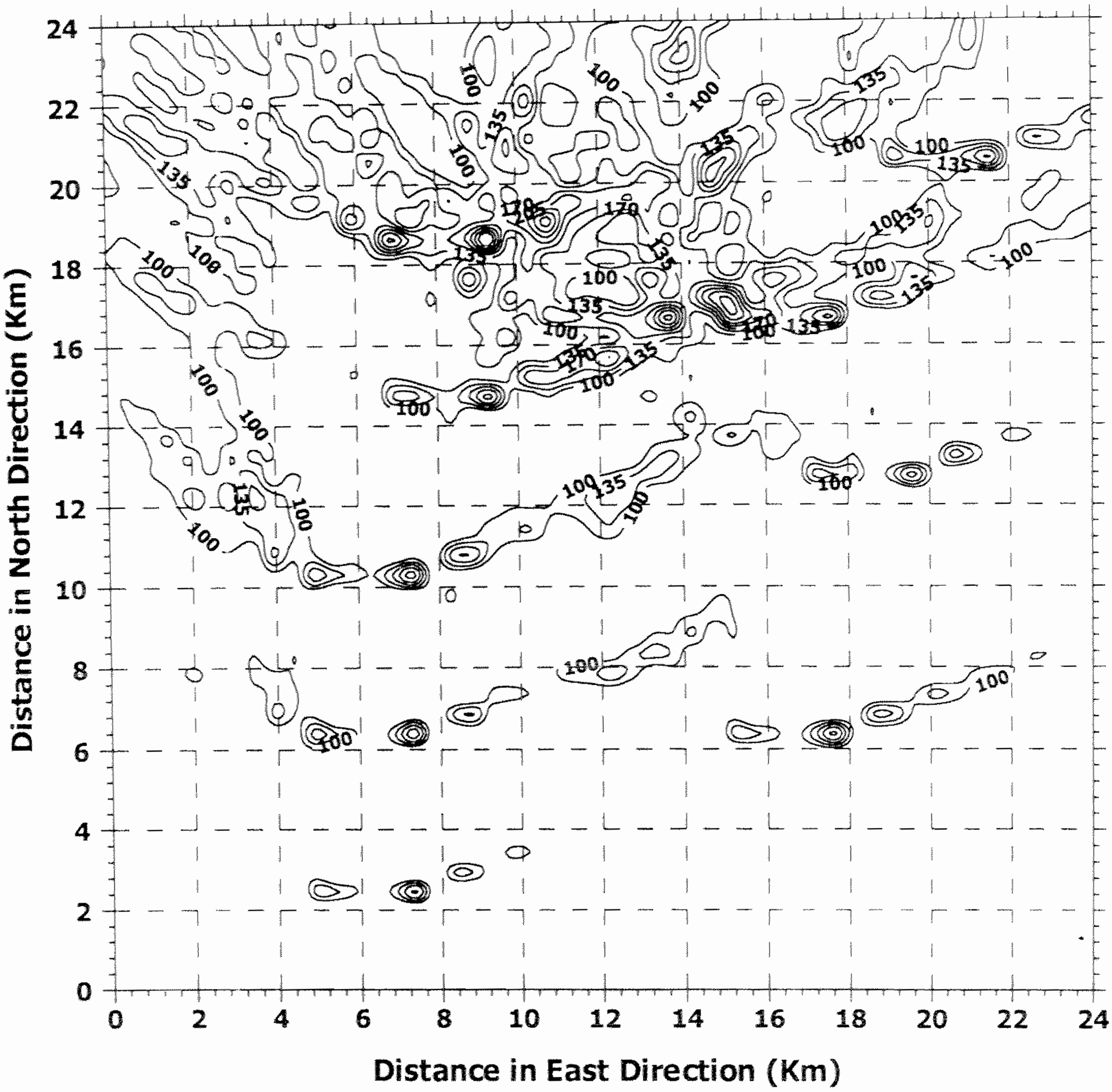


Fig. 6.1.1.58 : Predicted SPM Isopleths : Post Monsoon - Alappuzha [Emission Load : 51840 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	357	9.5	18.5	Cherthala
2nd	326	11.0	19.0	Kanjikuzhy
3rd	324	13.5	16.5	Kanjikuzhy
4th	304	15.0	17.0	Viakom
5th	300	15.0	16.5	Viakom

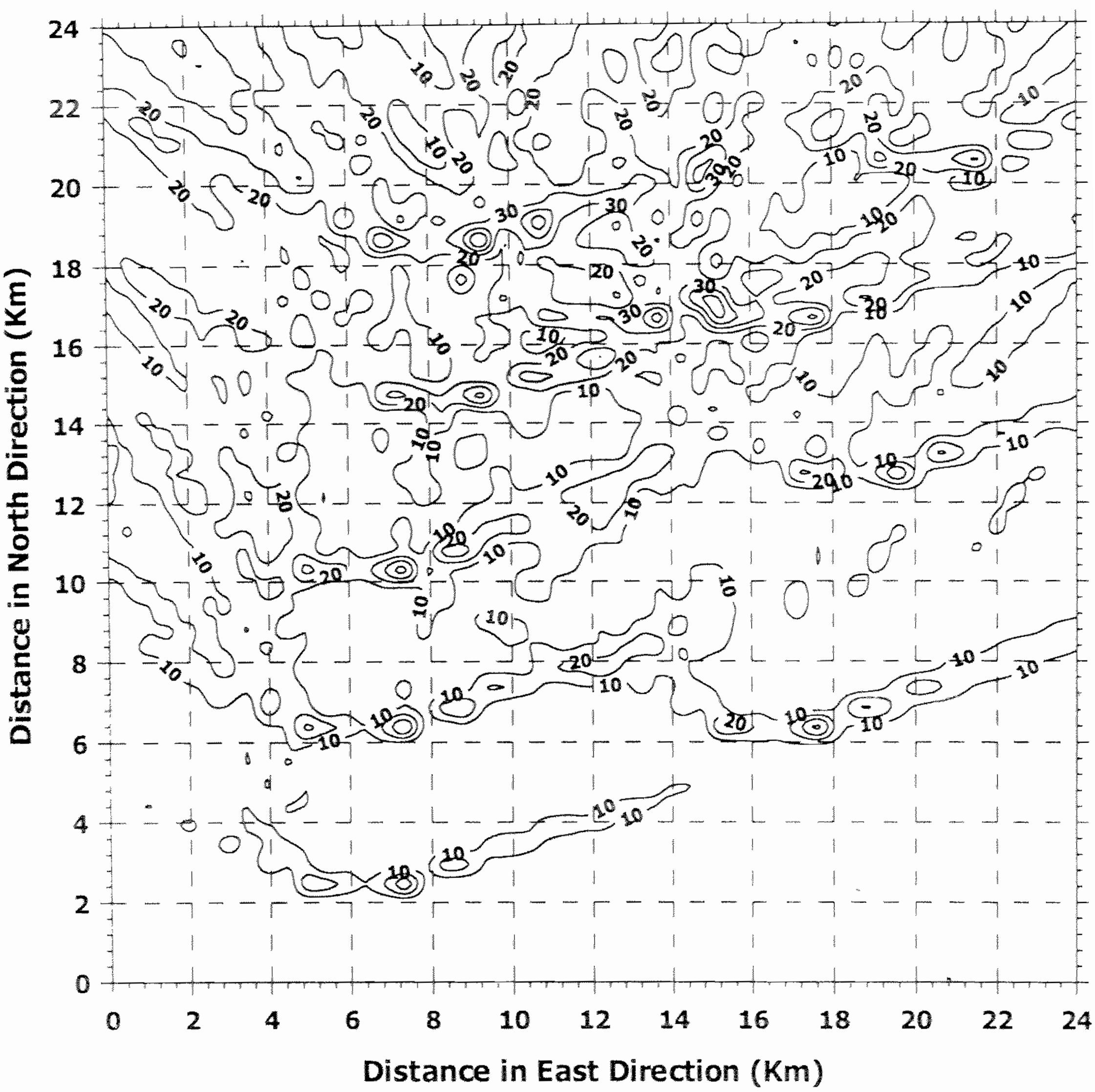


Fig. 6.1.1.59 : Predicted SO_2 Isopleths : Post Monsoon - Alappuzha
[Emission Load : 8640 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	59.5	9.5	18.5	Cherthala
2nd	54	11.0	19.0	Kanjikuzhy
3rd	53.9	13.5	16.5	Kanjikuzhy
4th	50.7	15.0	17.0	Viakom
5th	50	15.0	16.5	Viakom

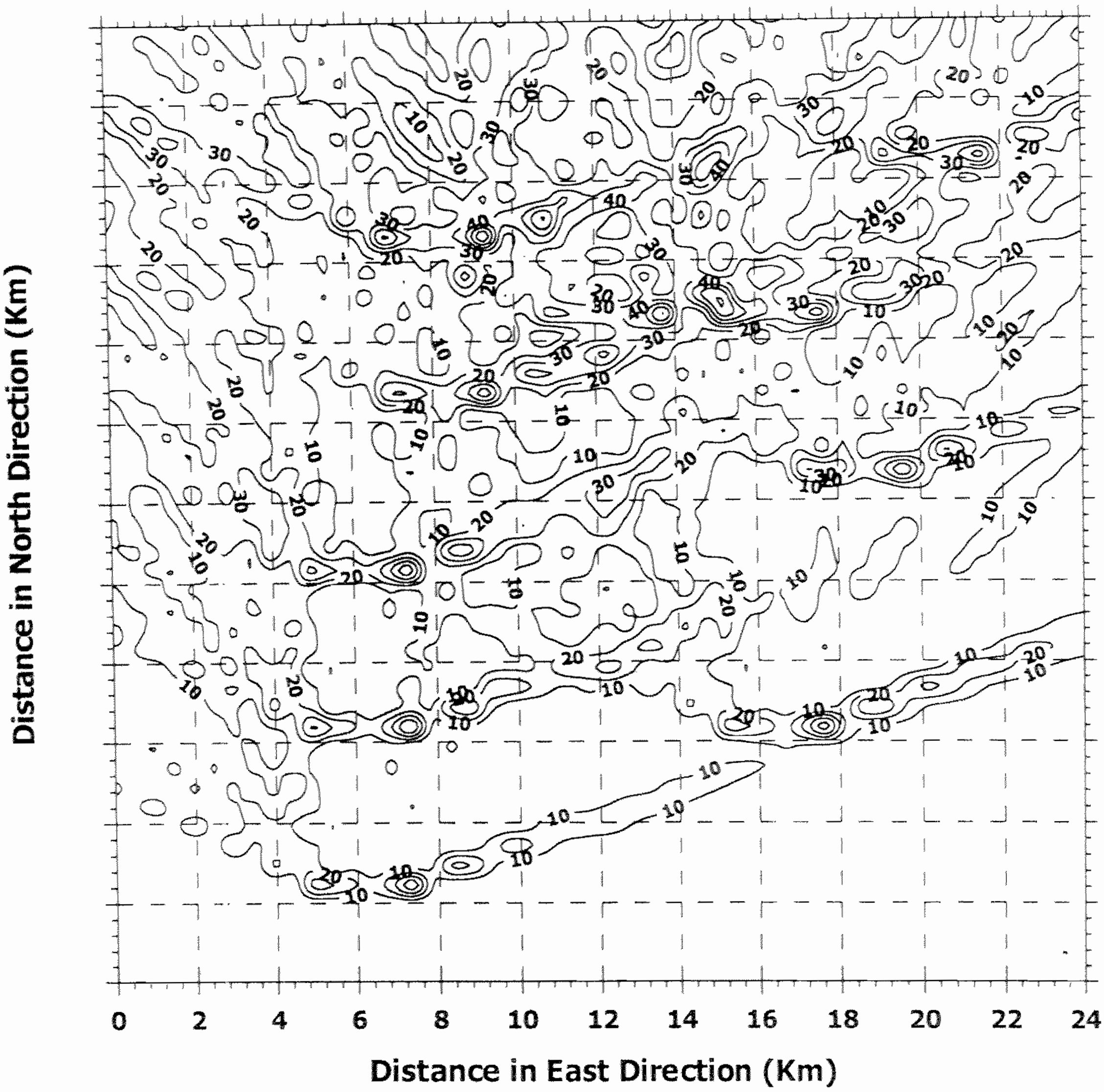


Fig. 6.1.1.60 : Predicted SPM Isopleths : Post Monsoon - Alappuzha
[Emission Load : 11232 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	77	9.5	18.5	Cherthala
2nd	71	11.0	19.0	Kanjikuzhy
3rd	70	13.5	16.5	Kanjikuzhy
4th	66	15.0	17.0	Viakom
5th	65	15.0	16.5	Viakom

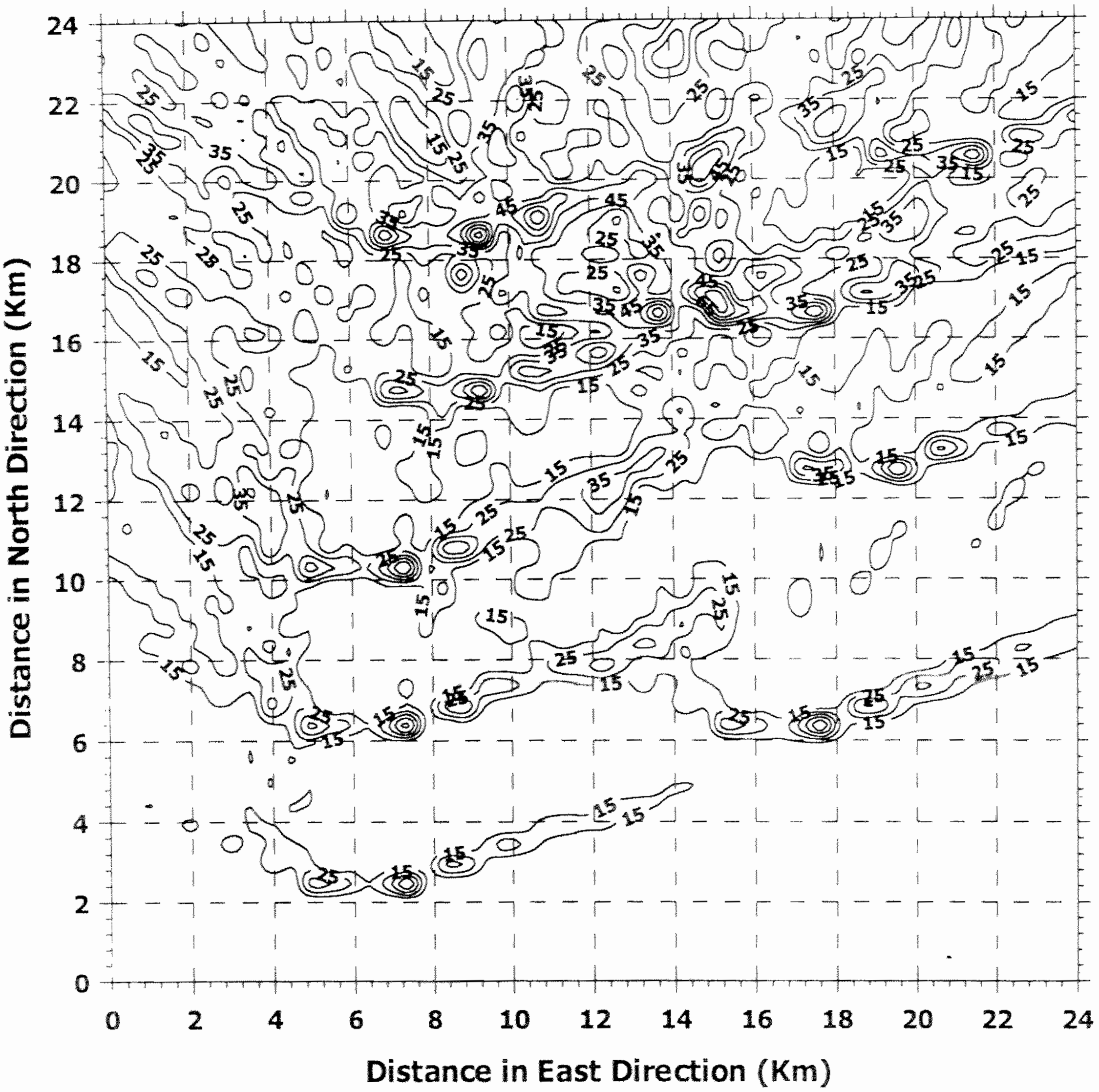


Fig. 6.1.1.61 : Predicted SO_2 Isopleths : Post Monsoon - Alappuzha [Emission Load : 12960 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	89	9.5	18.5	Cherthala
2nd	82	11.0	19.0	Kanjikuzhy
3rd	81	13.5	16.5	Kanjikuzhy
4th	76	15.0	17.0	Viakom
5th	75	15.0	16.5	Viakom

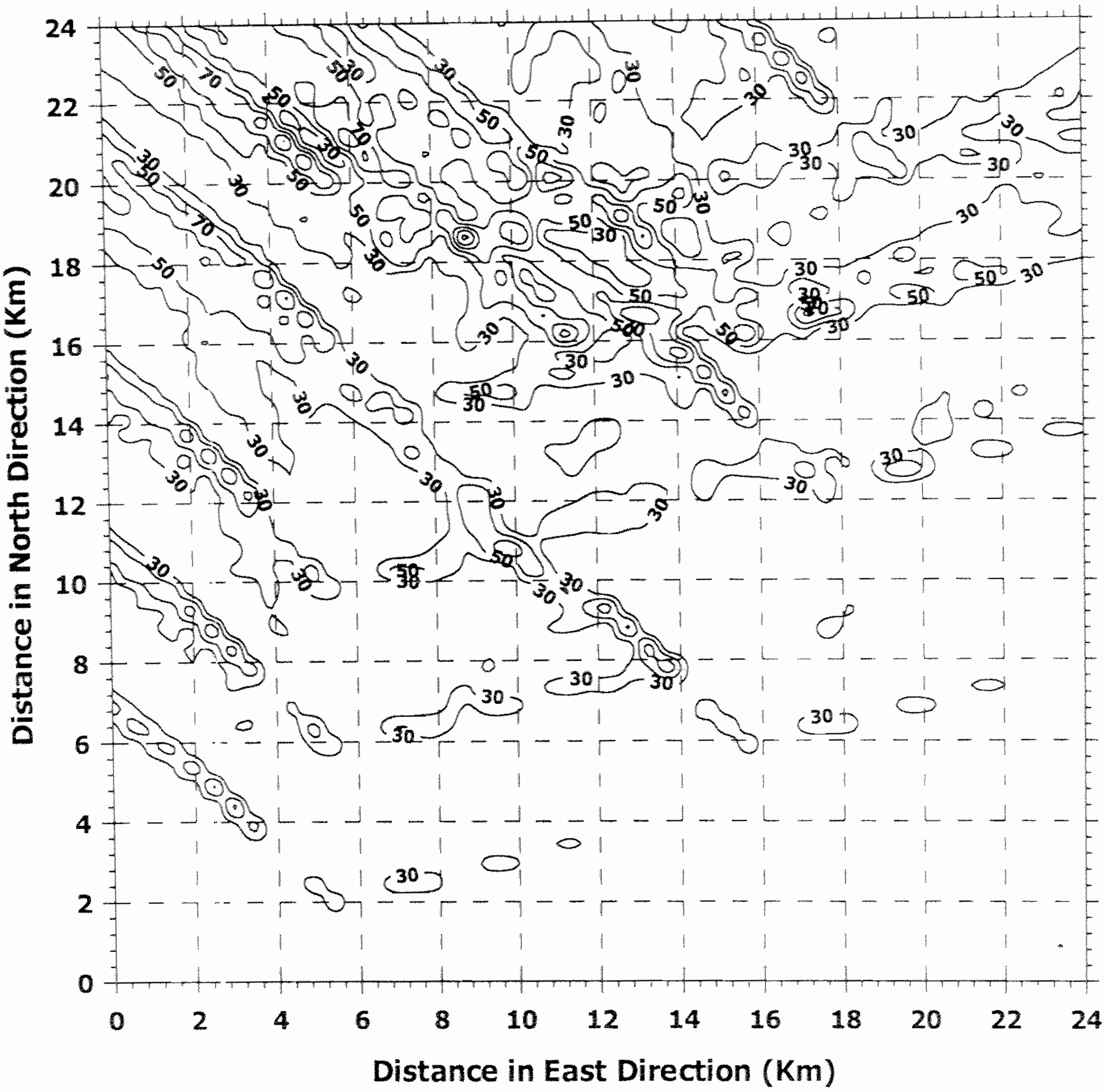


Fig. 6.1.1.62 : Predicted SPM Isopleths : Winter- Alappuzha
[Emission Load : 19008 kg/day]

Highest Value	24 hrly Average Conc. (µg/m³)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	136	9.0	18.5	Cherthala
2nd	110	4.5	21.0	Pattanakad
3rd	108	13.0	16.5	Kanjikuzhy
4th	108	5.0	20.5	Pattanakad
5th	105	12.5	19.0	Kanjikuzhy

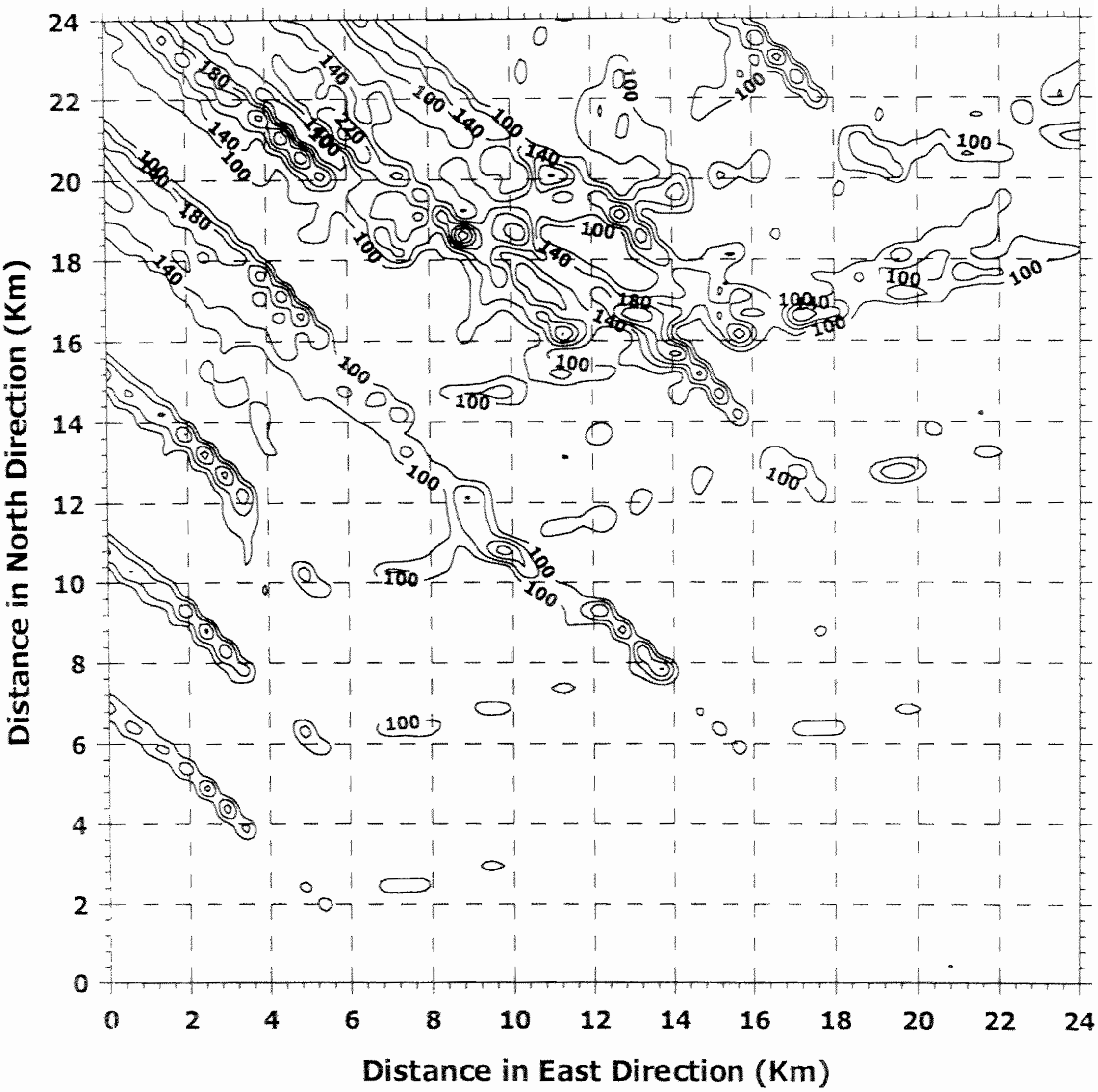


Fig. 6.1.1.63 : Predicted SPM Isopleths : Winter- Alappuzha
[Emission Load : 51840 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	370	9.0	18.5	Cherthala
2nd	300	4.5	21.0	Pattanakad
3rd	294	13.0	16.5	Kanjikuzhy
4th	293	5.0	20.5	Pattanakad
5th	286	12.5	19.0	Kanjikuzhy

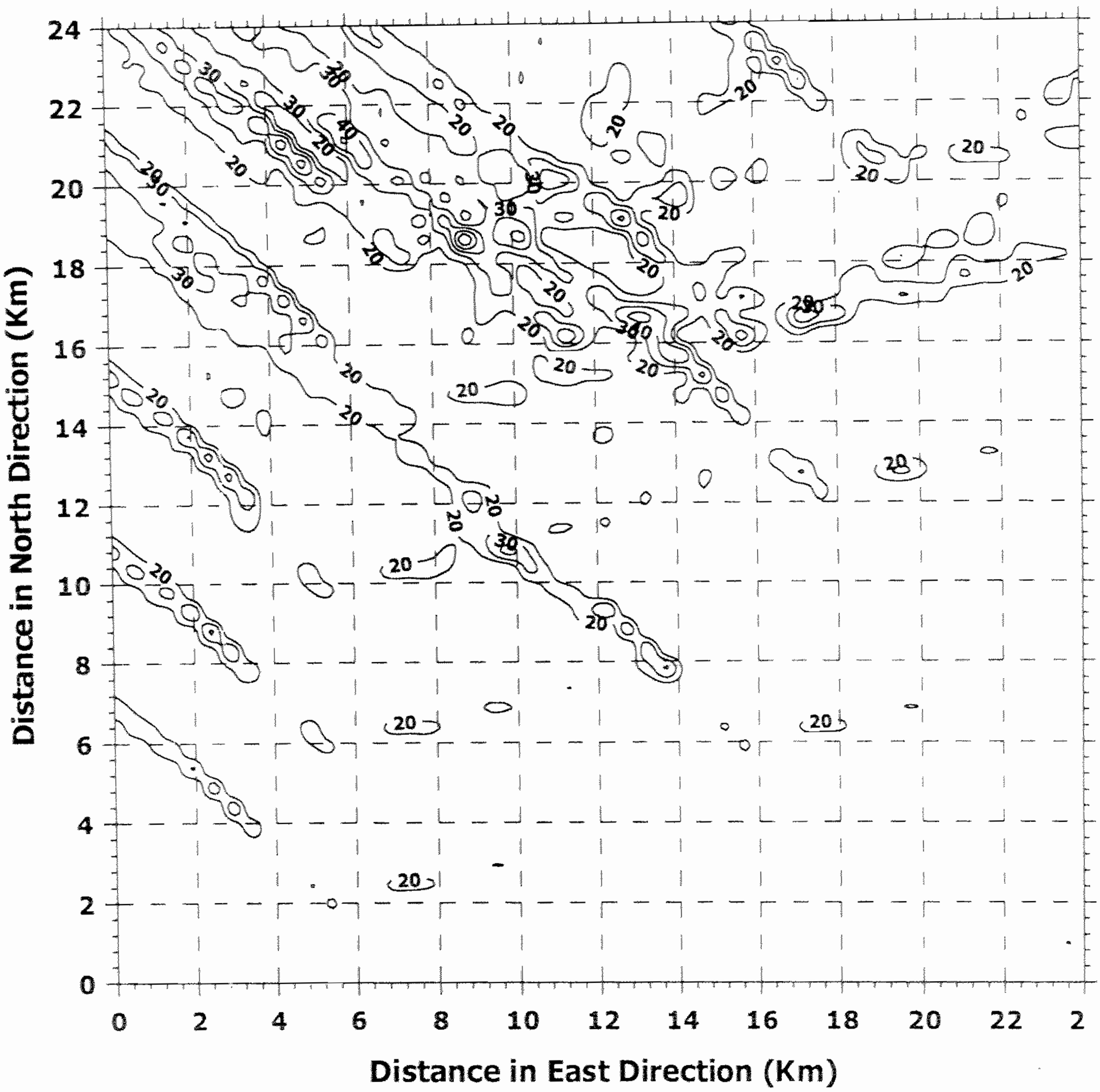


Fig. 6.1.1.64 : Predicted SPM Isopleths : Winter- Alappuzha
[Emission Load : 9504 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	68	9.0	18.5	Cherthala
2nd	55	4.5	21.0	Pattanakad
3rd	54	13.0	16.5	Kanjikuzhy
4th	54	5.0	20.5	Pattanakad
5th	52	12.5	19.0	Kanjikuzhy

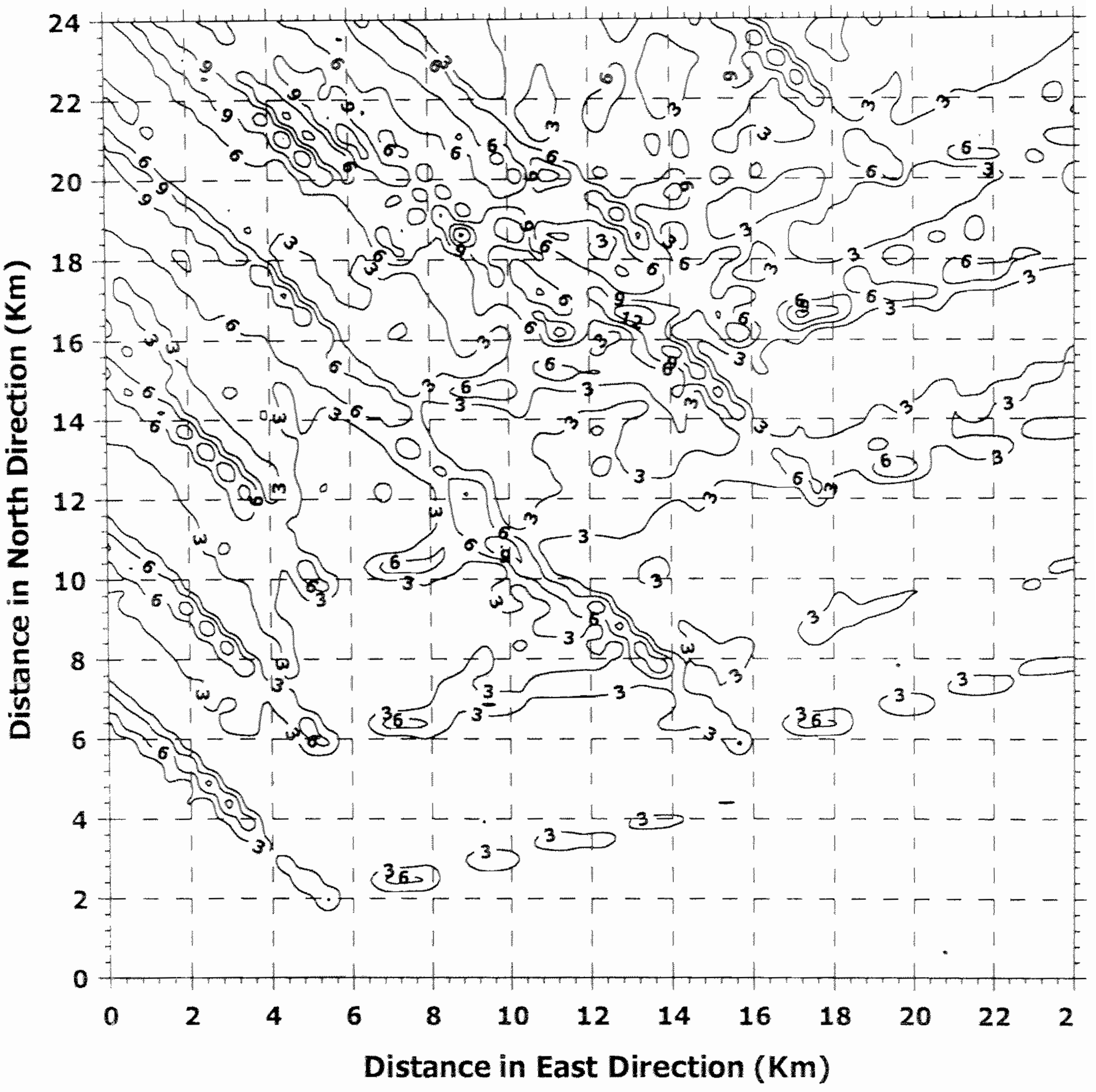


Fig. 6.1.1.65 : Predicted SO_2 Isopleths : Winter- Alappuzha
[Emission Load : 2592 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	19	9.0	18.5	Cherthala
2nd	15	4.5	21.0	Pattanakad
3rd	15	13.0	16.5	Kanjikuzhy
4th	15	5.0	20.5	Pattanakad
5th	14	12.5	19.0	Kanjikuzhy

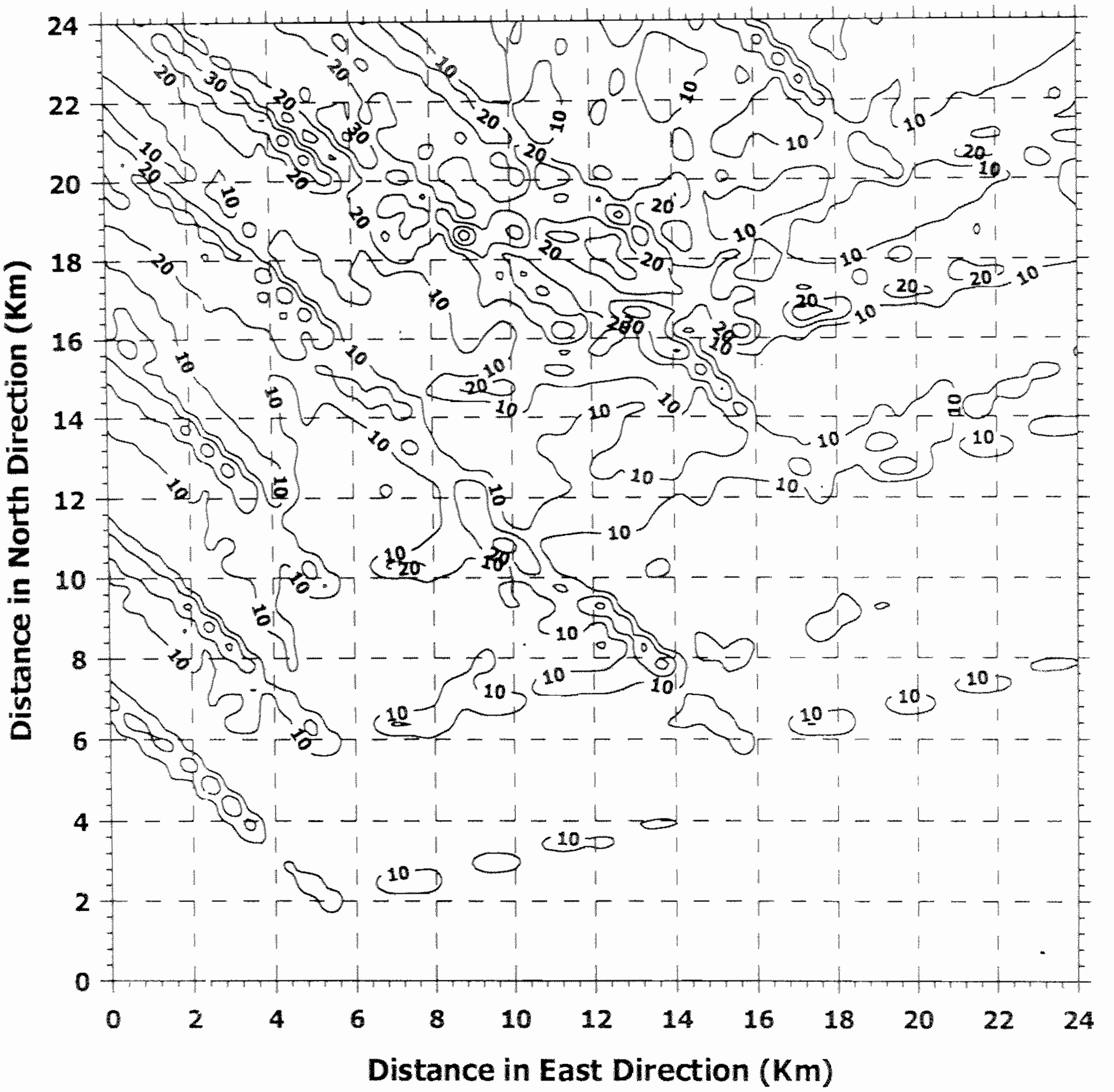


Fig. 6.1.1.66 : Predicted SO_2 Isopleths : Winter- Alappuzha [Emission Load : 7776 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	56	9.0	18.5	Cherthala
2nd	45	4.5	21.0	Pattanakad
3rd	44	13.0	16.5	Kanjikuzhy
4th	44	5.0	20.5	Pattanakad
5th	43	12.5	19.0	Kanjikuzhy

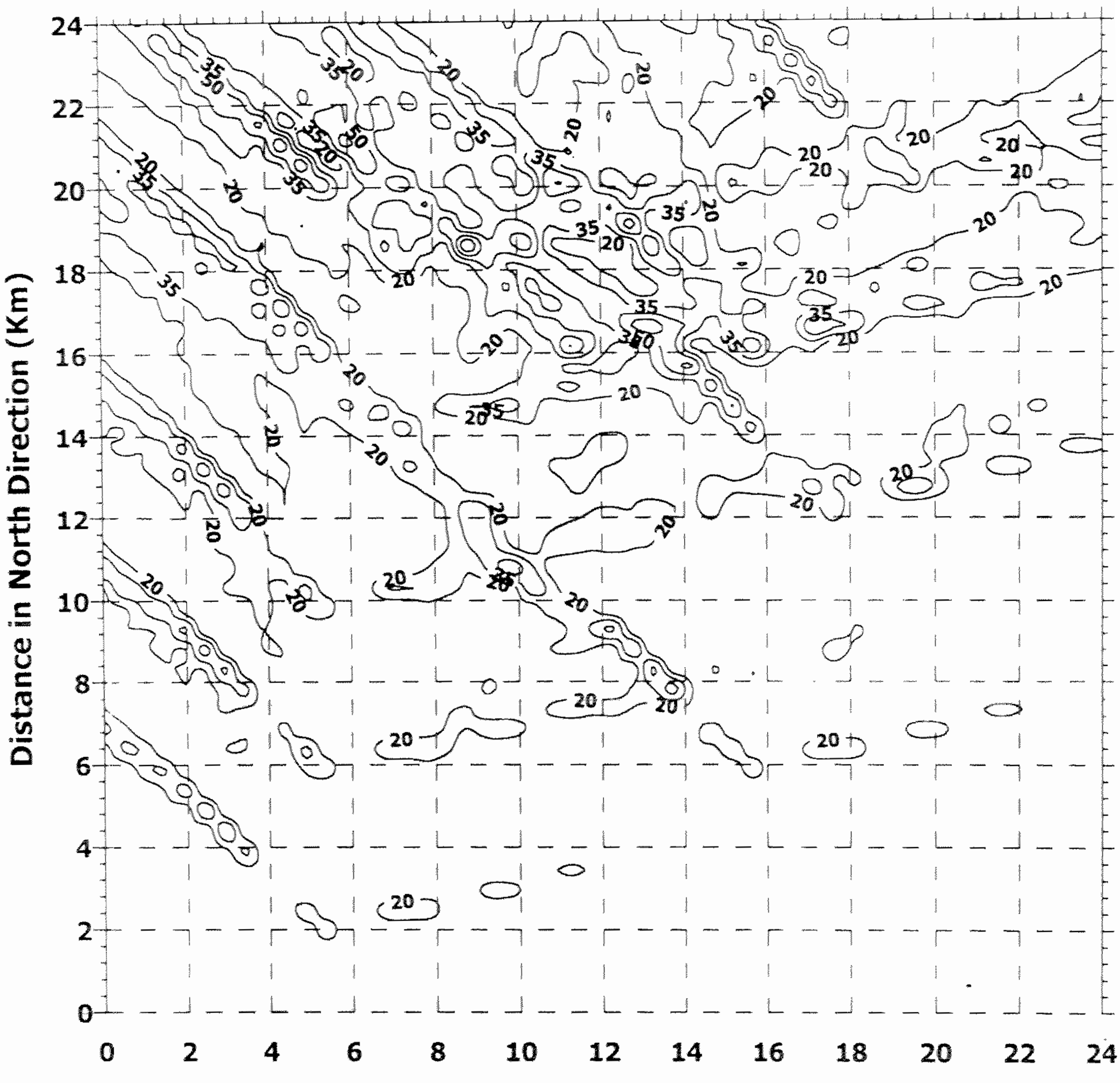


Fig. 6.1.1.67 : Predicted SO_2 Isopleths : Winter- Alappuzha
[Emission Load : 12960 kg/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	93	9.0	18.5	Cherthala
2nd	75	4.5	21.0	Pattanakad
3rd	73	13.0	16.5	Kanjikuzhy
4th	73	5.0	20.5	Pattanakad
5th	72	12.5	19.0	Kanjikuzhy

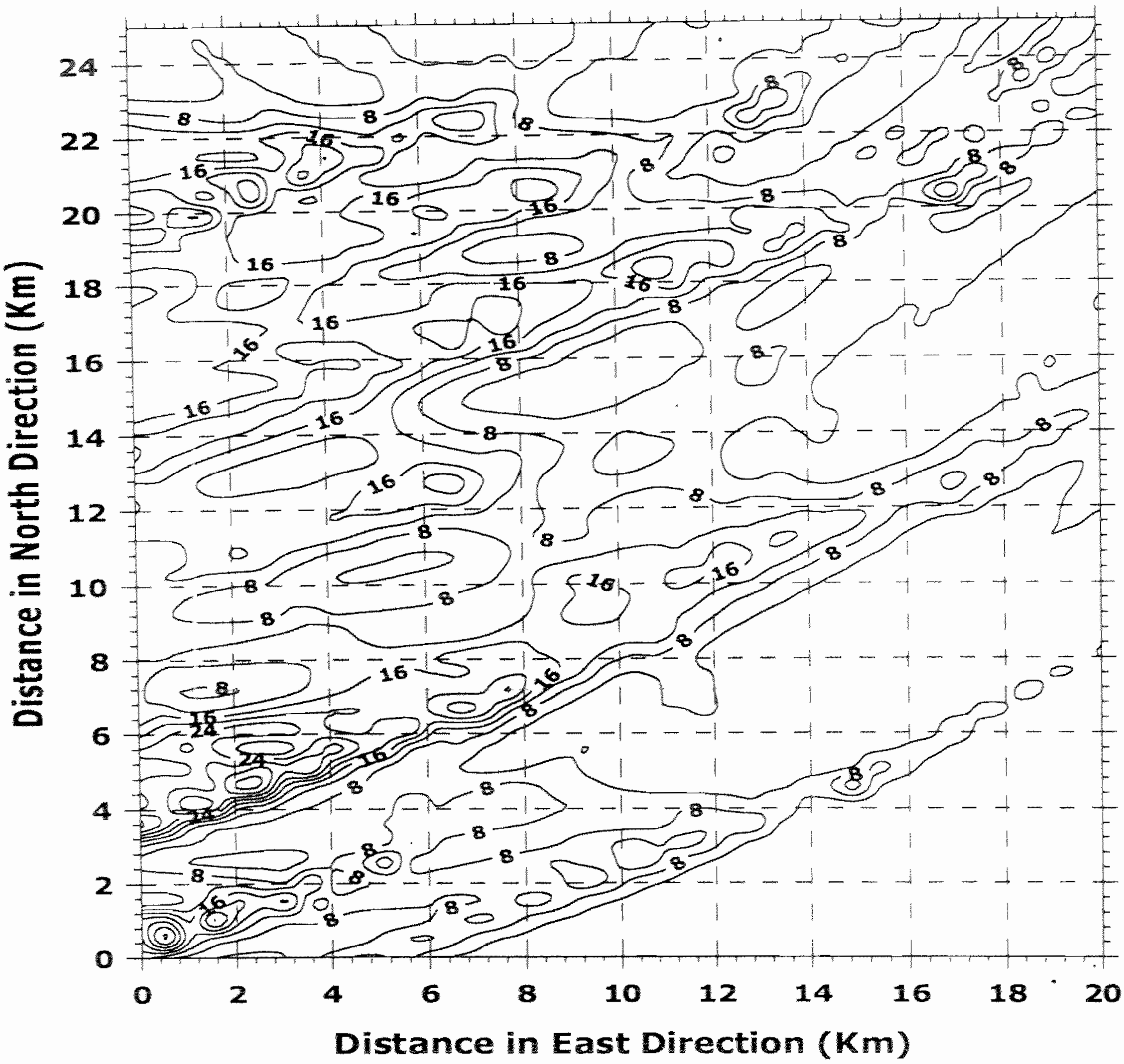


Fig. 6.1.1.68 : Predicted SO_2 Isopleths for 10 Chosen Pockets in Ernakulam [Emission Load : 24 tons/day]

Highest Value	24 hrly Average Conc. ($\mu g/m^3$)	Occurrence at		Place/Area
		East (Km)	North (Km)	
1st	43	7.5	7.0	Ernakulam
2nd	41	2.0	4.5	Kochi
3rd	40	2.5	4.5	Kochi
4th	40	11.0	18.5	Trikkakarra
5th	39	3.5	5.0	Kochi

6.1.2 Assimilative Capacity of Water Environment

6.1.2.1 Surface Waters

6.1.2.1.1 Wastewater Discharges (Non point)

Pollution of Pamba Thriveni, the confluence of the streams of Kakki and Kochupamba takes place during the Sabarimala pilgrimage season in October-January every year. It is estimated that around 50 million people visit Sabarimala, a pilgrim centre situated in the upstream portion of the Pamba basin, during this period every year.

6.1.2.1.2 Water Quality

Many streams originating from the hills flow through Sabarimala and join together to form Njunangar. Marakkoottam, Sabaripeedom, Appachimedu, Chelikkuzhi and Cheriyanavattom flow into the Njunangar before it merges with the river Pamba about 50 m downstream of the Arattukadavu near the Pamba temple. The pollution in Pamba is due to defecation of the pilgrims and bathing. Some of the earthen tanks constructed along the river Pamba are filled with human excreta and are left open. The tanks overflow quite often and also pollute the river. The total coliform count (number per 100 ml) is reported to vary from 4000 to 78000, where as the maximum permissible limit is 500 MPN/100 ml only.

Qual II Model

As a water quality planning tool, the Enhanced Stream Water Quality Model (QUAL 2E), which is a steady state model for conventional pollutants was used for simulating the flow requirements needed for diluting coliform contents to the stipulated standards. The details of the model used and results obtained are :

Water Quality Simulation in Pamba River

A 2 km stretch of Pamba River is segmented into 6 reaches, each of which is sub-divided into elements of equal length of 100 m. Stream network with computational elements and reaches is given in **Fig. 6.1.2.1.**

A layout of Pamba River at this stretch is given in **Fig. 6.1.2.2** and the stretch is shown in **Fig. 6.1.2.3.**

Only coliforms are mainly considered since the other parameters are not of much significance in the considered ecosystem. Primary data collected by CWRDM from this stretch on 26-11-1999, 23-12-1999 and 14-3-2000, is given in the earlier **Table 3.3.1.4.** Further, a set of data collected during November 1999 by KSPCB was also made available to CWRDM **(Table 6.1.2.1).** All these data were made use of for running this model.

Assumptions/Limitations

There are no point loads in the form of drains/sewers. The point loads considered are points/elements with accumulated waste where the coliforms are generated within the system itself by the bathing of pilgrims of Sabarimala. The six point loads considered are (1) in Kakki near parking ground, (2) just upstream of Thriveni Bridge (3) at Nadappalam (4), (5) & (6) between Nadappalam and Ganapathi Temple (Arattukadavu). For running the model, a flow of 0.1 m^3/s is assumed for the point load. The coliform count is assumed as zero for the headwaters in the initial condition.

To bring down the observed coliform count (46000 MPN/100 ml) to the maximum permitted level of 500/100 ml (as per the CPCB/ KSPCB criteria), the discharge in the main stream has to be increased from an observed value of about 4 m^3/s to the order of about 35 m^3/s. This is possible only if water is released from the upstream reservoirs or by impounding water upstream and release it as and when required. A plot between simulated coliforms and discharge is furnished in **Fig. 6.1.2.4.**

6.1.2.2 Ground Water

Relationship Between Rainfall and Runoff in the Study Area

The rainfall-runoff model suitable for different purposes depends on incorporation of different factors, such as,

- Time scale of modeling,
- Measurement of physical parameters of the river basin,
- Reliability and type (conventional or automatic) of data from the hydro-meteorological network of the basin,
- Specific use of the model and the purpose of application, and
- Available computing facilities.

The availability of data is a major problem for the widespread application of rainfall-runoff models. In most countries, there are usually plenty of rainfall records, but the more elaborate and expensive stream flow measurements, which are essential for the assessment of water resources or of damaging flood peaks are often seldom available for a specific river under investigation. At the design stage of many hydrological works, simulation of possible discharge series may be needed.

Such simulations are usually obtained from time series analysis of observed historical records of discharge, but in the absence of such long series, they may, alternatively be obtained by studying the input functions, which may then be simulated and transformed into the corresponding output function. The main objective of the present study is to apply the linear perturbation model (LPM) to estimate the river flow in the Meenachil and Achencoil rivers of Kerala, which fall in GKR study area and to compare the efficiency of the model between its non-parametric (unconstrained) and parametric (gamma function) forms. This model has been developed at the Department of Hydrology, University of Galway, Ireland. Different scientists and engineers have applied few such rainfall-runoff models to different river basins of Kerala.

Model Requirement

Ideally it is expected that the model represent as closely as possible the actual physical processes occurring in the basin. In that case, it is also essential that it represent accurately the transformation of the input into the output. The utility of the model is reflected in the extent to which it satisfies this practical objective, which is termed 'model efficiency'. The second requirement is 'consistency'. The third requirement is 'versatility'. A versatile model is one, which is accurate and consistent when subjected to diverse applications. An examination of parameter stability and the significance of model parts are necessary. This is achieved by dividing the available records into two periods, one of which is used for model calibration and the other for verification. The practice has been to use most of the data for calibration and to confine the verification period to one or two years. Standard errors of estimates of model parameter values would be most useful in assessing the significance of separable model parts and stability of parameter estimates.

Efficiency Criteria

Criteria, which express model accuracy, are generally linked with the objective function used for optimizing its parameters. A commonly used objective function is the sum of squares of the differences between the observed (y_o) and the estimated (y_e) discharges with the summation taken over the whole of the calibration period.

$$F = \Sigma (y_o - y_e)^2$$

F is an index of residual error, which reflects the extent to which a model is successful in reproducing the observed phenomenon. But Nash and Sutcliffe (1970) introduced a dimensionless quantity called the 'efficiency' R^2 analogous to the coefficient of determination in linear regression, as one minus the portion of the initial variance represented by *F*. Defining the initial variance F_0 as

$$F_0 = \Sigma (y_o - y_a)^2$$

Where y is the sample mean of the discharge records over the calibration period, the criterion becomes,

$$R^2 = (F_0 - F) / F_0$$

While applying to calibration period, these quantities are all obtained within that period. Therefore, R^2 is identical to the coefficient of determination and varies between zero and one.

Area of Study and Data Used

The study area comprises of the river basins of Meenachil and Achencoil. A total of 10 years of daily rainfall data from six rain gauges and concurrent discharge data from one station (Kidangoor) were used for the study in the Meenachil basin **(Fig. 2.2.1.5).** The data are from January 1, 1985 to December 31, 1994 of which first eight years of data are used for calibration of the model and the subsequent two years for verification. The same depth of data has been used to develop the model in Achencoil basin **(Fig. 2.2.1.8)**. Rainfall data from five rain gauges and concurrent discharge from one station (Kollakadavu) were utilized.

The Linear Perturbation Model (LPM)

For rivers with a relatively predictable seasonal variation, considerable improvement in conventional rainfall-runoff models may be obtained by concentrating on the relationship between the series of departures from the seasonal behavior in rainfall and discharge, as input and output, respectively rather than, as conventionally, treating the total rainfall series as input and the total discharge series as output (Nash and Foley, 1982). The linear perturbation model (LPM) may be viewed as an attempt to overcome the basic weakness inherent in the classical unit hydrograph approach, wherein the departures (storm runoff) from the base flow are related by a linear model to the corresponding departures (rainfall excess) from the corresponding rainfall loss series. The physically undefined base flow and rainfall loss series are replaced, in the case of LPM, by the physically defined seasonal mean daily series of input and output, respectively. This model is based on the following assumptions:

1. If in a particular year, each input function, is equal, for each day of the year to its expected value for that date, the output will also equal its expectation for that date. That is, if the expected values of rainfall and discharge on each date d are denoted by i_d and q_d respectively, then the input i_d produces the output q_d.

2. Perturbations from the date expected input values (i_d), are linearly related to the corresponding perturbations from the date expected values (q_d).

On catchments with high seasonal variations in discharge, the substraction of the seasonal means from the original series would remove much of the dependence on linearity that means, the assumption of a linear relationship between the departures would be less restrictive than the same assumption concerning the actual input and output values. For a single input series, the LPM may be described by

$$Yi = \sum_{j=1}^{m} x_{i-j+1} h_j + e_i ; \qquad i = 1, 2, \ldots, n$$

Where $y_i = q_i - q_d$ and $x_i = i_i - i_d$; $\qquad d = 1, 2, \ldots, 365$

m is the memory length, the interval between the occurrence of rainfall and the time when its effect on the stream flow ceases. Having determined the seasonal component q_d the model may be calibrated by the method of ordinary least squares, with or without volumetric constraints.

The above equation can be written as:

$$Y = XH + E$$

The optimum value of H can be determined by method of ordinary least squares from

$$H = [X^T X]^{-1} X^T Y$$

Application of the Model - Non-parametric Solution

The model has been applied to the Meenachil river basin. Seasonal mean rainfalls and seasonal mean discharges were calculated for the periods of calibration. Smoothing was done by the method of unconstrained Fourier analysis using the first four harmonics. The smoothed seasonal mean values were subtracted from the observed rainfall and discharge series for the periods of calibration to yield the time series of the perturbations x and y. The pulse response function was estimated by the method of ordinary least squares, the pulse responses were convoluted with the rainfall perturbations to obtain the estimated outflow perturbation series. The estimated discharge series was calculated by adding the seasonal mean discharge to the estimated outflow perturbation series. The differences between observed and computed discharges were squared and summed and the usual measure of efficiency R^2 calculated. **Table 6.1.2.2** gives the summary of results as applied to Meenachil basin and that of Achencoil basin.

Parametric Solution – the gamma function model

Parametric modeling provides a more drastic constraint to the shape and volume of the estimated pulse response function wherein a solution for the pulse response function is sought within the constraints of some assumed model form, say, the gamma function. When a system whose impulse response is given by the gamma function

$$h(t) = (1/k\,\Gamma n)\, e^{-(t/k)}\, (t/k)^{n-1}$$

relates an input in blocks of duration T, to an output expressed as a series of ordinates at the same interval, the corresponding pulse response becomes (Nash, 1960)

$$h(T,t) = [S(t) - S(t-T)]/T$$

The parameters this model can be estimated by progressive optimisation, implying a search (Rosenbrock, 1960) in the n, k, G_g space. The parameter pair n and nk should be chosen rather than n and k, because n is a shape parameter and the product nk is a scale parameter. G is called the gain factor. When the input and output are expressed in the same units, the ratio of the total output to the total input volume is known as the gain factor G. The estimated gamma function parameters are:

$n = 0.49$; $nk = 11.59$ and $G_g = 0.49$ for Meenachil basin, and
$n = 1.74$; $nk = 4.35$ and $G_g = 0.82$ for Achencoil basin.

Table 6.1.2.3 gives the summary of results as applied to Meenachil basin and that of Achencoil basin. **Fig. 6.1.2.5** provides a comparison of pulse responses of the LPM derived by ordinary least squares and under the gamma form for the Meenachil basin and that of Achencoil basin is furnished in **Fig. 6.1.2.6.**

6.1.2.3 Coastal Waters

Waste Water Discharges : At present there is no point source of effluent discharge into the coastal waters. The effluents from industries and towns are discharged directly into the backwater system. Most of these discharges are in the upstream area of the backwaters. According to KSPCB, the estimate of industrial effluents discharged into the backwaters is about 53,000 m^3/day. The estimated total effluent discharged into the backwaters including industrial and municipal waste is about 1,04,000 m^3/day.

Coastal Water Quality : Water quality data was collected during two lean periods of February and October. Based on these data, water quality of the coastal waters is found to be within the prescribed standards for various designated uses. Details are given in **Section 3.3.4.**

Hydraulic Data : Current measurements were carried out during March and December. Data on currents during March has been used for simulation, the details of which are given in **Section 3.3.4.1.**

6.1.2.3.1 Methodology for Estimation of Assimilative Capacity

A two-dimensional hydrodynamic model was used to simulate the tides, currents, DO and BOD off Kochi for estimation of assimilative capacity of the region. The model provides a transient solution for shallow water bodies and it can accommodate irregular coastline, complex bathymetry and open boundaries. This model has been widely used for studying transport of pollutants and thermal plumes in coastal waters.

6.1.2.3.2 Salient Features of the Model

- 2D vertically integrated shallow water momentum equations
- Finite difference method for solutions
- Square grid of 500 m
- Time dependent

The 2D vertically integrated shallow water momentum balance equations for a cartesian co-ordinate system with x-axis and y-axis directed eastward and northward respectively and the z-axis positive downward, are used in the model for simulation of tides and velocity fields. The governing equations are discretized, by integrating them over each element in the grid, using an integration method known as Nodal Point Integration. Solutions for variables at each node are obtained using matrix solvers such as alternating direction implicit (ADI) or successive over-relaxation (SOR) method. The ADI method solves the set of algebraic equations in three sweeps along X, Y and Z co-ordinates. For each sweep only the values at the grid node in that direction are computed at an advanced time step, taking other values from the previous time step. The SOR method employs an explicit scheme in which there is only one unknown parameter per equation. The equation then can be solved for a new value at each node.

6.1.2.3.3 Model domain and Bathymetry

The model domain has been selected with a southern boundary lying along 9'15'N and the northern boundary along 10°2' N. The maximum depth in the model domain is 35 m, which forms the western boundary. The eastern boundary of the domain is kept along the coastline where the depth is around 0 m. The depth values are digitized from the bathymetry chart of the region east of 76° 22.2' E. In order to carry out simulation, the domain of the region has been divided into 112 x 64 elements with a grid size of 500 m equally along the X and Y directions, thereby keeping a distance of 20 km offshore and 50 km along the coast.

6.1.2.3.4 Model Parameters

The currents measured during March 1999 have been used to represent the transition period with very slow current speed. The zonal (U) and meridional (V) components of the currents were derived from the measured currents and included in the model to provide boundary conditions along the open boundaries.

The wind speed and direction are also given as input. The temperature flux at the surface is given as input based on the measured data. The frictional stress at the bottom of the basin is computed using the near bottom current velocity and a constant friction coefficient. Water level variations at the open boundaries are either given from the measured values or taken from the predicted tides in the Tide Table.

The southern, western and northern boundaries are kept as open boundaries and the current component and tides are supplied here as initial and boundary conditions.

The initial and boundary values of U, V and η, given as basic input parameters are selected from the resolved components of observed currents and Tide Tables respectively. The bottom friction (τ_b) is computed from the measured near bottom current velocity. The maximum permissible time step yielding a stable solution is given by $\Delta t \leq \Delta x/c$ where, Δx is space step and c is wave celerity. In shallow water, $c = \sqrt{gH}$. This time step Δt is important for transient flows, as long waves propagate across a grid interval of length Δx in time Δt. For explicit schemes like SOR, the time step used must not exceed the value obtained by the above equation.

6.1.2.3.5 Model Calibration

Calibration of the model has been carried out using the measured currents and tides. The measured currents during March 1999 exhibit tidal oscillation between the southeastward and northwestward direction. The U component varied between -0.16 and 0.18 m/s and the V-component between -0.15 and 0.16 m/s. The simulated currents also showed U and V values in the same range. Mostly the currents are parallel to the coast flowing in a northward or southward direction depending on the tide.

6.1.2.3.6 Modeling Scenarios

Modeling scenarios were developed for varying pollution loads for two locations of outfall at depths of 10 m and 20 m in the model domain using the simulated currents and tides. Pollution load has been taken as point source and considered as continuous discharge. The reaeration coefficient, deoxygenation coefficient, BOD decay rate and saturation concentration of dissolved oxygen are estimated using measured values of temperature, salinity and currents based on the standard methods given in Thomann and Mueller (1987).

The model runs were carried out by keeping the ambient level of BOD at 3 mg/L and DO at 4.5 mg/L based on measured values. BOD of the effluents was taken as 30 mg/L. The concentration of DO has been analyzed for various quantities of effluent load varying between 10 and 50 m^3/s with BOD as 30 mg/L to obtain the horizontal spread and concentration of BOD.

Model runs were carried out for a period of 42 hours. Maximum values of DO and BOD at the two outfall locations are given in **Tables 6.1.2.4.** Variations in DO and BOD with time for different quantities of effluents at the outfall location at 10 m depth are given in **Figs. 6.1.2.7 and 6.1.2.8**. Variation in DO and BOD with time for various effluent quantities at the outfall point at 20 m depth is given in **Figs. 6.1.2.9 and 6.1.2.10**. Horizontal spread of the plume and BOD concentration after 24 hours for the outfall location at 10 m depth and 20 m depth for a discharge rate of 10 m^3/sec are given in **Figs. 6.1.2.11** and **6.1.2.12** respectively

Variation in BOD with distance from the outfall location at 10 m depth is given in **Fig. 6.1.2.13**. Ambient level of BOD at 3 mg/L is attained at a distance of 2 km after 24 hours of discharge of the effluent at the rate of 10 m^3/s (8,64,000 m^3/day) with BOD loading of 30 mg/L. Thus the total BOD load is 25,920 kg/day. The water quality standard for various designated uses prescribed in IS 7967-1976 for coastal waters after receiving any effluent discharge is 5 mg/L of BOD_5. The maximum level of BOD attained at the outfall point at 10 m depth is about 4.5 mg/L. Therefore, the assimilative capacity of the coastal waters off Kochi can be estimated as 25,920 kg/day for the hydrographic conditions during the month of March.

At present there is no point source of effluent discharge into the coastal waters. The effluents resulting from industries and municipal waste are discharged into the backwater system. According to KSPCB, the estimate of industrial effluent discharged into the backwaters is about 53,000 m^3/day with an average BOD loading of about 43 mg/l. The estimated total effluent discharged into the backwaters including industrial and municipal waste is about 1,04,000 m^3/day. Assuming BOD load as 50 mg/l, the total BOD loading is about 5,200 kg/day. The estimated assimilative capacity is about 25,920 kg/day. This indicates that the effluent presently discharged into the backwater system, if discharged at 10 m depth in the coastal waters can be easily assimilated. Further it is also found that at 20 m depth, the assimilative capacity is greater than that at 10 m depth. This indicates that the assimilative capacity increases with distance from the coast.

It may be noted that uncertainties due to several factors including indeterminacy exist in the estimation of assimilative capacity. Hence, it is suggested to limit the assimilative capacity as 50% of the estimated value at present for the purpose of any waste load allocation.

6.1.2.4 Determination of Limiting and Controlling Ecological Factors for Predicting Benthic Abundance

Regression models for predicting benthic abundance based on the parameters temperature, Salinity, DO BOD, NO_2-N, NO_3-N, NH_4-N, PO_4-P & Silicate has been worked out using the method given under section 4.3.2. Average distribution, variation in the distribution and coefficient of variation of the parameters given above along with their correlation coefficient with total benthic abundance are presented in **Table 6.1.2.5.**

The prediction regression equations based on the selected parameters, temperature (X1), salinity (X2), DO (X_3), NO_2-N (X_4) and NH_4-N (X_5), for predicting benthic abundance is

$$Y= -0.1070-0.5157\ X_1-0.3064\ X_2-0.3904\ X_3-0.01471\ X_4-0.1789\ X_5 + 1.0246\ X_1 X_2-0.4604\ X_1 X_3 + 0.4118\ X_1 X_4 + 1.0044\ X_1 X_5-0.4353\ X_2 X_3-0.1176\ X_2 X_4-0.0222\ X_2 X_5-1.2401\ X_3 X_4-0.0070\ X_3 X_5 + 0.0429\ X_4 X_5.$$

The model parameters are graded based on their relative importance **Table 6.1.2.6** as follows

(DO^*NO_2-N) > (T*Sal) > (T*NH_4-N) > Temp > (T*DO) > (Sal*DO) > (T*NO_2- N) > DO > Sal > NH_4-N > (Sal*NO_2-N) > (NO2-N*NH_4-N)> (Sal*NH_4-N) > (NO_2-N) > (DO*NH_4-N).

This model indicated about 38% of the variability in the distribution of benthos. Calculated value of F statistic is, $F_{(15,34)} = 3.0023$ and it is significant at 5% level of significance.

In this case ($DO*NO_2$-N) is the most important limiting factor, which implies that decomposition of particulate organic carbon from detritus will be increasing and this on the other hand will increase the bacterial carbon. (T*Sal) being a controlling factor it means that density of water is the corresponding physical parameter to be considered in the prediction of benthic production. Since BOD and its interaction effect with any other parameter is found to be not an important factor in the prediction of benthic abundance, it can be stated that in the study area the pollution level is within the tolerable limits as far as benthic distribution is concerned.

Table 6.1.2.1

Water Quality Status of River Pamba

Station/ Parameter	Value of Sample Collected in November 1999							
	15th	16th	17th	18th	19th	20th	21st	22nd
Thriveni								
pH	6.9	7.0	7.0	7.1	7.0	7.0	7.0	7.0
DO	7.8	8.1	7.9	6.9	7.3	7.9	7.4	7.6
BOD	0.4	0.8	1.1	0.3	0.6	-	-	-
Total Coliforms	4700	8800	14000	22000	7700	16200	22000	-
Colour	10	10	10	10	10	10	10	15
Nadappalam								
pH	6.9	7.0	7.0	7.0	7.0	7.0	7.0	7.0
DO	7.9	7.9	7.3	6.8	7.0	7.7	7.4	7.6
BOD	1.0	1.0	1.4	1.3	0.8	-	-	-
Total Coliforms	5200	9500	18500	25500	8500	18500	23000	-
Colour	10	10	10	10	10	10	10	10
Near Ganapathy Temple								
pH	6.9	6.9	6.9	7.0	7.0	7.0	7.0	7.0
DO	8.0	7.8	7.2	6.8	7.0	7.5	7.3	7.4
BOD	0.9	1.1	0.9	1.2	1.0	-	-	-
Total Coliforms	6800	14000	25000	35000	14000	80000	32000	-
Colour	-	10	10	10	10	10	10	15
Con. Njunanagar								
pH	6.9	7.0	6.9	7.0	7.0	7.9	7.0	7.0
DO	7.6	7.8	7.0	6.6	6.8	7.3	7.1	7.5
BOD	1.1	1.5	0.8	1.5	0.9	-	-	-
Total Coliforms	7800	9200	24200	28500	23000	30000	19000	-
Colour	10	10	15	15	10	15	15	20
Intake	1700	NIL	100	1200	1500	5400	300	-

T. Coliforms (No./100 ml), Colour (hazen unit), DO & BOD (mg/L), Intake (TC/100ml)

Source: Secondary/Primary data collected by CWRDM/KSPCB

Table 6.1.2.2

Summary of Results of LPM - Non-parametric Form

Period	Memory (days)	Initial Variance per unit time	Residual Variance per unit time	Model Efficiency R^2 (%)
Meenachil Basin				
Calibration	15	124.60	28.45	80.60
Verification	15	132.80	39.82	76.12
Achencoil Basin				
Calibration	20	116.28	26.02	81.69
Verification	20	122.34	38.32	78.43

Table 6.1.2.3

Summary of Results of LPM – Parametric Form

Period	Memory (days)	Initial variance per unit time	Residual Variance per unit time	Model Efficiency R^2 (%)
Meenachil Basin				
Calibration	15	124.60	30.84	78.21
Verification	15	132.80	43.28	73.24
Achencoil Basin				
Calibration	20	116.28	28.84	77.28
Verification	20	122.34	42.54	73.42

Table 6.1.2.4

Maximum value of DO and BOD at the Outfall Point

Unit : mg/L

Effluent Quantity (m^3/s)	At 10m depth		At 20m depth	
	DO (max)	BOD (max)	DO (max)	BOD (max)
10	4.2	4.5	4.4	3.7
20	4.0	6.0	4.3	4.5
30	3.7	7.2	4.1	5.2
40	3.5	8.6	3.9	6.0
50	3.3	9.8	3.8	6.6

Table 6.1.2.5

Summary of Statistical Parameter for Benthic Abundance: Coastal Waters

Parameters	Average	Standard Deviation	Coefficient of Variation	Correlation with Benthos
Benthic				
Temperature (T)	29.015	1.7293	5.9601	0.0330
Salinity (S)	32.803	1.0764	3.2814	0.1407
Diss.Oxygen (DO)	3.1946	0.5197	16.2670	-0.1394
BOD	1.4344	0.9089	63.3671	-0.0306
NO_2-N	0.4508	0.2751	61.0279	0.1983
NO_3-N	2.2456	1.6501	73.4828	0.1535
NH_4-N	2.0014	5.4551	272.5658	-0.1974
PO_2-P	0.9218	0.5567	60.3899	0.2423
Silicate (Sil)	6.4450	2.5825	40.0694	0.0678

Table 6.1.2.6

The Relative Importance and Significance of Regression Coefficients

Parameters	Relative Importance	*t*- Statistic
DO* NO_2-N	-1.2401	-3.8531
T*Sal	1.0246	3.8025
T* NH_4-N	1.0044	2.5540
Temperature	-0.5157	-1.9661
T*DO	-0.4604	-1.4392
Sal* DO	-0.4353	-0.9614
T* NO_2-N	0.4118	1.1303
Dissolved oxygen	-0.3904	-2.6112
Salinity	-0.3064	-1.4329
NH_4-N	-0.1790	-0.7061
Sal* NH_4-N	-0.0222	-0.1754
NO_2-N	-0.0147	-0.0862
DO* NH_4-N	-0.0069	-0.0332

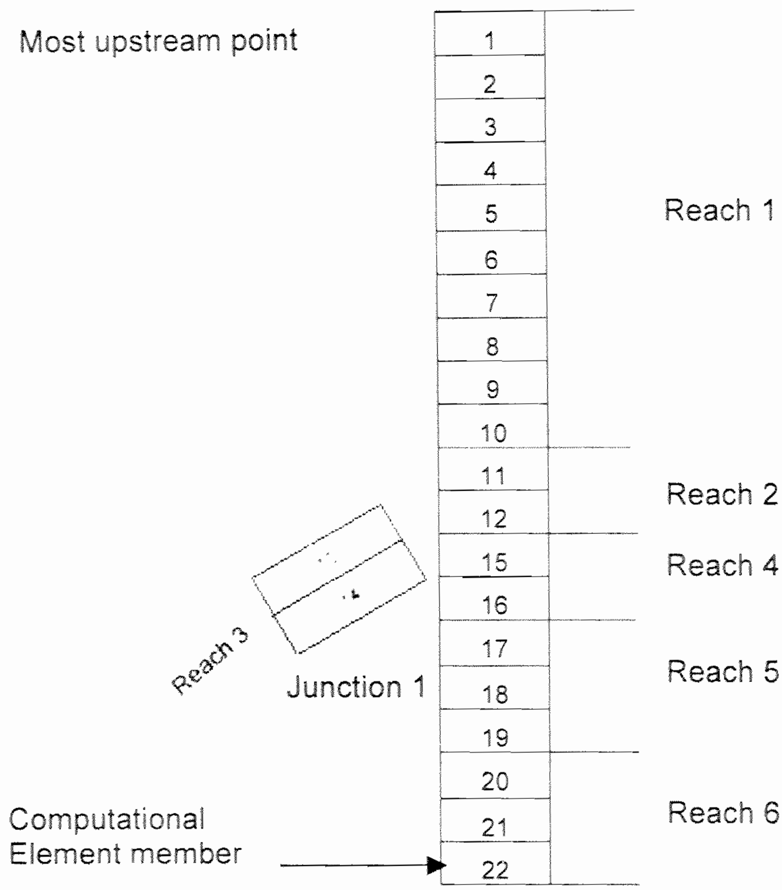


Fig. 6.1.2.1 : Stream Network with Computational Elements and Reaches

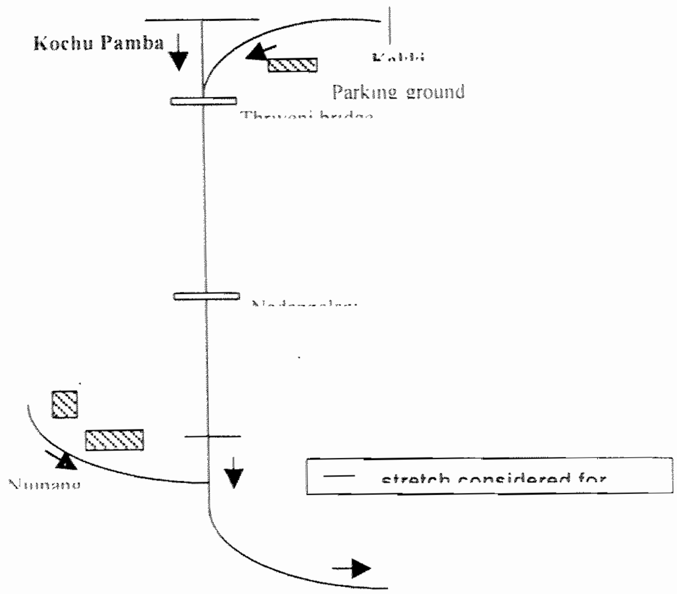


Fig. 6.1.2.2 : Layout of Pamba River at Thriveni

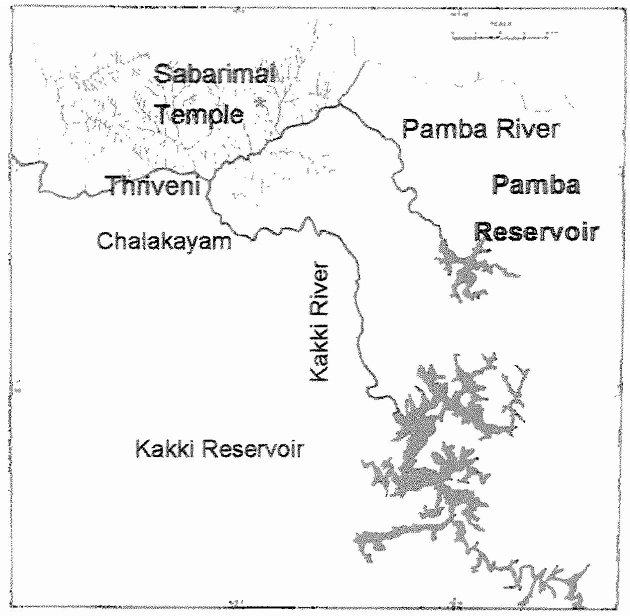


Fig. 6.1.2.3 : Stretch of River Pamba Considered for Modeling

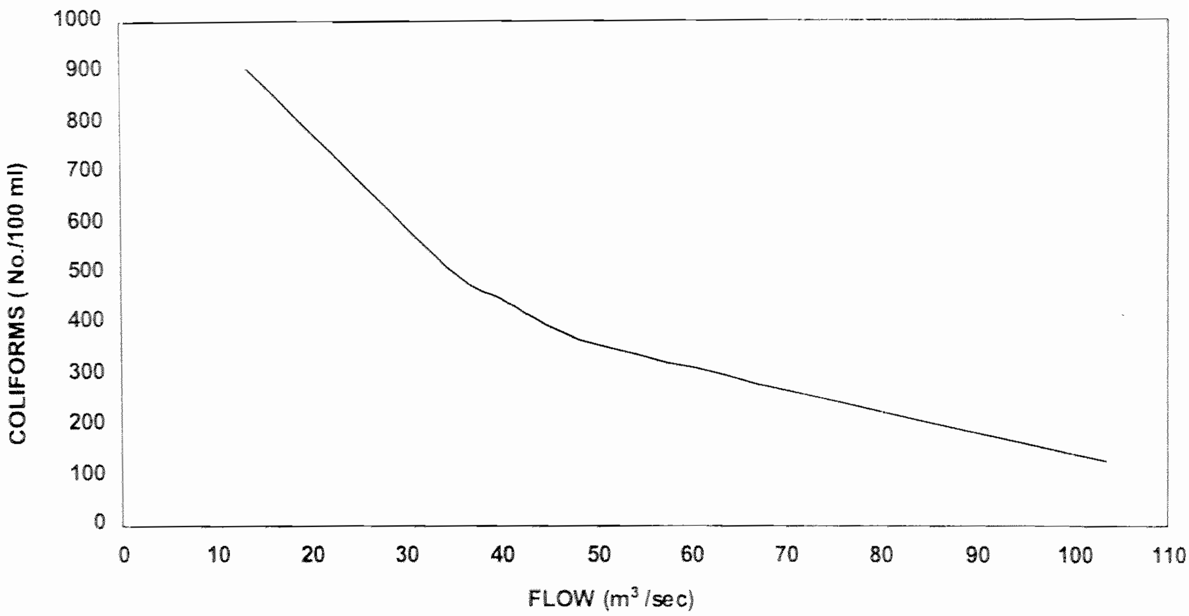


Fig. 6.1.2.4 : Variation in Coliforms with Flow

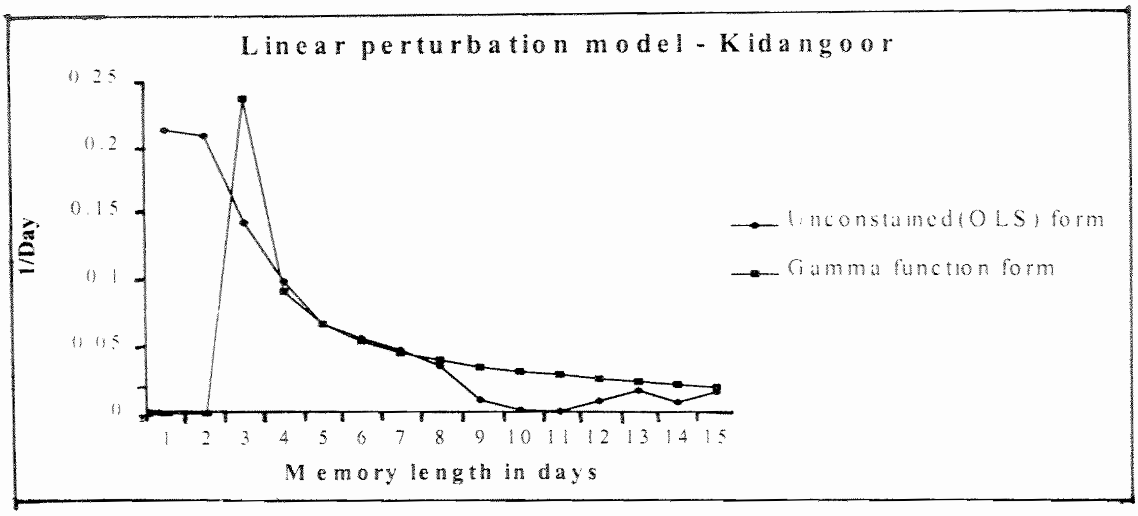


Fig. 6.1.2.5 : Comparison of the Pulse Responses of the Non-Parametric Linear Perturbation Model – Meenachil Basin

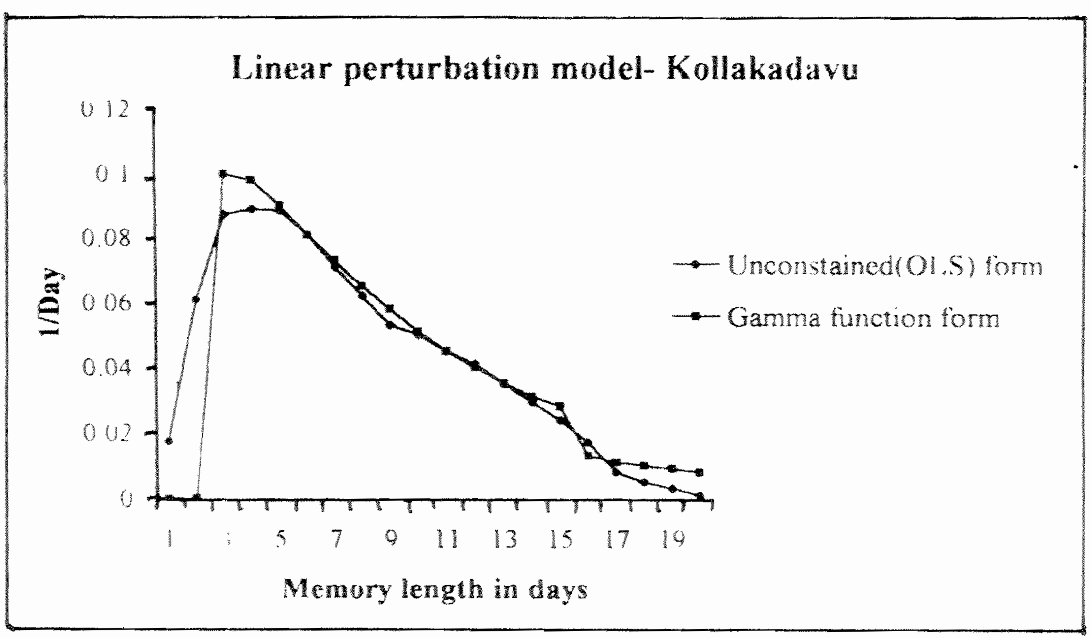


Fig. 6.1.2.6 : Comparison of the Pulse Responses of the Non-Parametric Linear Perturbation Model – Achencoil Basin

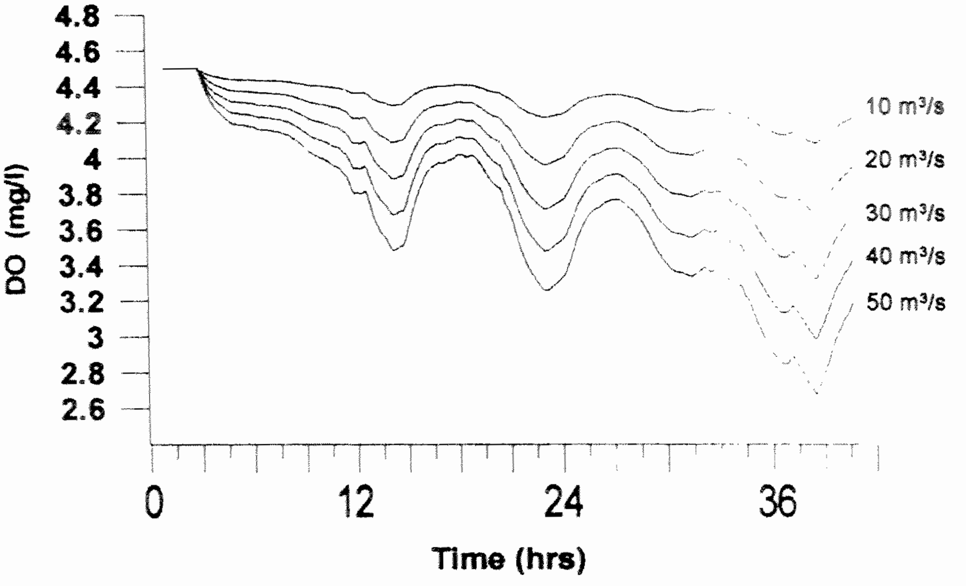


Fig.6.1.2.7 : Concentration of DO at the Outfall for Varying Effluent Quantities (Ambient DO = 4.5 mg/l, Depth of Outfall = 10m)

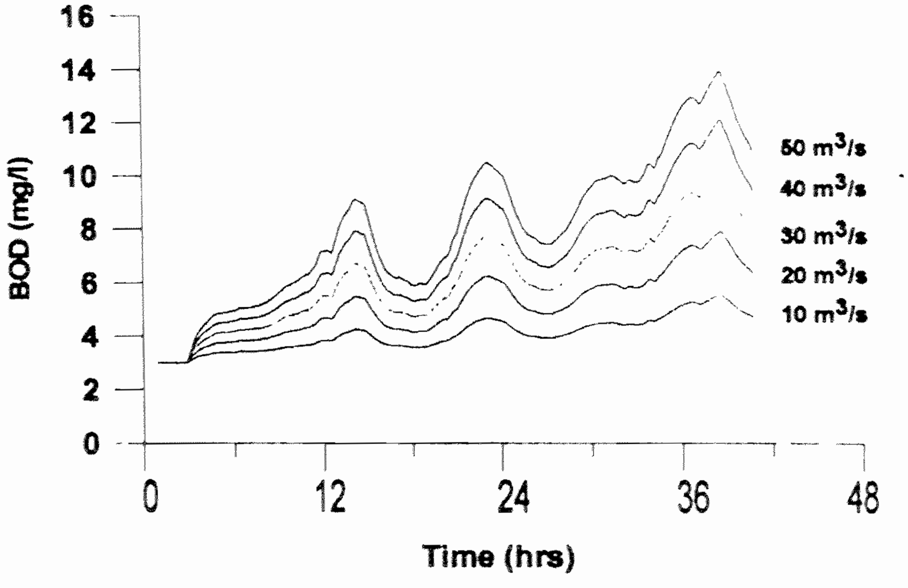


Fig.6.1.2.8 : Concentration of BOD at the Outfall for Varying Effluent Quantities (Effluent BOD = 30 mg/l, Depth of Outfall = 10m)

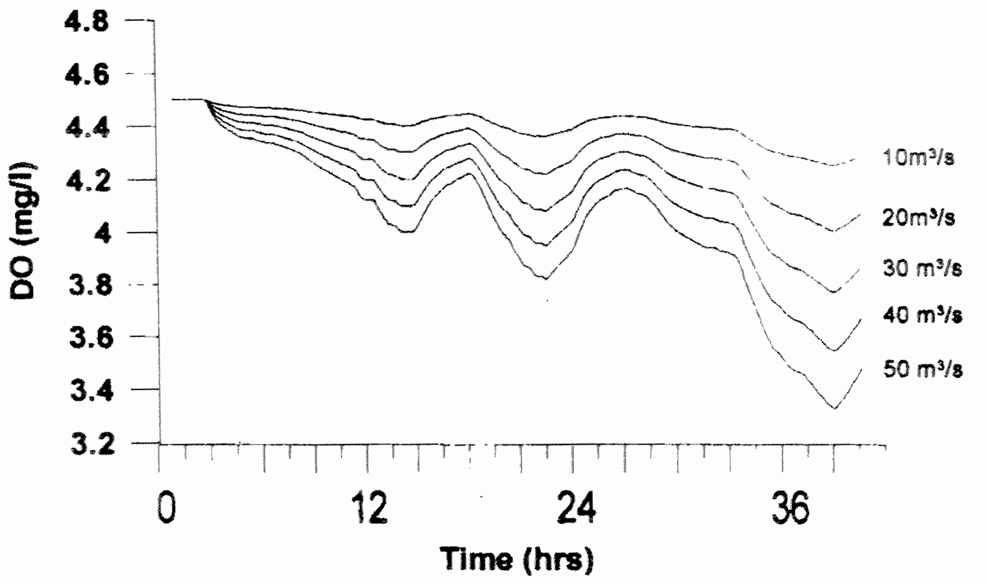


Fig.6.1.2.9 : Concentration of DO at the Outfall for Varying Effluent Quantities (Ambient DO = 4.5 mg/l, Depth of Outfall = 20m)

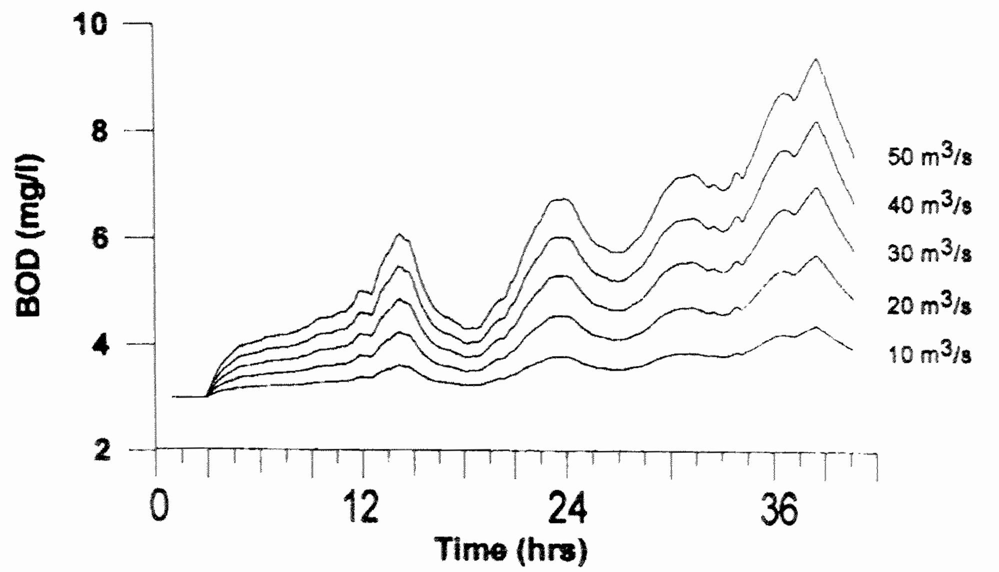


Fig.6.1.2.10 : Concentration of BOD at the Outfall for Varying Effluent Quantities (Effluent BOD = 30 mg/l, Depth of Outfall = 20m)

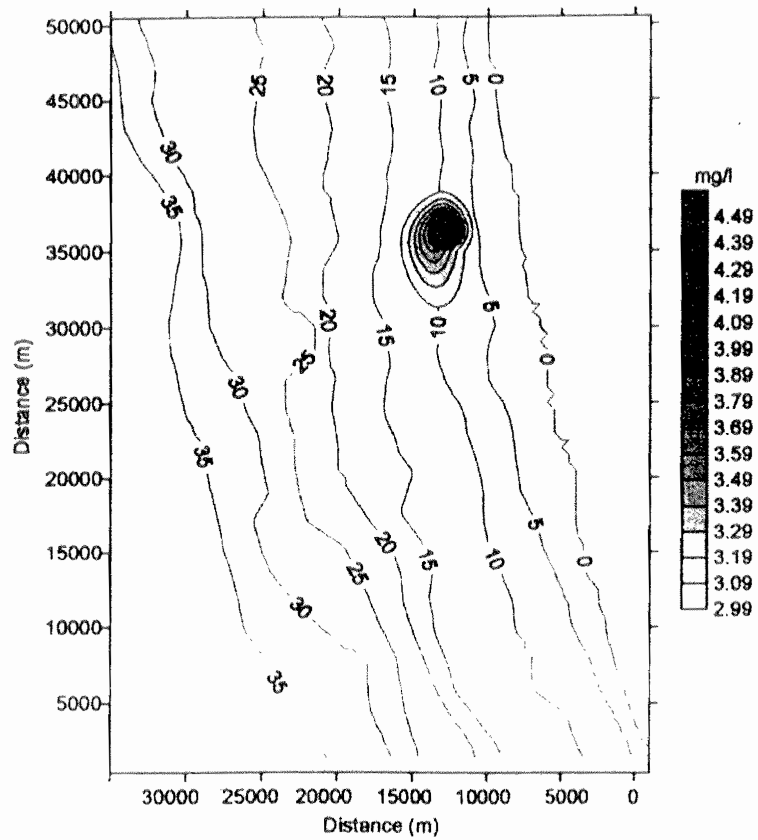


Fig.6.1.2.11 : Distribution of BOD (mg/l) after 24 hrs of Discharge of $10m^3/s$ (Outfall Depth = 10m, Outfall BOD = 30mg/l)

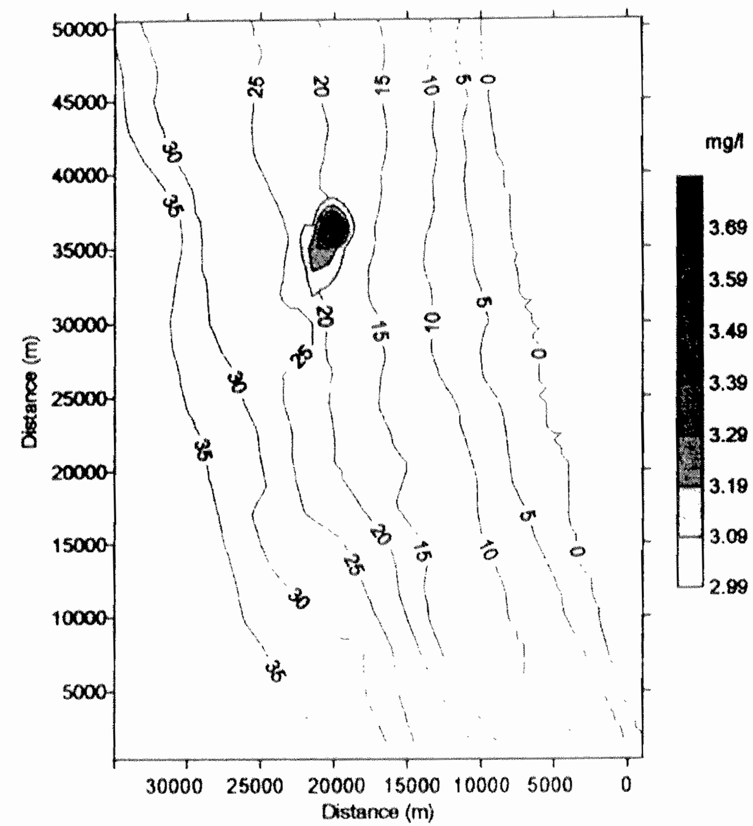


Fig.6.1.2.12 : Distribution of BOD (mg/l) after 24 hrs of Discharge of $10m^3/s$ (Outfall Depth = 20m, Outfall BOD = 30mg/l)

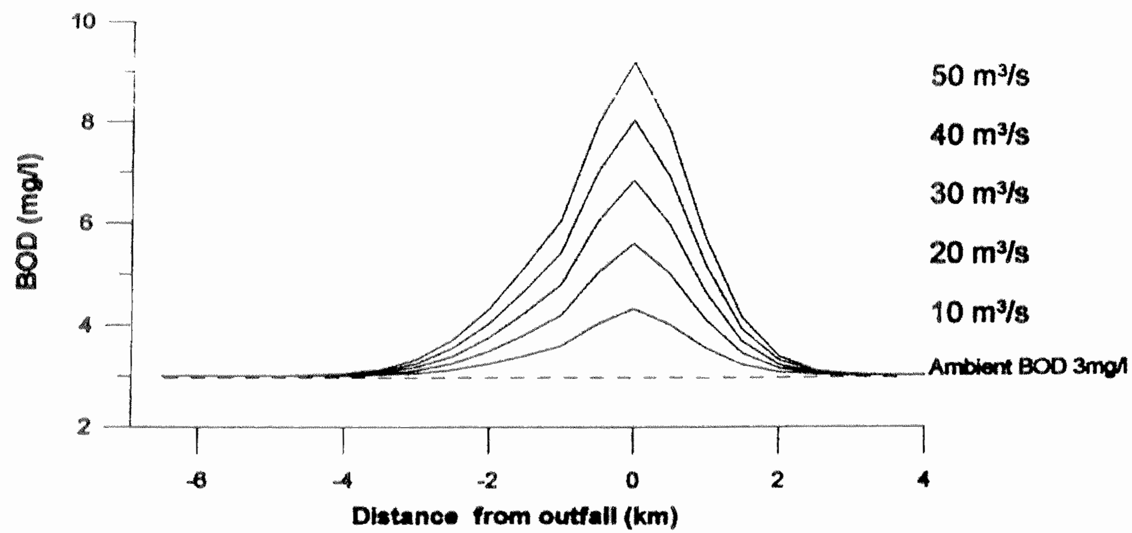


Fig.6.1.2.13 : Distribution of BOD (mg/l) after 24 hrs of Discharge (Effluent BOD = 30 mg/l)

6.1.3 Assimilative Capacity of Biological Environment

6.1.3.1 Assimilative Capacity of Terrestrial Ecosystem

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

The Eloor industrial belt is recognized as a critically polluted area in the study region. There are seven large industrial units, causing significant air pollution. Details on the emission of sulphur dioxide (kg/day) are given in **Table 6.1.3.1.** Studies on the isolines of SO_2 reveal that the most affected regions are Eloor, Varapuzha, Cheranelloor and its surroundings. Green peace investigation report also has identified this region as the toxic hot spot.

6.1.3.1.1 Homesteads as Sink for Pollutants

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

168 households were surveyed in the three Panchayat regions. Trees grown in the homesteads, its density and diversity were studied. Total area of land under homesteads surveyed was 42.63 acres of which 25 acres were from Eloor of 81 households, 6.09 acres from Cheranelloor of 27 homesteads and 11.45 acres from Varapuzha of 60 households. A total number of 58 species were recorded in the region of which 44 represented Eloor. Average size of land holding was 0.25 acres per household with an average of 141 trees per acre. Tree density is high in Varapuzha from a mean landholding of 0.19 acres/household followed by Eloor with 135 trees per acre from a mean land holding of 0.31 (acre/household). The details are summarized in **Table 6.1.3.2.**

In the homesteads of Eloor and Varapuzha, arecanut is most dominant, followed by coconut. Among the 58 species found in the homesteads, coconut, arecanut, plantains, mango and jack were the common assemblages. Density of these species is given in **Table 6.1.3.3.**

6.1.3.1.2 Sink Potential of Species in the Homesteads

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

Stomatal density per mm^2 of the leaf on lower epidermis for each species collected from the study site and from a control (KFRI campus) was compared (**Table 6.1.3.4**). For arecanut and coconut, stomatal density was lower in the polluted sites and for plantain and jack the stomatal density was higher. Among the dominant trees of the homesteads, mango and jack could be an effective potential sink for pollutants. Certain tree species have been recommended for greenbelt with reference to its sink potential based on stomatal density.

Certain plant species with respect to their stomatal density in the leaf is listed in **Table 6.1.3.5** for green belt with reference to its sink potential. Tree species with highest stomatal density among the selected species were *Castanospermum australe*, an exotic tree and *Mangifera indica*.

6.1.3.2 Assimilative Capacity of Aquatic Biology

Determination of Limiting and Controlling Ecological Factors for Predicting Zooplankton Abundance : Coastal Waters

A regression model for predicting total zooplankton abundance in relation to the physico-chemical parameters like temperature, salinity, DO, BOD, NO_2-N, NO_3-N, NH_4-N, PO_4-P and SiO_4 and their first order interaction effects was fitted using the method of least squares. The explained variability has been adopted as the criterion for selecting the best model. The relative importance of the parameters is used as the criterion for deleting the least important factors. Based on these two criteria the equation of the model has been selected and the grading of the input parameters are worked out. Various input parameters, their average values, spatial variation and the correlation of the input parameters with total zooplankton abundance are given in **Table 6.1.3.6.**

The fitted regression equation based on 6 parameters, temperature (X_1), Salinity (X_2), BOD (X_3), NH_4-N (X_4), PO_4-P (X_5), SiO_4 (X_6) and their f interaction effects is

$$Y = 0.5238 - 0.9928 X_1 + 0.5707 X_2 - 0.1613 X_3 + 0.7636 X_4 + 0.8454 X_5 + 0.0954 X_1 X_2 + 0.6604 X_1 X_3 + 0.6681 X_1 X_4 - 2.1916 X_1 X_5 - 0.3211 X_1 X_6 + 0.7794 X_2 X_3 - 0.3042 X_2 X_4 + 1.2171 X_2 X_5 - 0.5201 X_2 X_6 + 0.1829 X_3 X_4 - 1.6005 X_3 X_5 - 0.1831 X_4 X_5 + 1.0203 X_4 X_6 + 1.1862 X_5 X_6$$

Explained variability = 69.93%
Calculated value of F statistic, $F_{(21,31)} = 6.7586$

The model parameters are graded based on their relative importance **(Table 6.1.3.7)** as follows:

(T*PO_4-P) > (BOD*PO_4-P) > (Sal*PO_4-P) > (PO_4-P*SiO_4) > (NH_4-N* SiO_4) > Temp > (PO_4 .P) > (Sal*BOD) > (NH_4N) > (T*NH_4N) > (T*BOD) > (Sal) > (Sal* SiO_4) > (T* SiO_4) > (BOD* SiO_4) > (Sal*NH_4-N) > (SiO_4) > (NH4-N*PO_4-P) > BOD > (T*Sal)

The model equation states that interaction effects are more important than single factor effects particularly (T*PO_4-P), (BOD*PO_4-P) and temperature are found to be most important model parameters. They are also most important limiting factors. The first factor indicates that food consumption rate and assimilation of nitrogen by zooplankton community are the important factors and these are controlled by PO_4-P limitation. Also (PO_4-P*SiO_4) is found to be a controlling factor indicating that nutrient re-mineralization by zooplankton community is an important ecological parameter controlling the zooplankton abundance.

Table 6.1.3.1

Details of Industrial Stacks in Eloor Industrial Area

Name of industry	SO_2 Discharge (Kg/day)	Stack Height (m)	Stack Diameter at Exit (m)	Stack Velocity (m/s)	Temp at Exit (°C)
Source I					
Travancore Cochin Chemicals	1987	15.0	1.10	3.00	250
	3974	25.0	1.20	2.50	300
	1987	25.0	0.40	9.00	200
Hindustan Organic Chemicals	322	39.0	1.45	6.50	130
	322	51.0	1.85	11.50	275
FACT (Udyog Mandal)	9936	75.0	2.50	1.00	65
	13478	25.0	1.22	1.07	200
	5530	16.6	1.22	1.07	200
Hindustan Insecticides	5616	12.2	0.78	3.50	180
Indian Rare Earths	816	18.0	0.77	3.13	132
Cominco Binani Zinc Ltd.	201517	40.0	0.80	3.85	400
ASCL Caprolactam	1656	90.0	3.35	5.54	150
	48	30.0	0.36	8.64	343
Source II					
FACT (Ambalamughal)	14005	65.0	1.80	8.60	65
	2634	105.0	--	8.58	185
	1946	39.0	2.75	16.89	45
	4980	33.4	1.85	11.35	55
Carbon and Chemicals	2901	40.0	2.70	12.00	450
Cochin Refineries	802	45.0	1.25	7.13	300
	1777	60.0	1.55	6.42	235
	395	21.0	1.44	9.67	240
	447	32.0	2.21	8.17	272
	584	80.0	--	--	--

Table 6.1.3.2

Details of Homesteads Around the Eloor Industrial Complex

Place	Total Number of Homesteads Surveyed	Total Area Surveyed (Acres)	Total Number of Tree Species	Average Size Of Land Holding (Acres)	Number of Individuals/ Acre
Eloor	81	25.09	44	0.31	135
Cheranellur	27	6.09	33	0.23	100
Varapuzha	60	11.45	25	0.19	188
Total	**168**	**42.63**	**58**	**0.25**	**141**

Table 6.1.3.3

Density of the Most Dominant Tree Species in the Homesteads

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

Table 6.1.3.4

Stomatal Density in Leaf of Dominant Species in the Homesteads

Species	Stomatal Density (per mm^2)	
	Control	Polluted
Arecanut	214	182
Coconut	172	143
Plantain	168	179
Mango	626	--
Jack	299	360

Table 6.1.3.5

Assimilative Capacity of Plants and Plants Recommended for Green Belt with Reference to its Sink Potential

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

Table 6.1.3.6

Summary of Statistical Parameter for Zooplankton Abundance: Coastal Waters

Parameters	Average	Standard Deviation	Coefficient of Variation	Correlation with Zooplankton
X1-Temperature (T)	28.9425	1.7104	5.9096	0.0625
X2-Salinity (S)	32.8126	1.0651	3.2460	0.6190
X3- DO	3.2360	0.5351	16.5364	0.2500
X4-BOD	1.4521	0.8931	61.5051	0.0770
X5-NO_2-N	0.4411	0.2733	61.9590	-0.0388
X6-NO_3-N	2.3049	1.6542	71.7682	0.1925
X7-NH_4-N	1.9392	5.3143	274.0415	-0.1517
X8-PO_4-P	0.9096	0.5462	60.0415	0.1424
X9-SiO_4	6.4443	2.6877	41.7065	0.1496
Mean of log values of Zooplankton	**4.6967**			

Source: Primary data collected by NIO

Table 6.1.3.7

Relative Importance and Significance of Regression Coefficients

Parameters	Relative Importance	*t*- Statistic
DO* NO_2-N	-1.2401	-3.8531
T*Sal	1.0246	3.8025
T* NH_4-N	1.0044	2.5540
Temperature	-0.5157	-1.9661
T*DO	-0.4604	-1.4392
Sal* DO	-0.4353	-0.9614
T* NO_2-N	0.4118	1.1303
Dissolved oxygen	-0.3904	-2.6112
Salinity	-0.3064	-1.4329
NH_4-N	-0.1790	-0.7061
Sal* NH_4-N	-0.0222	-0.1754
NO_2-N	-0.0147	-0.0862
DO* NH_4-N	-0.0069	-0.0332

6.2 Estimation of Supportive Capacity – Indicators and Limiting Factors

6.2.1 Natural Resources

6.2.2 Transformational Resources

6.2.3 Distributive Resources

6.2.4 Socioeconomic Resources

Chapter VII

Business As-Usual Scenario

7.0 BUSINESS AS-USUAL SCENARIO

In order to preserve the fast depleting natural resource base and improve environmental quality, delineation of sustainable development plan for the region is a basic prerequisite. The need for exploring alternative development growth scenarios (environmentally compatible) can be justified by its comparison with a scenario, which is known as Business - As - Usual scenario (BAU). BAU involves forecasting of future consequences in terms of the demand on resource base and pollutant emissions if the present activities are continued without any special additional effort to conserve the resource base and protect environmental quality. Population and industrial growth rate trends, if extrapolated will give an idea about increase in food grain requirements, agricultural land and water requirement, wastewater generation, and land degradation etc. The increase in demand on resource base and increase in waste generation resulting in environmental degradation under BAU scenario is discussed in this chapter.

7.1 Population Growth

The population projection methodology for the Kerala State adopted by the Centre for Development Studies, Trivandrum has been made use of for the estimation of the projected population for all panchayats, municipalities and the corporation of Kochi falling within the study area. The projection technique takes into account the Crude Death Rate (5.9 per 1000 population), Neonatal Mortality (10 per 1000 live births), Post-Neonatal Mortality (3 per 1000 live births), Infant Mortality Rate (13 per 1000 live births), Total Fertility Rate (1.7 children per women), Gross Reproductive Rate (0.08 number of daughters per women), Crude Birth Rate (16.6 per 1000) and the Expectation of Life at Birth (**Table 7.1.1**). The assumed migration rate of 0.25 is kept constant throughout the projection period.

Using tables of population projections made for the State, projected population values for each district have been arrived at using the ratio method. Projected value of population of a particular district is obtained by dividing the population value of the district for the base year by that of Kerala State and multiplying the same by the projected value of the population of Kerala State. The formula used is:

$$P_{(y+5)}D = (P_y D / P_y K) \times P_{(y+5)} K$$

where,

D = District name, y = year , K=Kerala

$P_{(y+5)}D$ = Population of $(y+5)^{th}$ year for district D

$P_y D$= Population of y^{th} year for the D district

$P_y K$ = Population of y^{th} year for Kerala State

$P_{(y+5)} K$ = Population of $(y+5)^{th}$ year for Kerala State

The population value for each panchayat is calculated using proportion method. Projected value of population of a particular panchayat is obtained by multiplying the proportion value of that panchayat by the projected value of the corresponding district. This proportion value is obtained by dividing population value of the panchayat by that of the corresponding district value. The formula used is:

$$P_{y+5}\, i = r_j \times P_{y+5}\, D$$

where,

$r_i = P_y\, i \,/\, P_y\, D$

r_i = proportion for i^{th} panchayat

$P_y\, i$ = Population of i^{th} panchayat for y^{th} year

$P_y\, D$ = Population of corresponding district for y^{th} year

$P_{y+5}\, i$ = Population of i^{th} panchayat for $(y+5)^{th}$ year

$P_{y+5}\, D$ = population of corresponding district for $(y+5)^{th}$ year

Projected population totals and density of population for each panchayat are calculated for 1991-96, 1996-2001, 2001-2006, 2006-2011, 2011-2016, 2016-2021 and 2021-2026.

7.1.1 Trends of Population Growth

The cumulative growth of population (i.e., incremental growth in population during a unit period added to the total population) figures for the period 1981-2026 show an increase in total population in the study area but at a declining rate (**Table 7.1.2 and Fig. 7.1.1**).

The slope of the cumulative and the marginal population growth curves (marginal population growth is the incremental population growth during a unit period of time) clearly indicate a declining population growth trend in the study area. A district-wise breakup of the above figure is given in the **Tables 7.1.3 & 7.1.4** and **Figs. 7.1.2 & 7.1.3**. The curves showing marginal growth in density indicate that the population growth has lost much of its momentum and the study area will attain Zero Population Growth (ZPG) during the period 2026-2036. Moreover, it is possible that the area may have short periods of negative growth rates. This observation is very much in conformity with the statement that "Kerala is likely to achieve Zero Population growth (ZPG) in 25-30 years".

7.1.2 Population Trend – Concerns

The achievement of below replacement of fertility two decades ahead of the all- India target year of 2011, declining mortality rate, improvement in the expectation of life at birth and low birth rate and its social and economic consequences need detailed study for the preparation of future plans for human resource management. One way in which demographic trend affects socio-economic conditions is through changes in the age composition of the population. The changes in the proportion of children in Kerala's population, the proportion of working age population and the proportion of elderly population are important parameters having far reaching consequences.

A dramatic decline in the number of children is expected in the study region. The expected decline in the school age population will influence educational planning, the requirement of classrooms, teachers etc. Repercussions of the decline in child population will be adversely felt in many economic activities catering to the needs of children such as garment making, toy making, health care etc. **Table 7.1.5** gives the projected values of school age population for Kerala State and **Fig. 7.1.4** provide graphic representation for the same.

However, the unemployment problem due to demographic pressure may not disappear for quite some time. At the current rate, it is only after 2021 that we may expect a decline in the number of persons in the working age group. The increase in the working age group at a declining rate will be felt immediately. Therefore, the unemployment among the young may greatly ease in the coming years. But an increase in the old age population will be a major challenge for providing suitable employment for the older people in the immediate future. An increase in the number of " young old-" (60-74) and "old-old" (75 years and more) in the coming years necessitates improvements in medical facilities to combat old age diseases, need for more social security, assistance schemes etc. **Table 7.1.6** shows the projected values for the "young-old" and the "old-old" population during 1991- 2026. **Fig. 7.1.5** clearly indicates the expected sharp increase in the population of this group of Kerala's population.

7.1.3 Population Growth and Settlement Planning

The density of population and its growth over the past three decades and the projected population values up to 2026 for the urban centres indicate two major trends. They are Kochi - based and Kottayam - based (**Figs. 7.1.6 & 7.1.7**). The movement of population in the Kochi growth centre over the decades clearly indicate a north east growth direction with more concentration towards north. The Kottayam region is showing an east-south-east movement of population with more growth in density in the southern zone. This region will experience a high demand for land for settlement and hence needs immediate attention for a proper settlement planning.

High rate of growth of population is recorded in the northeast part of Idukki district, north of Idukki dam and township. Panchayats like Alakkode (148.60%),Vazhathope (139.96%), Bisonvally (00000000067.89%), Marayoor (64.87%), Udumbanchola (64.38%), Vattavada (54.61%), Kanthalloor (51.04%), Rajakumari (48.36%), Kuttampuzha (46.11%), Vellathooval (45.94%), Nedumkandam (45.85%), Kattappana (45.20%), Mannamkandam (45.04%), and Santhanpara (43.97%) are expecting very high growth of population by 2026. The corresponding increase in human settlements is a matter of concern when the fragility of the ecosystem is considered and their susceptibility to landslide hazard (**Figs. 7.1.8 & 7.1.9**)

The Alappuzha region is almost stagnant in terms of population growth, barring the region adjoining the border of the Greater Kochi Development Authority. However, the increase in population and settlements, though marginal, in the Kuttanad region of Alappuzha and Kottayam districts need immediate attention and advanced planning.

Table 7.1.1

Expectation of Life at Birth

Years

Period	Male	Female
1991-1996	73.43	79.43
1996-2001	74.47	80.47
2001-2006	75.20	81.20
2006-2011	75.78	81.78
2011-2016	76.29	82.29
2016-2021	76.74	82.74
2021-2026	77.15	83.15

Source : Data estimated by CESS

Table 7.1.2

Growth in Density of Population in the GKR

Growth	Growth in Density (%) during							
	1981-91	**1991-96**	**1996-01**	**2001-06**	**1906-11**	**2011-16**	**2016-21**	**2021-26**
Cumulative	9.83	15.53	21.68	27.38	32.3	36.19	39.1	40.98
Marginal	9.83	5.7	6.15	5.7	4.92	3.89	2.91	1.81

Source : Data estimated by CESS

Table 7.1.3

District wise Cumulative Growth in Density of Population (1981-2026)

Districts	Cumulative Growth in Density of Population during							
	1981-91	**1991-96**	**1996-01**	**2001-06**	**2006-11**	**2011-16**	**2016-21**	**2021-26**
Ernakulam	10.76	17.03	23.53	29.35	34.23	37.96	40.78	42.57
Kottayam	8.50	14.84	21.61	27.87	33.18	37.56	41.18	43.85
Alappuzha	7.31	13.41	19.77	25.66	30.89	35.30	38.95	41.80
Idukki	12.04	17.19	22.53	27.26	30.90	33.19	34.28	34.22
Pathanam-thitta	9.79	16.21	23.36	30.25	36.57	42.11	46.79	50.37
Thrissur	10.60	14.52	19.30	23.88	28.04	31.02	32.61	33.09

Source : Data estimated by CESS

Table 7.1.4

District wise Marginal Growth in Density of Population (1991-2026)

Districts	Marginal Growth in Study of Population during						
	1991-96	1996-01	1901-06	2006-11	2011-16	2016-21	2021-26
Ernakulam	6.27	6.5	5.82	4.88	3.73	2.82	1.79
Kottayam	6.34	6.77	6.26	5.31	4.38	3.62	2.67
Alappuzha	6.1	6.36	5.89	5.23	4.41	3.65	2.65
Idukki	5.15	5.34	4.73	3.64	2.29	1.09	-0.06
Pathanamthitta	6.42	7.15	6.89	6.32	5.54	4.68	3.58
Thrissur	3.92	4.78	4.58	4.16	2.98	1.59	0.48

Source : Data estimated by CESS

Table 7.1.5

Growth Trend of School Age Children in Kerala (1991-2026)

Age Group	Number of Children during the Year							
	1991	1996	2001	2006	2011	2016	2021	2026
0-4	2773770	2284932	2446869	2463120	2393159	2246981	2054644	1923392
5-9	3036045	2743081	2255899	2418065	2434680	2365100	2219216	2027174
10-14	3022820	3018597	2726516	2240088	2402425	2419276	2349884	2204188

Source : Data estimated by CESS

Table 7.1.6

Growth Trend of "Young-Old" and "Old-Old" Population in Kerala (1991-2026)

Age Group	Number of People during the Year							
	1991	1996	2001	2006	2011	2016	2021	2026
60-64	863548	912366	1003460	1157268	1411400	1717978	1956212	2336740
65-69	679445	800421	851446	941069	1089343	1333202	1628514	1860441
70-74	446583	600619	715935	767829	853969	993659	1222205	1500534
75+	559285	667734	871173	1097964	1287133	1485063	1734533	2093052

Source : Data estimated by CESS

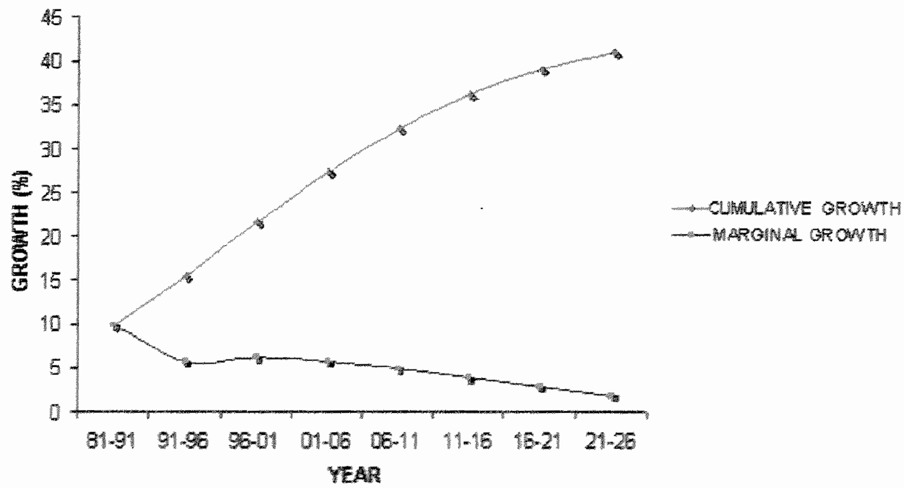


Fig. 7.1.1 : Growth Density

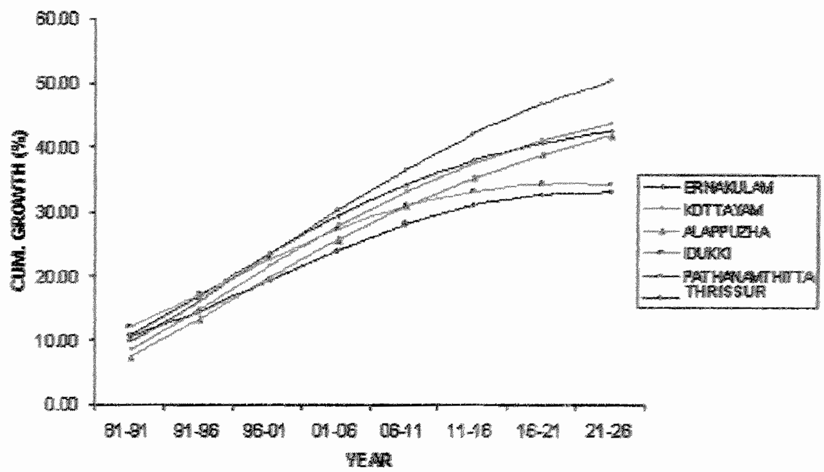


Fig. 7.1.2 : Cumulative Growth Density

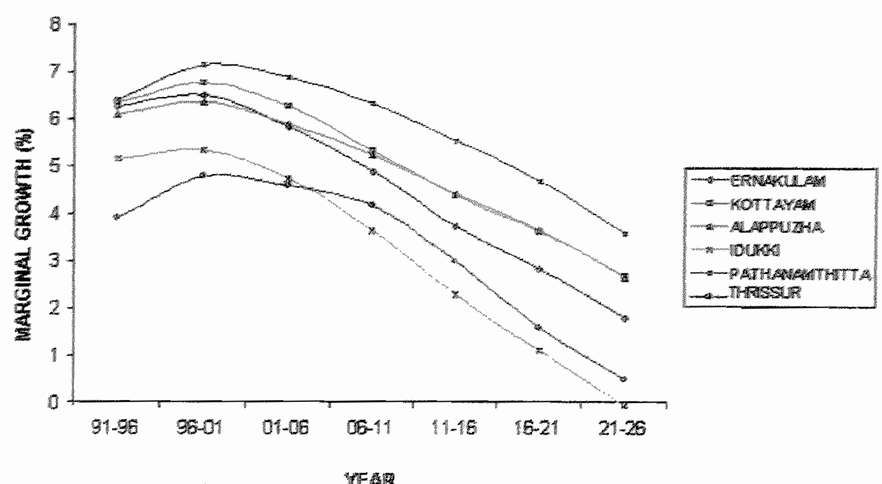


Fig. 7.1.3 : Marginal Growth Density

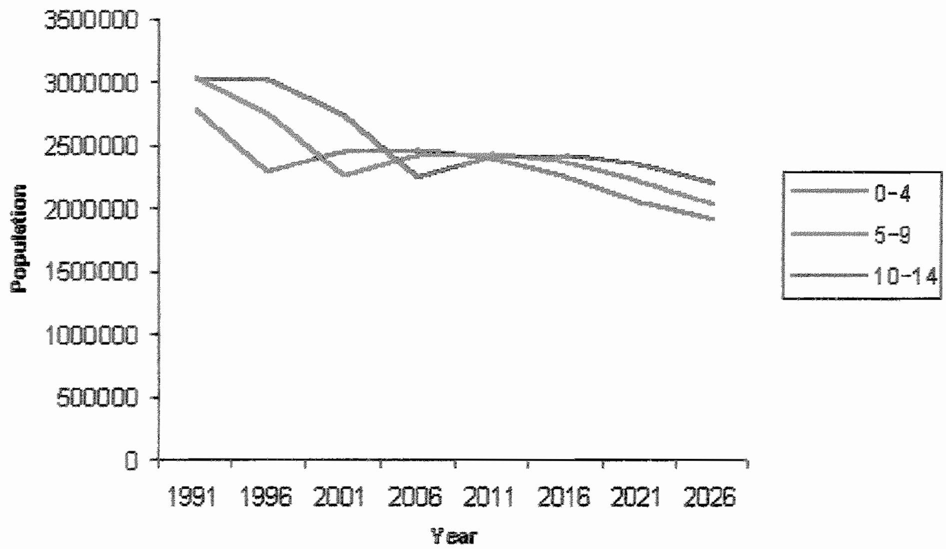


Fig. 7.1.4 : Growth Trend of School Age Population (1991-2026)

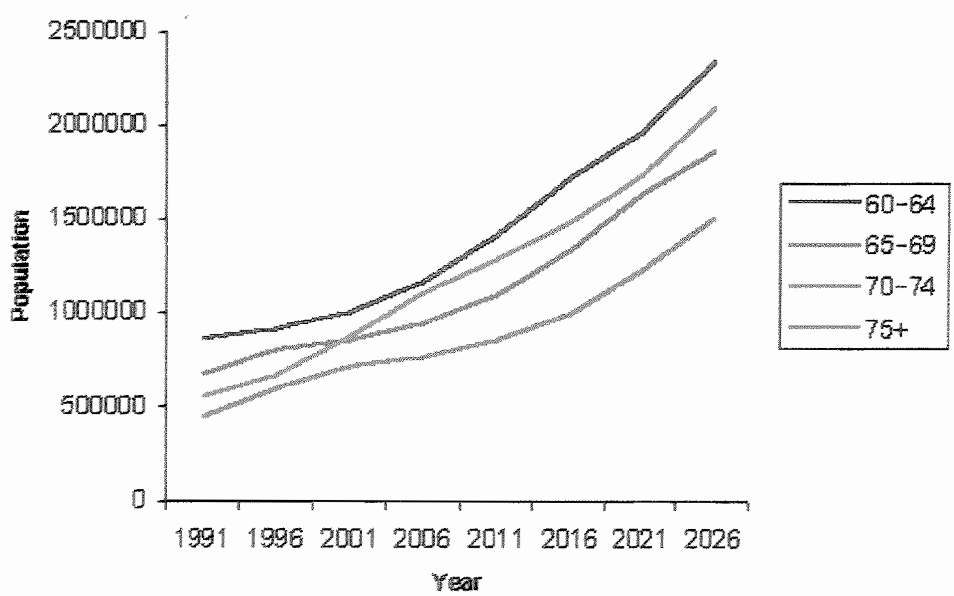


Fig. 7.1.5 : Growth Trend of "Young-Old" & "Old-Old" Population in Kerala (1991-2026)

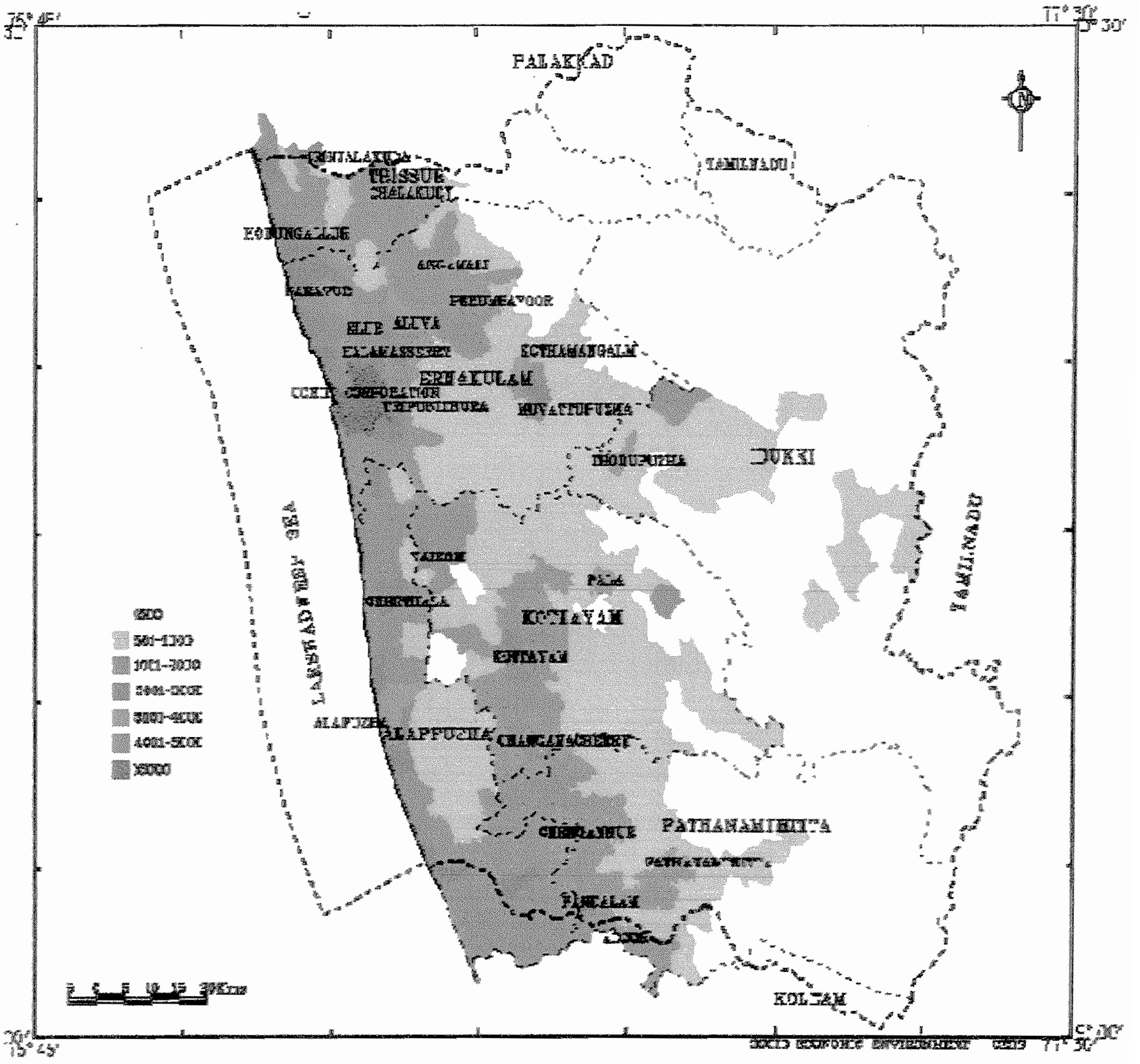


Fig. 7.1.6 : Present Density of Population in GKR

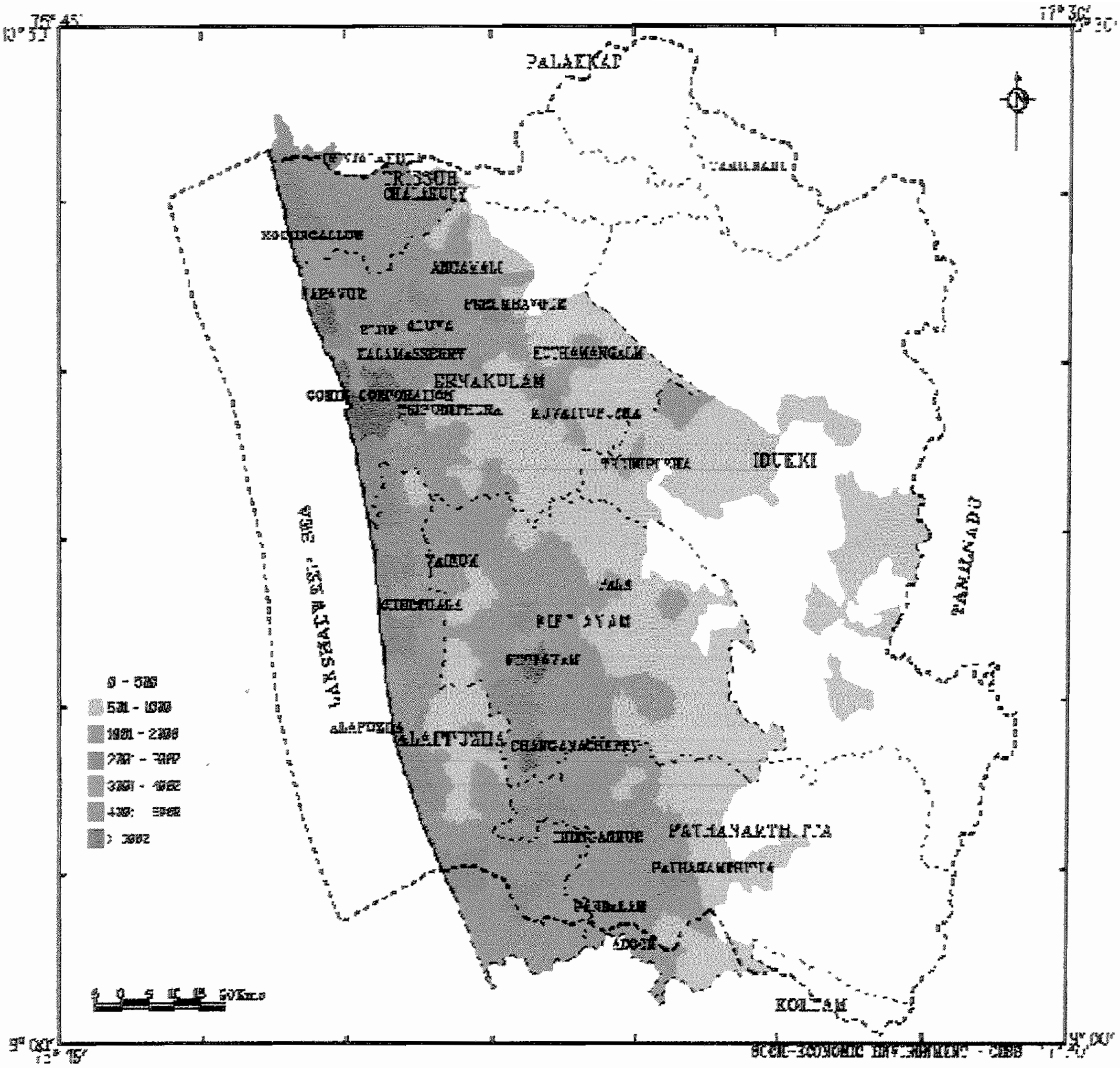


Fig. 7.1.7 : Projected Density of Population in GKR – 2026

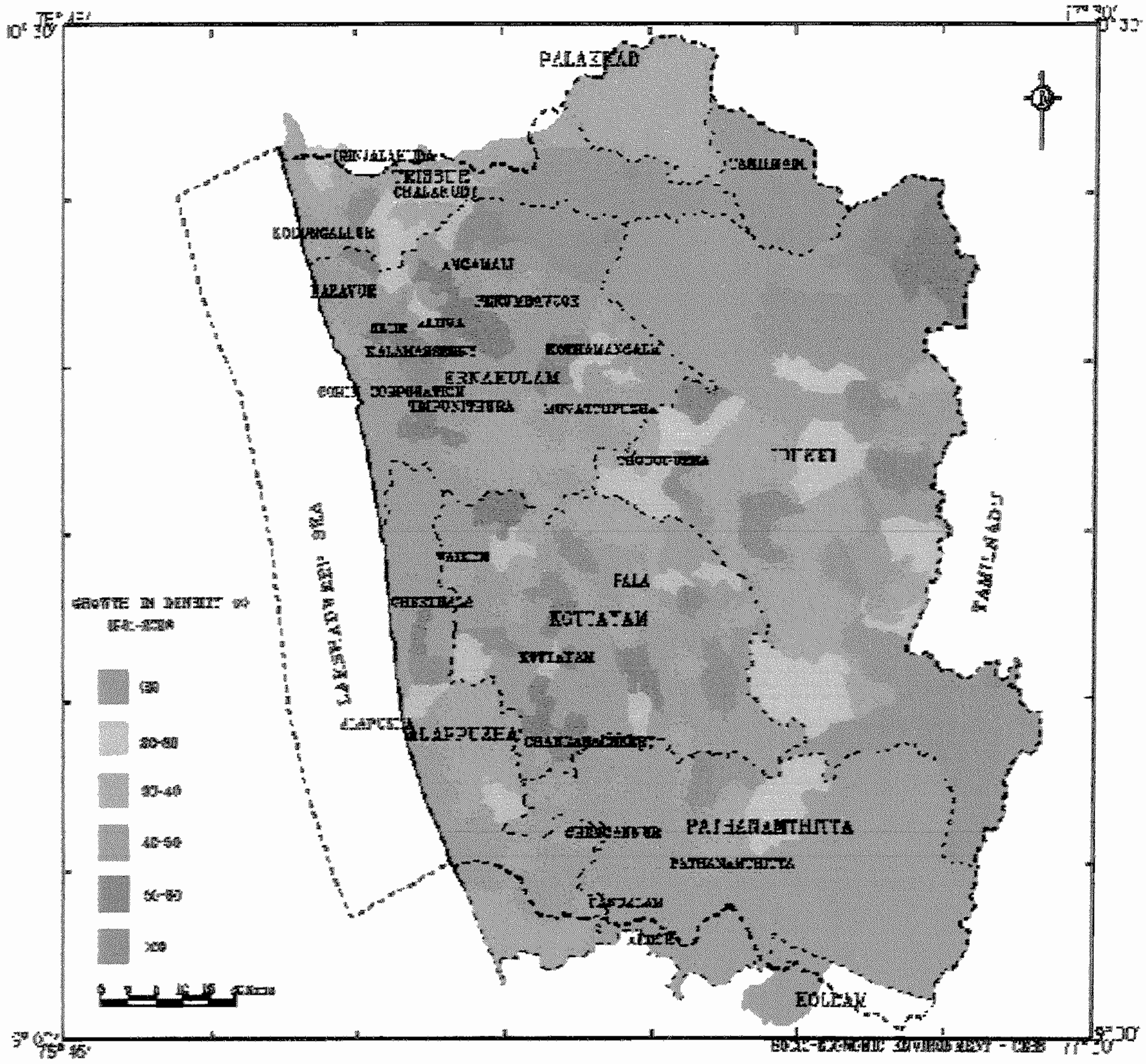


Fig. 7.1.8 : Projected Growth in Density – (1981-2026)

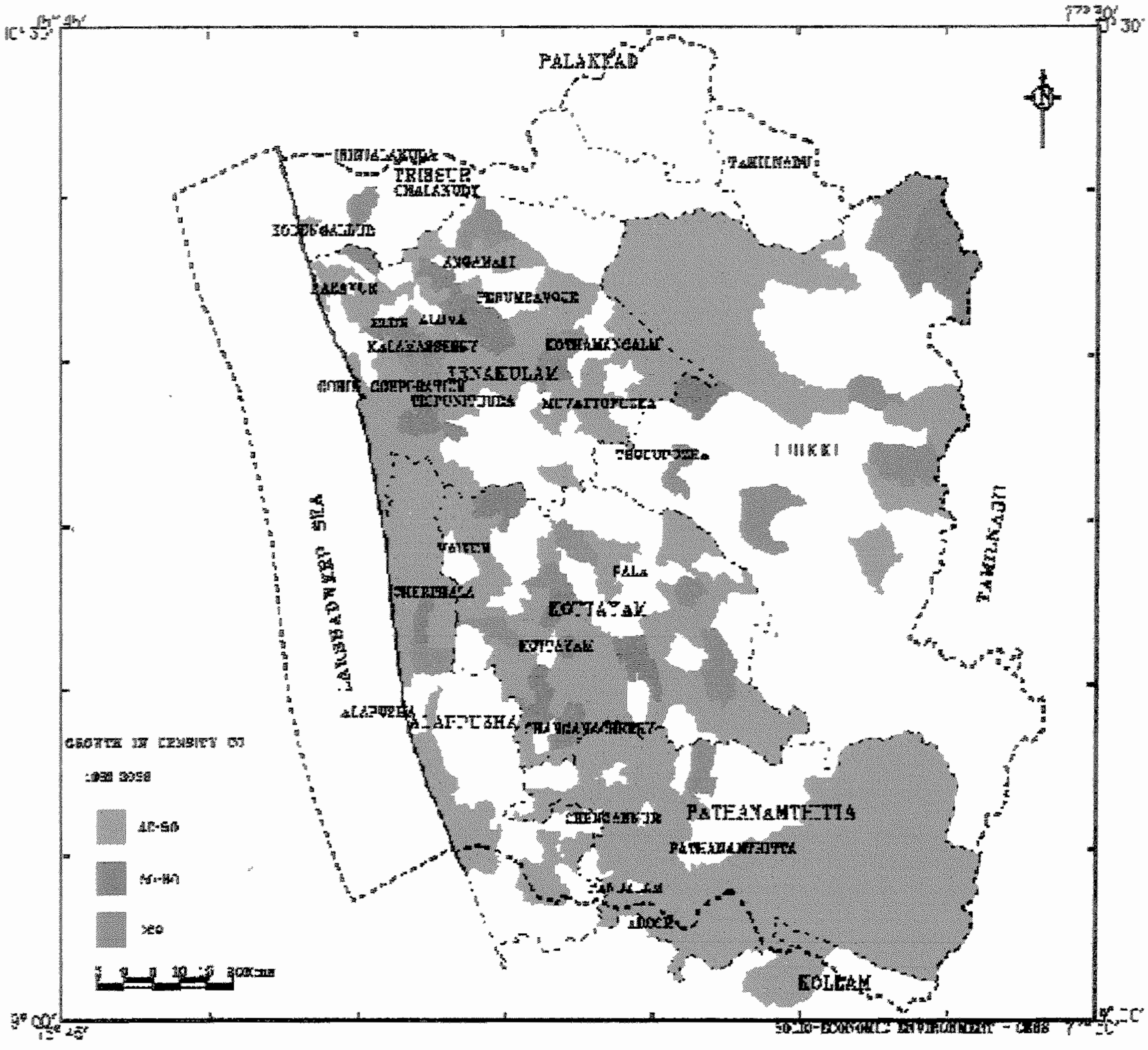


Fig. 7.1.9 : Projected Growth in Density (1961-2026) – 40% Growth Region

7.2 Water Demand

7.2.1 Domestic and Livestock Water Requirements

The domestic water requirements were calculated for each individual river basin considering the present population and the projected population of 2025 AD. In working out the water demand for domestic purposes 200 lpcd was taken. **Table 7.2.1** gives the water requirement for domestic purposes.

Based on the estimates of KWA, only 40% of the rural population in the area is at present provided with protected water supply. Based on a survey of CWRDM, almost 60% of the population in the urban areas is also provided with protected water supply. The National Water Policy of 1987 and the State Water Policy of 1992 clearly state that all the existing and future reservoirs both irrigation and hydel should have drinking water supply component. As far as Kerala is concerned, in addition to the Aruvikkara and Peppara reservoirs, which were built for water supply alone, only Malampuzha and Peechi have drinking water component, i.e., only 4 out of the more than 30 reservoirs. None of the reservoirs in the study area has this component. Perhaps, the cheapest, best and the only long-term solution to meeting most of the domestic and industrial water needs in the future is to draw water from all existing and future reservoirs.

Table 7.2.2 presents the present and future (2025 AD) water requirements for the livestock population in the river basins; the figures recommended by Kerala Agricultural University (1997) have been adopted for computation of water demand.

7.2.2 Irrigation Water Requirement

Making use of the statistics on the area irrigated, an attempt was made to estimate the present utilization of water for irrigation purposes. Most of the minor irrigation projects in the midland and lowland cater to rice cultivation while only 50% of the projects in the highland cater to rice cultivation. It is assumed that 25% of the irrigation water already being utilized is available as return flow. The monthly ET0 values for different river basins with the existing cropping are furnished in **Table 7.2.3**. The crop coefficients for common crops (FAO, 1984; CWRDM, 1990) grown in this area are given in **Table 7.2.4**. Experience in this humid tropical region reveals that even a cropping system scientifically designed for this area will require much more water than what is estimated for the present cropping system (CWRDM, 1997). In a State like Kerala, the plantation/spice crops form the backbone of farming activity and therefore, not only rice crop but also these crops require irrigation facilities. Statistics on the year wise area under crops in Kerala shows that, in particular, rice cultivation is systematically decreasing while rubber cultivation is increasing. The present and future water requirements for irrigation are presented in **Table 7.2.5**.

7.2.3 Industrial Water Requirement

From the available information and through interaction with certain industries, a basin wise water demand for industries was arrived at. Even though the projection of industrial growth in this area could not be done based on an incremental increase method, it is assumed that the manufacturing sector may increase in size and output by around 300% in 25 years. In the present case, 300% increase rate is taken for the period ending in 2025 AD. This may be possible in the area, considering the possible coming up of infrastructural facilities like the major sea port at Kochi, intermediate port at Alappuzha and international airport at Nedumbassery as well as the development of coastal railway, doubling of the railway lines, electrification activities of the Indian Railways, development of National Highways, introduction of National Waterway No.3 etc.

The Government of Kerala has requested the assistance of the World Bank for the improvement of Inland Water Transport on three select feeder canals in the Vembanad Estuary. They are Alappuzha–Kottayam, Alappuzha–Changanassery and Kottayam–Vaikom. The Thermal Power Plant at Kayamkulam also will be a boon for the industrial growth in this area. The present economic policies of the Govt. of India and the initiatives of the NRIs of the State are expected to drastically change the industrial climate in the coming years. It is in this background projections have been made. Industrial water requirements of different river basins are furnished in **Table 7.2.6.**

7.2.4 Water Availability

7.2.4.1 Surface Water

The total surface water potential of each of the river basins was worked out based on the actual flow data from the downstream of the river basin. Considering the streamflow data from the highland and midland catchments, the surface water potential in these physiographic zones of each of the river basins was computed. Attempts were also made to understand the temporal distribution using flow duration curves.

Based on the criteria stipulated in Chapter 2, the utilizable surface water potential was estimated for different sub-basins of the river basins and also for the river basins as a whole; the method used for computing utilizable yield was as per the publication of PWD, Kerala (1974). The availability of utilizable surface water in different seasons was also worked out for different zones and for the basin as a whole.

7.2.4.2 Groundwater

The groundwater recharge, as estimated by CGWB, for different taluks of the river basins was adopted here. The utilizable groundwater potential was considered to be only 50% of the total recharge. Based on the surveys carried out by CWRDM in different physiographic zones, especially in the coastal zone, it is estimated that 20% of the recharge is already utilized for different purposes. However, in estimating the potential available for future use, the total present utilization has been deducted from the total utilizable surface and groundwater potential.

7.2.4.3 Return flows

Though irrigation is a consumptive use, it is assumed that 25% return flows are possible from the present major/medium and minor irrigation projects. These return flows from existing projects are reflected in the water potential. From the total surface water potential arrived at, the utilizable potential was estimated in space and time. The utilizable groundwater potential was also estimated for different sub-basins and physiographic zones.

7.2.5 Present Utilization

7.2.5.1 Domestic

According to the statistics available, 40% of the rural population and 75% of the urban population in the area are provided with protected water supply. This figure has been adopted for computing the present utilization for domestic purposes. At present, water supply of only 70 lpcd for the rural and 140 lpcd for the urban population are given. As a conservative estimate, 150 lpcd for the rural and 200 lpcd for the urban areas are taken for the purpose of estimating the present demand.

7.2.5.2 Irrigation

The area under irrigation through major/medium, minor, lift and petty works was available from Irrigation Department, Revenue Department, Department of Economics and Statistics and Department of Agriculture of Kerala (Farm Guide, 2000). CWRDM has also carried out a census of minor irrigation projects for the Government of India. The area covered by different crops in the command was also known. From these details, the present utilization of water for irrigation was estimated, considering the irrigation requirements of different crops.

7.2.5.3 Industrial requirements

The present utilization of water for industries was estimated based on the data collected from industries concerned, Kerala Water Authority, Pollution Control Board and from enquiries with similar other industrial houses.

7.2.5.4 Pilgrimage

Based on the statistics collected from different agencies, it is estimated that a minimum of around 25 million pilgrims visits Sabarimala in the Pamba river basin during post-monsoon period. Exact figures were not available. The total water requirement for this purpose was estimated, taking 150 lpcd for an average of 2.5 days' stay by a pilgrim in the Pamba basin.

7.2.5.5 Basin wise- Use of Wetland

The requirements of water for flushing out the conservative pollutants from the upper reaches of the Vembanad wetland to the mouth was estimated by using the approach of Stommel (1953). For a minimum flushing period of 20 days, the fresh water demand was estimated. Generally, 20-day period is considered to be high. Considering the strategic locations of the outlet points of Pamba river and the possibility of meeting part of the requirements from this river, this demand was added to the other demands of the Pamba river basin. The water for flushing has to reach the wetland in its upper reaches to serve the purpose efficiently. Since the flows in Pamba alone cannot meet the requirements, whatever flows available from other rivers also have to be utilized for the purpose of flushing, especially that from Achencoil which joins upstream of the wetland. The total fresh water requirement for bringing down the salinity levels to 2 ppt at Thanneermukkam barrage site was estimated to be 1658 Mm^3. For ecological reasons, it is desirable to keep the barrage open as much as possible; this has been also the recommendation of the Indo-Dutch Mission (1988). If sufficient flows are maintained for flushing, it will automatically take care of the salinity control also**(Table 7.2.7).**

7.2.6 Water Balance

Table 7.2.8 gives the basin wise annual water availability and demand. It is observed that all these seven river basins will face water deficit in due course; the quantum of deficit is also shown in table. The seasonal availability, demand and deficit/ surplus are furnished in **Table 7.2.9**.

Analysis of Plans for Forestry (KFRI)

Management Plan

Proposed Ninth Five Year plan for the forestry and wildlife sector with focus on action oriented programs in the study region is analyzed. The broad heads and its outlay during the year 1997-2002 are given in **Table 5.4.5.2**.

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

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

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

For the enhancement of efficient utilization of forest resources the outlay is one crore. Major tasks are to maximize production and efficient use of wood, Non Wood, alternate wood products and to introduce value added products for better economic returns. Strengthening Forest and Wildlife conservation has an outlay of 30 crores. This has an objective to develop and implement a comprehensive and integrated programme for improving forestry biodiversity conservation in the state for the posterity and for the sustainable ecological functions. The main operational and associated objective of the bio diversity conservation component of the activities, would be establishing an integrated state-wide strategy through strengthened capacity and increased opportunities for planning and management of the totality of habitats and eco systems within the Estate.

Protecting ecosystems with in wildlife sanctuaries and communication systems, environmental education upgrading amenities and interpretation programmes, training and capacity building for improved bio-diversity management and enforcement of laws for preventing poaching and illegal trade are the activities contemplated under the scheme. Besides development of wildlife sanctuaries and national parks, activities like, wildlife research, wildlife preservation, new sanctuaries and parks, watchers and guards among tribals etc. are also included under this broad category.

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

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

Strengthening of institutions is to bring substantial changes in the State's forest policy framework which of weaknesses such as market is now characterized by a number distortions, disincentives to good forest management, forest resources use etc. These reforms which, as whole, would create an enabling environment for the sector to grow and perform better in the future. The Plan should support institutional reforms by enabling KFD to concentrate its activities in three core areas identified (conserve the forest and its bio-diversity, provide forest products to local communities and industries and to improve livelihood of tribes and other poor people who live in and around the forest) instead of attempting to do everything in the forestry sector.

Other objectives are to encourage KFD progressively to share some of its present responsibilities and benefits by forming partnerships with local people, NGOs, private sector, panchayats and other suitable government agencies with a stake in forestry. To promote professionalism in KFD by encouraging specialization through international and external training of its staff and by bringing in experts on contract, in areas where it has limited or no expertise.

To streamline the working of KFD through a process of reorganization or redeployment of staff, delegation of managerial authority and accountability to lower levels and promoting career development. For this purpose, department is to review and propose changes to KFD's current functions, staff levels and skills, management structures, administrative procedure and coordination within the organization and with other government agencies.

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

82 NWFPs commercially exploited from this region have been marketed through Girijan Sahakaran Co-operative Societies (GSCS). 500 species providing NWFPs are found in Kerala forests (Nambiar *et al.*, 1985). There is an increasing demand for medicinal plants and plant products for industrial uses. Existing marketing mechanism is redundant and non enterprising. Fixing floor prices of these items, exploring the possibilities of value addition through semi processing has immense scope. There is a wider group of people, industries and end users outside the forest, dependent on these resources.

Hence sustainable extraction from forest, regulating yield, processed for value addition can generate higher income for the forest dwellers which might help in forest conservation through controlling the existing unscientific and unsustainable practices like over harvesting, early harvesting and destructive harvesting depleting the resource base. Strengthening of NWFP based institutions with the help of better marketing and income-generating opportunities can enhance social well being and ecosystem integrity.

A watershed based development approach involving soil and water conservation, rehabilitation of degraded forests through Assisted Natural Regeneration (ANR) along with reeds and bamboo, increasing the productivity of existing plantation forests is warranted in degraded areas of territorial divisions. The management of Protected Areas (PAs) has to be dealt with slightly different objectives. Maintenance of ecosystem integrity with conservation of biodiversity on one hand and maintenance of livelihood of forest dwellers depending on forests for subsistence on the other is a major challenge. Attempts to strike a balance has to initiate efforts for strengthening of institutions, enhancement of livelihood activities through linking biodiversity based micro enterprises.

The areas with in the region can be categorized according to the type of the proposed managerial inputs as territorial divisions, Protected Areas, and Periyar Tiger Reserve (PTR) (**Table 5.4.5.3**). Areas coming under the Territorial Divisions are forest tracts of Chalakudy, Vazhachal, Malayattoor, Munnar, Mankulam, Kothamanglam, Kottayam, Ranni, Konni and Achenkoil. Areas coming under Protected Area are Iddukki Wildlife Sanctuary, Thattekad bird Sanctuary and Eravikuiam National Park. In Periyar Tiger Reserve, under Eco-development Project of Global Environment Fund and International Development Agency, the action plan, which has initiated has a set of site specific objectives.

Table 7.2.1

Basin wise Annual Domestic Water Requirement

Basin	Present demand (Mm^3)	Demand in 2025 (Mm^3)
Chalakkudi	51.31	72.38
Periyar	247.33	349.40
Muvattupuzha	142.88	183.07
Meenachil	93.78	117.17
Manimala	61.83	87.35
Pamba	90.01	107.94
Achencoil	101.74	128.10
Total	**788.88**	**1045.41**

Source : Secondary data collected by CWRDM

Table 7.2.2

Basin wise Annual Water Requirement for Livestock

Basin	Present Demand (Mm^3)	Demand in 2025 (Mm^3)
Chalakkudi	3.36	5.10
Periyar	11.90	21.80
Muvattupuzha	6.53	7.48
Meenachil	4.69	6.06
Manimala	2.73	4.05
Pamba	4.86	6.70
Achencoil	4.99	7.74
Total	**39.06**	**58.93**

Source : Secondary data collected by CWRDM

Table 7.2.3

Monthly Et_0 Values for Different River Basins

Month → Basin ↓	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Chalakkudy	170	179	219	215	177	125	118	133	133	149	153	171
Periyar	177	181	245	218	178	119	124	137	133	152	149	172
Muvattu-puzha	159	128	162	160	162	148	149	153	150	148	143	152
Meenachil	201	211	245	224	194	132	135	148	156	168	152	168
Manimala	241	117	222	212	213	210	206	238	236	232	179	235
Pamba	203	195	195	166	162	121	136	148	135	191	183	212
Achencoil	256	196	230	217	187	169	167	182	179	189	179	204

Source : Secondary data collected by CWRDM

Table 7.2.4

Crop Coefficient (Kc) of Important Crops of the Region

Crop	Paddy	Coco-nut	Banana	Tapioca	Vege-tables	Sugar-cane	Tea	Coffee	Pulses	Cocoa	Carda-mom
Kc	0.95-1.15	0.75	0.40-0.85	0.40	1.00	0.55-1.05	1.00	0.90	1.00	1.00	1.00

Source : Secondary data collected by CWRDM

Table 7.2.5

Basin wise Annual Irrigation Water Requirement

River Basin	Present Utilization (Mm^3)	Demand in 2025 (Mm^3)
Chalakkudy	318	854
Periyar	1700	3525
Muvattupuzha	647	1196
Meenachil	436	875
Manimala	419	980
Pamba	945	1185
Achencoil	430	1175

Source : Secondary data collected by CWRDM

Table 7.2.6

Basin wise Annual Industrial Water Requirement

River Basin	Present Demand (Mm^3)	Demand in 2025 (Mm^3)
Chalakkudy	15	45
Periyar	250	750
Muvattupuzha	80	240
Meenachil	9	27
Manimala	5	15
Pamba	5	15
Achencoil	51	153
Total	**415**	**1245**

Source : Secondary data collected by CWRDM

Table 7.2.7

Daily discharge into Kochi Estuary (m^3/sec)

(Achencoil + Pamba + Manimala + Meenachil + Muvattupuzha)

Date	1995											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	153	154	131	136	217	305	2253	2043	2136	316	591	213
2	158	150	132	123	246	299	1860	1362	1928	286	896	218
3	159	142	124	133	268	2891	1366	993	1762	312	997	216
4	159	145	125	123	257	260	1035	787	1637	384	1053	200
5	159	136	125	140	312	250	834	1224	1502	392	991	199
6	163	136	125	139	419	254	860	1084	1550	378	1150	193
7	159	144	123	145	760	238	1174	1275	1885	486	937	202
8	154	135	126	139	840	252	1020	1272	1533	671	892	187
9	153	139	125	153	1639	251	1033	1132	1185	624	709	182
10	154	130	133	134	2240	293	1244	942	791	482	675	191
11	170	143	134	149	2693	391	1642	887	670	426	588	181
12	172	126	139	166	2107	622	2103	764	569	427	510	180
13	176	135	151	155	1537	1046	2061	664	447	393	562	178
14	175	135	150	150	1157	1471	1610	553	396	324	476	189
15	177	132	178	153	1884	1520	1234	492	404	297	495	207
16	162	132	167	191	764	2343	1137	417	654	266	437	227
17	164	133	166	194	637	2270	1203	443	1026	242	406	232
18	161	131	149	206	510	1652	998	592	919	258	406	242
19	162	126	161	207	552	1178	847	655	783	243	380	242
20	163	130	149	201	401	941	802	742	696	232	354	236
21	161	129	148	214	443	856	815	679	694	265	320	236
22	156	128	159	204	383	792	745	1020	839	432	306	225
23	159	131	155	186	332	700	724	1082	757	517	313	226
24	159	131	150	179	301	745	625	1211	663	355	306	221
25	147	123	138	207	265	570	860	1079	568	376	297	222
26	163	129	135	192	268	574	761	1279	480	350	257	223
27	148	129	141	188	263	713	707	1704	430	323	245	215
28	145	128	137	199	275	669	690	1958	406	332	230	213
29	136		147	218	364	800	1377	2144	359	396	216	207
30	132		144	213	402	1056	2475	1907	343	333	217	216
31	137		140		341		2731	2053		343		215
	1996											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	203	153	79	98	203	196	230	932	462	1036	241	232
2	204	155	75	75	245	180	195	721	429	831	226	225
3	210	138	80	91	213	188	192	616	453	640	235	234

Contd...

Table 7.2.7 Contd...

Date	1995											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4	212	141	68	93	203	197	175	538	459	527	268	225
5	209	141	66	106	187	195	166	456	472	439	293	220
6	206	136	97	110	170	200	166	442	515	382	266	221
7	206	142	86	99	161	187	171	452	652	332	239	232
8	197	142	90	110	157	174	210	411	578	303	221	235
9	197	127	91	106	131	176	234	360	540	462	219	249
10	200	122	100	132	144	198	506	349	478	639	224	239
11	199	118	98	109	145	257	676	358	467	702	225	243
12	198	110	101	109	148	277	576	506	595	675	228	232
13	194	118	102	105	148	342	577	1067	667	853	231	231
14	193	116	93	113	145	405	553	828	642	1322	261	253
15	180	110	85	126	108	681	508	923	584	1402	251	268
16	184	109	82	146	109	713	563	1211	599	1293	238	316
17	190	118	90	171	133	944	626	1165	614	1603	228	327
18	195	109	89	211	146	1218	625	1007	605	2261	219	292
19	198	106	82	165	154	1569	813	846	618	2365	218	278
20	195	119	86	194	150	1410	1526	680	605	1796	211	264
21	193	113	83	217	144	1425	2165	618	574	1173	222	249
22	188	107	66	212	143	1300	2000	611	589	959	221	244
23	181	110	65	180	145	1068	1801	732	577	852	221	229
24	184	105	87	177	140	757	1823	815	556	756	243	232
25	182	101	91	178	146	516	1890	734	580	656	234	233
26	184	96.5	86	183	137	420	2013	644	556	513	249	231
27	179	102	96	176	142	353	1704	730	746	402	253	236
28	175	98	91	165	145	285	1492	688	1672	366	238	235
29	171	92.5	93	154	150	262	1463	629	1731	305	240	239
30	160		88	141	165	242	1403	556	1165	281	233	233
31	159		95		157		1041	477		261		234

Source : Secondary data collected by CWRDM

Table 7.2.8

Basin wise Annual Water Availability and Demand (Mm^3)

River Basin	Utilizable Potential			Present Utilization					
	Surface	Ground	Total	Dome-stic	Live stock	Irri-gation	Indus-tries	Total	Return to Potential
Chalakudy	1493	204	1697	28	3	318	15	364	80
Periyar	6305	460	6765	155	12	1700	250	2117	425
Muvattupuzha*	1859	306	2165	47	7	647	80	781	162
Meenachil**	1056	242	1298	35	5	436	9	485	109
Manimala	888	245	1133	23	3	419	5	450	105
Pamba***	3297	212	3509	30	5	945	5	985	236
Achencoil	1343	232	1575	23	5	430	51	509	108

River Basin	Future Demands-2025 AD					Minimum Flushing of Pollutants	Total	(+) Surplus / (-) Deficit
	Dome-stic	Live stock	Irri-gation	Indus-tries	Pligri-mage			
Chalakudy	72	5	854	45	-	642	1618	79
Periyar	349	22	3525	750	-	404	5050	1715
MuvattuPuzha*	183	7	1196	240	-	-	1626	539
Meenachil**	118	6	875	27	-	-	1026	272
Manimala	88	4	980	15	-	-	1087	46
Pamba***	116	7	1185	15	10	4745	6078	-2569
Achencoil	128	8	1175	153	-	-	1464	111

* Half of the tailrace from Idukki now flowing into the Muvattupuzha will be utilized at Malankara dam.

** This river is practically dry during the summer months; backup of freshwater from other rivers, flowing into Vembanad, help to maintain the drinking water requirements of Kottayam municipality (intake point at Peroor)

*** Flushing requirements for the rivers directly falling into Vembanad estuary are shown against Pamba because of its locational and hydrological advantages.

Source : Secondary/Primary data collected by CWRDM

Table 7.2.9

Basin-wise Annual Water Availability and Demand in Monsoon and Non-Monsoon Periods (Mm^3)

River Basin	Sea-son	Utilizable Potential			Present Utilization					
		Surface	Ground	Total	Dome-stic	Live stock	Irri-gation	Indus-tries	Total	Return to Potential
Chalakudy	M	1375	102	**1477**	14	1	106	7	**128**	27
	NM	118	102	**220**	14	2	212	8	**236**	53
Periyar	M	5387	230	**5617**	77	6	567	125	**775**	142
	NM	918	230	**1148**	78	6	1133	125	**1342**	283
Muvattupuzha	M	1562	153	**1715**	23	3	215	40	**281**	54
	NM	297	153	**450**	24	4	432	40	**500**	83
Meenachil	M	1013	121	**1134**	17	2	145	4	**168**	36
	NM	43	121	**164**	18	3	291	5	**317**	73
Manimala	M	835	123	**958**	11	2	140	2	**155**	35
	NM	53	122	**175**	12	3	279	3	**297**	70
Pamb	M	2835	106	**2941**	15	1	315	2	**333**	79
	NM	462	106	**568**	15	2	630	3	**650**	158
Achencoil	M	1209	116	**1325**	11	2	143	25	**181**	36
	NM	134	116	**250**	12	3	287	26	**328**	72

River Basin	Season	Future Demands-2025 AD					Minimum Flushing of Pollutants	Total	(+) Surplus / (-) Deficit
		Dome-stic	Live stock	Irri-gation	Indus-tries	Pligri-mage			
Chalakudy	M	36	2	384	22	-	321	**765**	712
	NM	36	3	470	23	-	321	**853**	-633
Periyar	M	174	11	1586	375	-	202	**2348**	3269
	NM	175	11	1939	375	-	202	**2702**	-1554
MuvattuPuzha	M	91	3	538	120	-	-	**752**	963
	NM	92	4	658	120	-	-	**874**	-424
Meenachil	M	59	2	394	13	-	-	**469**	665
	NM	59	3	481	14	-	-	**557**	-393
Manimala	M	44	2	490	7	-	-	**543**	415
	NM	44	2	490	8	-	-	**544**	-369
Pamba	M	58	3	593	7	-	2372	**3033**	-92
	NM	58	4	592	8	10	2373	**3045**	-2477
Achencoil	M	64	4	577	76	-	-	**721**	604
	NM	64	4	598	77	-	-	**743**	-493

M - Monsoon; NM - Non-monsoon

Source : Secondary/Primary data collected by CWRDM

Chapter VIII

Long Term Alternative Development Scenarios

8.0 LONG TERM ALTERNATIVE DEVELOPMENT SCENARIOS

The primary purpose of planned development is to fulfill the aspirations of the people for a sustainable source of livelihood and for basic essentials of food. clothing, shelter, energy, clean water, education and health. In addition, planned development must also provide the capabilities required to protect the resource base and enhance the environmental quality of the region. Economic or industrial growth is one of the means to achieve these ends and the focus has to be not just on the quantum of growth but also on the content of growth.

The primary instrument for the realization of these objectives is a strong commitment to achieve the full mobilization of human and material resources, and what is as important, an improvement in the productivity and efficiency of use of these resources.

The carrying capacity based planning approach ensures meeting the objectives of development without impairing ecological health and, also, it has potential for generating alternatives for future anthropogenic life supporting activities. The anthropogenic activities use natural resources, which cause the natural limits upon anthropogenic activities to become even more constraining. The constraints lead to search for new techniques, inventions and technological progress either in the form of resource saving or resource substituting. The invention of these new techniques requires the restructuring of these anthropogenic activities. Hence, human societies have to search for innovative activity mixes, technology choices, life styles and value systems to overcome the limiting factors imposed by the carrying capacity of the ecosystems. Hence, one will have to be cautious about absolute ecological constraints, inherent instabilities and also resilience of the ecosystems. Hence, carrying capacity based planning approach is an exploratory search for alternative paths of development within the carrying capacity of the region.

The technology choice would ensure the resource use intensities, residuals generation to be within the supportive and assimilative capacities of the region, while using the available resources to generate high value addition and in hinterland high employment levels. The technology choices would also involve upgradation and substitution of resources. The typology and locational choices of activities are chosen to ensure minimization of transportation, energy and material intensities.

Appropriate choice of urban and supporting transportation and communication network would be critical for achieving targeted resource use intensities and to achieve the improvement in equitable quality of life levels and environmental status. The alternative development scenarios have to be sensitive to

- Distribution of resource endowment
- Material flows

- Environmental media capacities

The life styles have to be compatible with the above choices and this would include choices and changes in consumption patterns, value systems. Even though such chances could be effected on a very long term, policy options such as pricing and property rights could have desired effect within short and medium terms. In addition, human resource upgradation to support the technology choices, activity typology, continuous upgradation of the capacities of anthropogenic activities is also to be considered. The technology, typology of activities and life style choices would determine resource allocation.

The exploratory search for alternatives could be an automated and exhaustive search. However, in the present study the search is knowledge directed and heuristics using the knowledge and preference structure of people and decision makers and this ensures transparent and participatory planning process. The knowledge to direct the search consists of resource endowment and media assimilative characteristics. The heuristics for search include preferences, desires, and feasibility estimates. The Delphi and Brainstorming group interaction processes are used to ensure the exploratory nature of experience and it also facilitated interaction among the interest groups. The Strength - Weakness - Opportunity - Threat (SWOT) analysis carried out by the study groups is used to ensure that the alternative development scenarios are within the supportive and assimilative capacity of the region.

8.1 Major Developmental and Environmental Concerns

In the recent years, great concern has been expressed with regard to deterioration of Vembanad lake and consequent loss of supportive functions of this wetland system, especially due to urbanization, industrialization and agricultural activities in the downstream zones of the rivers; air quality in Greater Kochi industrial area and deforestation in the upland region. The situation is likely to get further aggravated due to proposed developmental activities without adequate environmental safeguards

Major Developmental Concerns

- Heavy dependence of the population of the region on commercial activities and money received from gulf countries for economic growth.
- Diversion of agricultural land for rubber production
- Net loss in the realization from agricultural sector
- Environmentally incompatible mining practices
- Inadequate water supply in many towns in the region
- Increasing pressure on water and land resources
- Inadequate transportation network
- Inadequate power supply and increasing gap between supply and demand for communication facilities

- Migration of population and average living standard and quality of life
- Inadequacy of Institutional resources for skills upgradation
- Tremendous pressure on infrastructural facilities, amenities, transportation network etc.
- Managerial failures and regional imbalances
- Inadequate organizational and financial resources
- Inadequate attention to protection of heritage and cultural resources

Major Environmental concerns

- Large scale reduction in forest cover and wild life
- Low ventilation coefficients and dispersion levels of air pollution due to topographical and climatic features
- Impact on ambient air quality in industrial belts and transportation corridors
- Discharge of effluents from various industrial/domestic sources of pollution
- Land degradation due to deforestation, sand mining, etc
- Threat to wildlife, flora and fauna due to excessive exploitation of natural resources
- Salinity intrusion into ground water sources
- Ground water pollution
- Water logging and salinization in coastal areas
- High loss of topsoil and severe soil degradation
- Degradation of mangroves/sacred groves
- Excessive fishing and degradation of water quality

8.2 Sustainability Considerations and Approaches

Sustainability considerations should take into account the conflicting aspects of the economic agenda, social agenda and environmental agenda and achieve tradeoff between them while exploring the alternatives.

- **Economic Agenda** : Priority for GDP Growth
Competitiveness
Material Consumption
Technology Innovation
- **Social Agenda** : Welfare redistribution
Strong public services
Cultural diversity
Community Cohesion
- **Environmental Agenda** : Non- material quality of life
Conservation of resources
Ecological values

Economic assessment of policies and programmes is the standard measure for decision makers and practitioners and requires application of several approaches in parallel:

- **Integrated assessment analysis**: this compares the different opportunities and constraints from political, cultural, institutional and psychological dimensions.
- **Business opportunity approach**: this may come about through redrawing the lines between producers, distributors, investors and consumers in any one industry or sector.
- **Market transformation approach**: this looks at the goals which society is aiming to achieve, and redesigns institutions, management practices, markets and fiscal measures accordingly.
- **Scenario approach**: this recognizes the complexity and diversity of such questions, and uses interactive scenario analysis rather than fixed methods to work towards common solutions.

For a system to be viable and longlasting, or in other words 'Sustainable', there are some fundamental requirements.

- Efficiency in utilizing resources.
- Robustness and flexibility for short-term change.
- Adaptability and innovation for long term change.
- Internal feedback and self- organization.
- Co-existence and interdependency with other systems both larger and smaller.

For achieving the goal of environmental sustainability there are some fundamental targets:

- Higher energy efficiency, with four - to - ten fold reductions in carbon emissions and other impacts.
- Greater material efficiency, with reductions in throughput of a factor of four- to - ten.
- Improved environmental efficiency to reduce risks and enhance quality in air, water, ground, soil, biomass and productivity.

Scenario based approach has been adopted in this study and alternative development scenarios for Greater Kochi Region have been examined on the basis of different criteria as listed below

☆ Economic Growth based Scenarios

- State Domestic Product (SDP) Growth Rate – High
- State Domestic Product (SDP) Growth Rate – Medium
- State Domestic Product (SDP) Growth Rate – Low
- Primary Sector Growth Rate – High
- Primary Sector Growth Rate – Medium
- Primary Sector Growth Rate – Low
- Secondary Sector Growth Rate – High
- Secondary Sector Growth Rate – Medium
- Secondary Sector Growth Rate – Low
- Tertiary Sector Growth Rate – High
- Tertiary Sector Growth Rate – Medium
- Tertiary Sector Growth Rate – Low

☆ Eco-System based Scenarios

- Major Watersheds
- Agro-Systems
- Archeological / Cultural Heritage sites

☆ Environmental based scenarios

- Air Environment
- Water Environment
- Land Environment

- Biological Environment
- Industrial Environment
- Social Environment
- Economic Environment

☆ Resource (Allocation / Utilization) based Scenarios

- Air resource
- Water Resources
- Land Resources
- Biological Resources
- Energy Resources
- Mineral Resources
- Human Resources
- Infrastructural Resources
- Cultural Resources
- Aesthetic Resources

8.3 Kerala – Disparities in the levels of Development

It is necessary to understand and analyze the economic factors and growth rates of different districts of GKR/Kerala along with the associated disparities at a macro level before coming up with long term environmentally compatible development strategies and scenarios Greater Kochi Region (GKR) includes six districts (partly or fully) in the state of Kerala. One of the objectives of planned economic development is to achieve reduction in the disparities in the levels of development amongst the different districts/regions/states. Centre for Monitoring Indian Economy (CMIE) classifies states with average per capita income above Rs. 3000 as relatively rich states and states with average per capita income below Rs. 1900 and Rs. 3000 are termed as developing states.

According to the above classification, Kerala falls under rich category. Per capita income is the overall measure of the relative economic position of a state and its growth. Even though the average per capita income of Kerala State is on the rise, disparities in the productivities and infrastructure facilities (qualitative and quantitative) are responsible for the current situation. Other reasons for the present sorry state of affairs include rapid population growth, low levels of capital formation, under utilization and poor maintenance of the so called catalysts of development in agriculture and industry and lack of desired inputs and facilities.

A statistical profile of districts, which constitute GKR Region is presented in **Table 8.3.1**. It is desirable to analyze the carrying capacity of the basin under different growth scenarios with the help of various carrying capacity indicators. It is also required to develop long term development strategies keeping in view possible/achievable State Domestic Product Growth rates over the next twenty five years and related Primary. Secondary and Tertiary sectoral/sub-sectoral mixes with due consideration to related environmental consequences and implications of these alternative growth rates. These strategies will help in stepping up the overall rate of growth of the economy in the state, and hence of the economy of the region through collective endeavors.

Table 8.3.1

Greater Kochi Region – Profile of Districts

Sr. No.	Indicator	GKR Region Districts						Kerala
		Alappuzha	Ernakulam	Idukki	Kottayam	Pathanam-thitta	Thrissur	
1	Area (Km^2)	1414	2407	5019	2203	2622	3032	38863
2	Population ('000 Nos.)	2001.22	2817.24	1078.07	1828.27	1188.33	2737.31	29098.52
3	Urbanization (%)	30.46	48.74	4.72	17.55	13 05	26.31	26.39
4	Literacy (%)	93.87	92.35	86.94	95 72	94 86	90.18	89.91
5	Main Workers ('000 Nos.)	589.14	862.84	386.64	529.13	317 20	799.60	8196.80
6	**Agriculture**							
•	Average Size of holding (ha)	-	-	-	-	-	-	-
•	Gross Sown Area (% of RA)	119.49	106.79	40.22	107.39	47.55	53.02	78.39
•	Area under Coconuts (% of CCA)	33.13	26.05	-	19 59	32 02	40 63	29 93
•	Area under Rice (% of CCA)	33.38	24.96	-	10.43	9 27	30.60	16.95
•	Gross Irrigated area(% of CCA)	19.08	24.63	1.66	4.58	5 67	35.68	14.18
•	Fertilizer Consumption (Kg/ha)	70.08	77.75	74.68	120.41	78 88	69 54	63.39
•	Value of Production (Rs /ha)	37293	58483	28032	31792	75462	92991	66823
•	Value of Agricultural Production (Rs /capita)	29219	4997	5207	3980	7846	6370	6629

8.4 Sectoral Scenarios (Regional status) - GKR

8.4.1 Industry and Pollution

- Kochi Refinery, FACT fertilizer plant and other chemical industries dominate the industrial scenario
- Improper siting of industries without taking into account the environmental factors
- Absence of greater emphasis on natural renewable resources based / agro based / forest produce based industries
- Need for adoption of cleaner technologies of production in all industries
- High air pollutant concentrations in industrial and transportation corridors
- Low air pollution dispersion potential in the region
- Ambient Air Quality Status under fair-excellent category
- Non availability of identified land for siting hazardous waste disposal facilities

8.4.2 Land and Ecology

- Increase in sand mining and builtup land area and reduction in forest vegetation
- Increase in new plantation and degradation of older tree groves in some areas
- Significant change in sandy area along the river course and surface water bodies and drainage network
- Presence of plants of medicinal and economic importance abundantly in forests
- Need for conservation of mangroves, sacred groves, migratory corridors, wildlife sanctuaries and natural forests

8.4.3 Population and Quality of Life

- High population growth rate and density especially in urban area
- Heavy demand on natural, transformational and distributive resources (Land, water, food grains, energy, distribution systems) due to population pressures
- Heavy strain on amenities and infrastructure facilities, especially in urban areas
- Low to average standard of living
- Urban QOL(s) 0.594 - 0.786
- Rural QOL(s) 0.660 – 0.762

- QOL(s) low due to inadequate provision of amenities, security concerns, water scarcity, inadequate power supply, improper sanitation facilities, absence of medical facilities, antisocial elements, mosquito menace etc.

8.4.4 Transportation and Vehicular Pollution

- Excessive stress on existing transportation facilities including railways
- High vehicular population growth rate and heavy vehicular traffic
- Poor condition of road network
- Traffic congestion and need for proper traffic management particularly in urban areas
- High NOx emissions and NOx levels in ambient air near transportation corridors
- Poor maintenance of vehicles
- Non-implementation of emission control measures
- Additional transportation network (railway network and road bridges) requirement to meet the growing needs of the region.

8.4.5 Amenities and Infrastructure

- Kochi region towns inadequately equipped with infrastructural facilities and amenities in comparison to other urban centres
- Infrastructural facilities mainly available only in urban centres where the industries are located
- In general, infrastructural facilities and amenities available in the region in adequate to meet the growing needs of the region.

8.4.6 Energy and Environment

- Total power generation installed capacity in Kerala 1771 MW
- Major energy consumer Domestic Sector

8.4.7. Agriculture and Irrigation

- Low productivity of agricultural land and labour
- Multicrop pattern
- Absence of adequate irrigation facilities
- 135% Crop intensity
- 63 Kg/ha fertilizer consumption
- Diversion of agricultural land for non agricultural purposes

- Absence of modern farming practices and non usage of high yielding verities
- Non adoption of sustainable agricultural management practices.

8.4.8 Urbanization & Urban Planning

- Industrial towns/centres highly urbanized in comparison to other urban centres in the region
- High urbanization rate
- Non implementation of earlier urban development plans
- No proper planning of urban facilities
- Absence of urban development plan for future requirements
- Inadequate development of other urban centres
- Urban congestion and proliferation of slums
- No perspective landuse plan to meet the growing needs

8.5 Macro Scenarios – Economic Growth

Economic Development is a broader concept than economic growth. Conceptually, the trends in income and the structural changes together constitute economic development. Growth may well involve not only more output derived from greater amounts of inputs but also greater efficiency, that is, an increase in productivity or an increase in output per unit of input. Economic growth means more output, while economic development implies both more output and changes in the technical and institutional arrangements by which it is produced and distributed. The structural changes, which are quite fundamental in character, are inherent in the process of economic growth. A progressive shift in the production function (Functional relationship between flows of output and corresponding flows of inputs) is the direct outcome of technological advancement, and science is the base of modern technology. Change in the structure of national output is a concomitant feature of economic growth.

A change in the structure of investment and capital formation is another development during the process of economic growth and development. With industrialization and consequent urbanization, the structure of industries changes. Capital and producer goods industries grow in importance and consumer goods industries decline in relative importance. In the critical stages of development, resources are deliberately shifted from consumption goods to capital goods. Thus the investment structure changes. The investment in human capital (education and health) and in social overhead capital (like irrigation, transport etc.) increase very rapidly in the early stage of developing when the infrastructure of development, the dependence on foreign technology may also be very high. The point is that different capital formation proportions reflect the nature and tempo of economic growth.

The upward trend in per capita income/economic growth rate, which initiates and accelerates changes in production, employment, factor proportion, skill and capital formation directly brings about a change in the structure of composition. As income changes, the pattern of income distribution (between regions, between sectors and between persons) also changes. This is backed up by changes in relative price structure of the economy, the domestic terms of trade between agriculture and non-agriculture change. It is through the interaction of all these factors that the structure of consumption and the standard of living undergoes a fundamental shift reflecting changes in social values, benefits and consumer preferences.

Finally, with changes in the structure of employment, production, income distribution and consumption, there comes naturally a change in the structure of foreign trade. In the initial stage of development, an economy may have to import metals and machinery for modernization and industrialization. But as the industrialization proceeds with economic growth, the acceleration in the pattern of exports and imports change. Structure of foreign trade changes as economy changes from primary commodity - exporting to export of manufactured goods.

There are three major sectors of economy i.e. Primary Sector, Secondary Sector and Tertiary Sector, which contribute to Gross Domestic Product (GDP) of any region. The sectoral mix and growth rates influence the composition of GDP and growth rate of economy.

Primary sector mainly includes Agriculture, Forestry & Logging and Fishing. Secondary Sector mainly includes Mining & quarrying, Manufacturing (Factory and Non factory), Electricity, Gas & Water Supply and Construction. Tertiary Sector includes Transport, Communication, Trade, Finance & Real and Community & Personal Services.

In this section, an attempt is being made to formulate alternative development scenarios in relation to GDP growth rates achievable i.e.: Low Growth Scenario, Medium Growth Scenario and High Growth Scenario. Keeping in view the constraints imposed by the Carrying Capacity of the basin (both economic and ecological) in addition to environmental and resource availability constraints, each scenario needs to be examined to assess the feasibility of achieving the desired developmental goals and growth rates and finally arrive at the growth rate, which is economically and environmentally feasible. Past growth rates that could be achieved and future growth rate projections need to be taken into account while formulating the scenarios.

It is also desirable to arrive at environmentally adjustable GDPs by substituting pollution causing sectors of economy with green sectors without losing the related economic benefits. Other indicators of economic growth and prosperity also need to be considered to assess the related environmental implications. At the next level, sectoral contributions to GDP and growth rates need to be examined with respect to primary, secondary and tertiary sectors of economy. Future projections relating to the above should be made to examine and arrive at environmentally compatible optimum combination of sectoral mixes to facilitate meeting the desired growth targets under different scenarios. In the same way the role of subsectoral contributions (e.g. Agriculture, Mining, Industry, Forestry etc.) need to be examined in greater detail under each of the scenarios.

Presently, about 30 percent of the Gross Domestic Product (GDP) of the Indian economy originates from agricultural and allied activities (primary sector). These include crop production, output from livestock, forestry, fishing and all other related activities in the agriculture sector. Crop production is the dominant component (about 28 percent of GDP) in this sector. The share of industry is around 25 percent of the GDP (secondary sector). Mining and quarrying, manufacturing, electricity, gas and water supply are the activities classified under the industry sector. Manufacturing activities has the dominant share, it being about 20 percent of the GDP.

The services (tertiary) sector comprising a large number of activities accounts for about 45 percent of the GDP. Trade, hotels, restaurants, transport and communications, banking and insurance, real estate services, construction, public administration including defense and all other services account for another about 12 percent and the remaining 15 percent originates from other services. The shares of different sectors have undergone significant changes due to the varying rates of growth in each sector over a period of time.

Data on sectoral distribution of Gross Domestic Product shows that the contribution of Primary Sector has marginally come down since the commencement of First Five Year Plan where as the shares of secondary and tertiary sectors have gradually increased. In the case of Greater Kochi Region, maximum contribution to SDP is from Tertiary sector and relatively less contribution is made by agriculture sector and secondary sector. Lot of potential exists for enhancing the contribution of tertiary sector to the region's economy through infrastructure development. Similarly contribution from agriculture can be increased by bringing more area under agriculture and following good agricultural practices.

Kerala State income for the period from 1980-81 to 1992-93 (at current prices – Primary, Secondary and Tertiary Sectors) and per capita income is presented in **Table 8.5.1** and corresponding percentage increase is presented in **Table 8.5.2**. Gross State Domestic Product at Factor Cost by Industry of Origin (1980-81 to 1994-95) at Current Prices is presented in **Table 8.5.3** and corresponding percentages are shown in **Table 8.5.4**. District wise data of the constituent districts of GKR are presented in **Tables 8.5.5** and **8.5.6**.

Keeping in view the growth rate projections and observed past trends, for the purpose of the present study, three scenarios are considered to assess their potential for sustaining the economy of the region in future by taking environmental considerations into account and presented in **Table 8.5.7**.

The major sub-sectors, which are of importance from Carrying Capacity analysis and alternative development scenarios point of view are Agriculture, Forestry, Industry and Energy and Infrastructure Development in Greater Kochi Region. The above assume importance since under the three growth scenarios, conflict resolution is required to sort out the issues relating to Agriculture Vs Industry and Urbanization, Large and Medium Industries Vs Forest produce and Agro based industries, and Renewable Vs Nonrenewable sources of energy with due consideration to constraints and limitations (involved), Activity multipliers, Employment multipliers, Value addition, Resource and Investment requirements and imports and exports.

To illustrate these issues in further detail with respect to major conflicts between development and environment, couple of examples are cited here. Available fertile agricultural land needs to be preserved to meet food requirements of growing population but the available land also needs to be made available for industrialization and human settlements. In order to reduce the environmental pollution, forest produce, and agro based / other types of small scale industries need to be setup while the need for large and medium scale industries is desirable from economic growth point of view. It is desirable to meet energy requirements through renewable sources of energy to the extent possible.

Table 8.5.1

State Income by Broad Sectors – 1980-81 to 1992-93 (at Current Prices)

(Rs in Lakhs)

Year	Primary Sector			Secondary Sector			Tertiary Sector			Net State Domestic Product	Population	Per Capita Income (Rs.)
	Agriculture	Forestry, Fishing and Mining	Total	Manufacturing	Electricity, Gas, Water Supply and Construction	Total	Transport Storage and Communications	Trade, Hotels, Real Estate and Public Administration	Total			
1980-81	129384	20586	149970	53152	40005	93157	13625	125521	139146	382273	25357	1508
1981-82	131163	14980	146143	61585	42074	103659	14725	140446	155171	404973	25699	1576
1982-83	153826	23041	176867	71171	45454	116625	18781	158877	177658	471150	26046	1809
1983-84	199323	17725	217048	75013	54674	129687	23676	181917	205593	552328	26398	2092
1984-85	214908	18404	233312	79448	64685	144133	32009	204691	236700	614145	26754	2296
1985-86	203536	21715	225251	86335	79799	166134	37448	221508	258956	650341	27115	2398
1986-87	234755	22888	257643	90178	82577	172755	44678	260361	305039	735437	27481	2676
1987-88	261685	18990	280675	112815	86037	198852	56718	289511	346229	825756	28114	2937
1988-89	285915	25098	311013	131873	98152	230025	64082	313052	377134	918172	28402	3233
1989-90	308536	40585	349121	177944	114746	292690	73748	351209	424957	1066768	28693	3718
1990-91	351843	48758	400601	191390	129403	320793	80428	415527	495955	1217349	28987	4200
1991-92	527417	66659	594076	232742	141228	373970	87275	454844	542119	1510165	29378	5140
1992-93	544163	74632	618795	265457	183389	448846	112323	537556	649879	1717520	29775	5768

Table 8.5.2

State Income by Broad Sectors – 1980-81 to 1991-92 (at Current Prices) (Percentage Increase)

Year	Primary			Secondary			Tertiary			Net State Domestic Product	Per Capita Income
	Agriculture	Forestry Fishing and Mining	Total	Manufacturing	Electricity, Gas, Constructions	Total	Transport, Storage and Communications	Trade, Hotels, Real Estate Public Administration	Total		
1980-81	-	-	-	-	-	-	-	-	-	-	-
1981-82	1.37	(-)27.23	(-)2.55	15.87	5.17	11.27	8.07	11.89	11.52	5.94	4.51
1982-83	17.28	53.81	21.02	15.57	8.03	12.51	27.54	13.12	14.49	16.34	14.78
1983-84	29.58	(-)23.07	22.72	5.40	20.28	11.20	26.06	14.50	15.72	17.23	15.64
1984-85	7.82	3.83	7.49	5.91	18.31	11.14	35.20	12.52	15.13	11.19	9.75
1985-86	(-)5.29	17.99	(-)3.46	8.67	23.37	15.26	16.99	8.22	9.40	5.89	4.44
1986-87	15.34	5.40	14.38	4.45	3.48	3.99	19.31	17.54	17.80	13.08	11.59
1987-88	11.47	(-)17.03	8.94	25.10	4.19	15.11	26.95	11.20	13.50	12.28	9.75
1988-89	9.26	32.16	10.81	16.89	14.08	15.68	12.98	8.13	8.93	11.19	10.08
1989-90	7.91	61.71	12.25	34.94	16.91	27.24	15.08	12.19	12.68	16.18	15.00
1990-91	14.04	20.14	14.75	7.59	12.77	9.60	9.06	18.31	16.71	14.12	12.96
1991-92	49.90	36.71	48.30	21.61	9.14	16.58	8.51	9.46	9.31	24.05	22.38
1992-93	3.19	11.96	4.16	14 06	29.85	20.02	28.70	18.18	19.88	13.73	12.22

Table 8.5.3

Gross State Domestic Product at Factor Cost by Industry of Origin (at current prices) 1980-81 to 1994-95

(Base year 1980 - 81) (Rs in Lakhs)

Sr. No.	Industry of Origin	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94*	1994-95**
1	Agriculture	135345	138000	161686	208200	225234	215930	248430	277234	303214	328572	374558	557214	573863	581438	658130
2	Forestry and Logging	12532	8205	14583	8315	8723	9370	10285	7584	6702	10288	8604	12559	14618	14811	15131
3	Fishing	8852	7338	9284	10439	10380	13613	14038	12698	19873	31982	41231	55380	60939	61743	63077
4	Mining and Quarrying	548	750	897	831	1229	1161	1159	1599	2736	3125	4450	5228	6055	7017	81299
	Sub Total (Primary)	**157277**	**154293**	**186450**	**227785**	**245566**	**240074**	**273912**	**299115**	**332525**	**373967**	**428843**	**630381**	**655475**	**665009**	**744467**
5	Manufacturing	62304	72493	84131	89517	95011	104607	114235	140852	154690	204191	220024	280517	315079	355847	401112
5.1	Registered	35095	40580	45066	50999	54885	59594	65600	95269	105951	134582	112221	152374	166647	181662	198030
5.2	Unregistered	27209	31913	39065	38518	40126	45013	48635	45583	48739	69609	107803	128143	148432	174185	203082
6	Electricity, Gas & Water Supply	9251	8175	8203	8130	11482	11109	15560	14770	16997	21585	21782	21950	35222	37355	39681
6.1	Electricity	8557	7324	7329	6972	10616	9649	13226	11919	13537	17555	16203	16510	29120	30585	32123
6.2	Gas	85	95	101	109	87	459	909	960	1099	1177	1383	1586	1862	2105	2426
6.3	Water Supply	609	756	773	1049	779	1001	1425	1891	2361	2853	4196	3854	4240	4665	5132
7	Construction	36297	40595	45047	55771	63539	81178	80450	86929	99894	107719	124283	136472	167731	191180	217907
	Sub Total (Secondary)	**107852**	**121263**	**137381**	**153418**	**170032**	**196894**	**210245**	**242551**	**271581**	**333495**	**366089**	**438939**	**518032**	**584382**	**658700**
8	Transport, Storage & Commu	22769	27176	33768	39868	50205	57942	68632	83967	95638	110015	126971	149034	189957	226482	267439
8.1	Railways	1269	1884	2275	2570	2628	3729	4143	5391	6218	5686	6423	7496	9210	11130	12572
8.2	Transport by Other means & Storage	18331	22137	27610	32757	42161	48128	56811	69597	76552	89075	102123	120449	150864	176254	205917
8.3	Communication	3169	3155	3883	4541	5416	6085	7678	8979	12868	15254	18425	21089	29883	39098	48950
9	Trade, Hotels & Restaurants	60159	63178	73549	86180	93581	94656	114602	127490	137209	151755	175436	192876	246437	281677	321956
10	Banking and Insurance	11648	16486	20138	23294	27713	32076	37863	41245	50922	63160	73918	79227	92427	107182	124288

Contd...

Table 8.5.3 Contd...

Sr. No.	Industry of Origin	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94*	1994-95**
11	Real Estate & Ownership of Dwellings	20451	22270	24807	26077	27634	30486	32085	33302	35926	39475	42629	46283	52851	57972	63589
12	Public Administration	17178	19285	20055	22144	29093	36666	45464	51558	55121	58731	80013	90261	102005	112011	122999
13	Other Services	31236	37007	41102	48478	53832	63207	70795	78607	88334	90672	115911	125966	136539	147994	165605
	Sub Total (Tertiary)	**163441**	**185402**	**213419**	**246041**	**282058**	**315033**	**369441**	**416169**	**463150**	**513808**	**614878**	**683647**	**820216**	**933318**	**1065876**
	Gross State Domestic Product	**428570**	**460958**	**537250**	**627244**	**697656**	**752001**	**853598**	**957835**	**1067256**	**1221270**	**1409810**	**1752967**	**1993723**	**2182709**	**2469043**
	Population ('000)	**25357**	**25699**	**26046**	**26398**	**26754**	**27115**	**27481**	**28114**	**28402**	**28693**	**28987**	**29378**	**29775**	**30177**	**30584**
	Per Capita Income (Rs.)	**1690**	**1794**	**2063**	**2376**	**2608**	**2773**	**3106**	**3407**	**3758**	**4256**	**4864**	**5967**	**6696**	**7233**	**8073**

Population based on 1991 Census
* 1993-94 Provisional,
** 1994-95 Quick estimates

Table 8.5.4

Structure of Net State Domestic Product at Current Prices Percentage

Sr. No.	Industry	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
1.	Agriculture	33.85	32.39	32.65	36.09	34.99	31.30	31.92	31.69	31.14	28.92	28.90	34.93	31.69
2.	Forestry and logging	3.24	1.99	3.05	1.47	1.38	1.39	1.34	0.87	0.69	0.94	0.69	0.82	0.84
3.	Fishing	2.02	1.55	1.68	1.62	1.46	1.81	1.65	1.29	1.83	2.66	3.06	3.36	3.26
4.	Mining & Quarrying	0.12	0.16	0.16	0.12	0.16	0.14	0.12	0.14	0.21	0.21	0.26	0.23	0.24
	Sub Total (Primary)	**39.23**	**36.09**	**37.54**	**39.30**	**37.99**	**34.64**	**35.03**	**33.99**	**33.87**	**32.73**	**32.91**	**39.34**	**36.03**
5.	Manufacturing	13.90	15.21	15.11	13.58	12.94	13.27	12.26	13.66	14.36	16.68	15.72	15.41	15.46
5.1	Registered	7.59	8.26	7.77	7.56	7.39	7.32	6.65	9.10	10.07	11.27	8.23	8.22	8.04
5.2	Unregistered	6.31	6.95	7.34	6.02	5.55	5.95	5.61	4.56	4.29	5.41	7.49	7.19	7.42
6	Electiricity, Gas & Water Supply	1.44	0.90	0.59	0.32	0.70	0.36	0.81	0.41	0.34	1.18	0.96	0.80	1.36
6.1	Electricity	1.33	0.77	0.49	0.20	0.61	0.21	0.59	0.18	0.11	0.95	0.72	0.61	1.18
6.2	Gas	0.02	0.02	0.02	0.02	0.02	0.07	0 12	0.12	0.12	0.11	0 11	0.11	0.11
6.3	Water Supply	0.09	0.11	0.08	0.10	0.07	0 08	0.10	0.11	0.11	0.12	0.13	0.08	0.07
7	Construction	9.03	9.49	9.05	9.58	9.83	11.91	10.42	10.01	10.35	9.58	9.67	8.55	9.31
	Sub total (Secondary)	**24.37**	**25.60**	**24.75**	**23.48**	**23.47**	**25.54**	**23.49**	**24.08**	**25.05**	**27.44**	**26.35**	**24.76**	**26.13**
8.	Transport, Storage & Communi.	3.56	3.64	3.99	4.29	5.21	5.76	6.08	6.87	6.98	6.91	6.61	5.78	6.54
8.1	Railways	0.11	0.21	0.21	0.21	0.17	0.24	0 26	0.36	0.36	0.27	0.27	0.25	0.29
8.2	Transport by Other means	2 82	2.84	3.14	3.44	4.37	4.83	5.04	5.70	5 50	5 54	5.17	4.46	4.90
8 3	Communication	0.63	0.59	0.64	0.64	0.67	0 69	0.78	0.81	1 12	1.10	1 17	1 07	1 35
9	Trade, Hotels & Restaurants	15.06	14.91	14.88	14.84	14.45	13.70	14.67	15.14	14.07	13.39	13.53	11.95	13.42
10	Banking	2.99	4.00	4.20	4.14	4.43	4.83	5.04	4.76	5.41	5.75	5.89	5.06	5.17
11	Real Estates	3.19	3.05	2.79	2.33	2.14	1.61	1.23	0.92	0 47	0.38	0.36	0.04	0.04
12	Public Administration	3.96	4.16	3.71	3.49	4.10	4.74	5.32	5.38	5.24	5.17	5.70	5.15	5.07
13	Other Services	7 64	8.55	8.14	8.13	8.21	9.18	9.14	8.86	8.91	8 23	8.65	7.92	7.60
	Sub Total (Tertiary)	**36.40**	**38.31**	**37.71**	**37.22**	**38.54**	**39.82**	**41.48**	**41.93**	**41.08**	**39.83**	**40.74**	**35.90**	**37.84**
	N.S.D.P.	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 8.5.5

Comparison between State and District Per Capita Income of Kerala – 1980-91 to 1992-93 (at Current Prices)

(Rs. in Lakhs)

State/District	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
Alappuzha	1311	1441	1629	1953	2191	2366	2685	2911	3229	3507	4268	4865	5255
Ernakulam	2017	2218	2513	2824	3202	3441	3793	4323	4843	5337	6502	8010	8857
Idukki	1995	2229	2393	2927	3004	3376	3314	4064	4483	5472	4672	6073	6433
Kottayam	1452	1613	1912	2187	2265	2507	2875	3137	3423	3634	4038	4945	5473
Pathanamthitta	-	-	-	1898	2178	2564	2980	3104	3374	3768	4408	5056	5590
Thrissur	1462	1558	1806	2067	2161	2333	2620	2958	3240	3671	4422	5277	5921
State	1508	1576	1809	2092	2296	2398	2676	2937	3233	3718	4200	5140	5768

Table 8.5.6

District-wise Distribution of the Net State Domestic Product and Per Capita Income of Kerala

At Factor Cost by Industry of Origin for the Year 1992-93 (At Current Prices)

(Base Year – 1980-81) (Rs. in Lakhs)

Sr. No.	Industry of Origin	ALP	EKM	IDK	KTM	PTA	TSR	State
1	Agriculture	27225	47473	36681	41525	24832	43702	544163
2	Forestry and Logging	-	401	1307	145	2022	3537	14477
3	Fishing	5078	10980	28	415	67	3537	56049
4	Mining and Quarrying	153	401	35	169	108	369	4106
	Sub Total - Primary	**32456**	**59255**	**40587**	**42254**	**27029**	**48915**	**618795**
5	Manufacturing	18009	74653	3510	6566	6999	30769	265457
5 1	Registered	5657	58795	2235	524	842	19883	137984
5 2	Un-registered	12352	15858	1275	6042	6157	10886	127473
6	Electricity, Gas & Water supply	1945	2737	1854	2071	1139	2140	23424
6.1	Electricity	1719	2370	1776	1861	1018	1880	20275
6 2	Gas	136	185	71	124	81	177	1862
6 3	Water Supply	90	182	7	86	40	83	1287
7	Construction	8942	31305	10174	3247	5311	17724	159965
	Sub Total-Secondary	**28896**	**108695**	**15538**	**11884**	**13449**	**50633**	**448846**
8	Transport, Storage & Communication	7298	20006	2531	8491	4688	12725	112323
8.1	Railways	236	506	-	321	-	376	5013
8.2	Tran. Other means & storage	5676	16589	1861	6299	3764	9785	84210
8.3	Communication	1386	2911	670	1871	924	2564	23100
9	Trade, Hotel & Restaurants	17291	26512	5764	15907	9452	23746	230543
10	Banking and Insurance	5686	17058	1688	6663	5242	9239	88841
11	Real Estate & Ownership of Dwelling	44	129	14	38	24	71	649
12	Public Administration	5913	9396	1445	6418	3858	6757	87077
13	Other Services	10044	14219	3522	10697	4174	13827	130446
	Sub Total – Tertiary	**46276**	**87320**	**14964**	**48214**	**27438**	**66365**	**649876**
	Net State Domestic Product	**107628**	**255270**	**71089**	**102352**	**67916**	**165913**	**1717520**
	Population ('000)	**2048**	**2882**	**1105**	**1870**	**1215**	**2802**	**29775**
	Per Capita Income (Rs.)	**5255**	**8857**	**6433**	**5473**	**5590**	**5921**	**5768**

Table 8.5.7

State Domestic Product (SDP) Growth Scenarios

Sector	Annual Growth Rate	Kerala
Low Growth Scenarios (<3.5)		
Primary	7.0	2.52
Secondary	2.5	0.65
Tertiary	2.5	0.95
Medium Growth Scenario (3.5-5.5)		
Primary	4	1.44
Secondary	4	1.04
Tertiary	4	1.52
High Growth Scenarios (>5.5)		
Primary	2.5	0.90
Secondary	7.0	1.82
Tertiary	7.0	2.66

8.6 MAJOR SCENARIO ELEMENTS

8.6.1 Agriculture

Among the major natural resources of concern, land is the most important resource from many points of view since it provides the food that is required by all the human beings and sustains all animals. Agriculture forms the backbone of the economy of many developing countries and still employs the majority of people in most of the developing countries. Among the food items required to sustain human beings, cereals, milk and meat are the most important, both for human consumption and in their use of resources.

In order to produce the foodgrains required, fairly high agricultural growth rates need to be adopted and these will have both economic and environmental implications. However, if the priority is to be given to industrial sector to achieve rapid economic growth, low agricultural growth rates may only be possible because of the resource constraints, which may result in shortage of food grains. Adoption/ selection of appropriate agricultural growth rates over the next twenty five years under alternative macroeconomic developmental scenarios i.e. low growth, medium growth and high growth scenarios, warrants examination of past growth rate trends with respect to the above and possible resource use/associated environmental impacts.

Taking into account all the available data with respect to agricultural sector growth rates (in terms of area, yield and production) in India, Kerala and other agriculturally rich states in India, for the purposes of the present study, alternative scenarios with respect to agricultural growth rate (in terms of output and value added) are delineated as given below

Scenario	Agricultural Growth rate (Percent per annum)
High Growth (Industrial)	< 3
Medium Growth	3 – 5
Low Growth (Industrial)	5 – 10

8.6.2 Industry

In order to study the possible resource use and environmental implications associated with industrial typology and mix, production and consumption in future over the next twenty five years under alternative macroeconomic developmental scenarios i.e. low growth, medium growth and high growth scenarios, it is necessary to examine the past trends with respect to the above and formulate growth rates.

Important items of consumption that draw on major natural sources i.e. Land, Forests, Atmospheric Carrying Capacity, fossil fuels and minerals and metals and water include forest products, pulp and paper, clothing, fertilizers and pesticides needed to produce food, cement for housing and metals and minerals (iron and steel, copper and aluminium). It is the production of these items on large scale to meet the growing needs of the human population, which is responsible for environmental degradation and deterioration in the quality of air, water and land. Even at the present and projected consumption levels, the demand for the above products is growing at an alarming rate in the state of Kerala. The situation will be highly alarming when the present consumption levels in India are compared with the consumption levels in developed countries like USA (particularly, if India attains consumption levels similar to that of USA during the process of development).

Taking into account all the available data with respect to industrial growth in India, Kerala and other industrialized states in India, for the purposes of the present study, alternative scenarios with respect to industrial growth are defined as given below

Scenario	Industrial Growth Rate (Percent per annum)
Low Growth	< 3
Medium Growth	3 - 5
High Growth	5 - 10

8.6.3 Energy

In order to study the possible resource use and environmental implications associated with energy mix, production and consumption in future over the next twenty five years under alternative macroeconomic developmental scenarios i.e. low growth, medium growth and high growth scenarios, it is necessary to examine the past trends with respect to the above and formulate growth rates.

Taking into account all the available data with respect to power generation for India, Kerala and other industrialized states in India for the purposes of the present study, alternative scenarios with respect to power generation are defined as given below :

Scenario	Rate of increase in Power Generation Capacity (percent per annum)
Low Growth	< 5
Medium Growth	5 – 10
High Growth	> 10

Annexure

Appendix. 3.5.2.1.: Angiosperms of GKR

1 Abelmoschus angulosus Wall
2 Abelmoschus esculantatus (L.) Moench
3 Abelmoschus manihot (L.) Medic
4 Abelmoschus moschatus Medic
5 Abrus precatorius L
6 Abrus pulchellus Wall ex Thw
7 Abutilon indicum (L.) Sweet
8 Abutilon persicum (Barm.f.) Merr
9 Abutilon ramosum (Cav.) Guill
10 Acacia auriculiformis A Cunn Ex Benth
11 Acacia caesia (L.) Willd
12 Acacia concinna (Willd.) DC
13 Acacia pennata (L.) Willd
14 Acacia torta (Roxb.) Craib
15 Acalypha brachystachya Hornem
16 Acalypha frutiscosa Forssk
17 Acalypha hispida Burm F
18 Acalypha malabarica Muell-Arg
19 Acalypha racemosa Heyne
20 Acampe ochracea (Lindl.) Hochr
21 Acampe praemorsa (Roxb.) Blatter
22 Acanthephlippium bicolor Lind
23 Acanthospermum hispidum DC
24 Acanthus ilicifolius L
25 Achyranthes aspera L
26 Achyranthes bidentata Bl
27 Aclisia secundiflora (Blume) Bakh F
28 Acrocarpus fraxinifolius Wight & Arn.
29 Acrocephalus hispidus (L.) Nicols & Sivadasan
30. Acronychia pendunculata (L.) Miq.
31 Acrotrema arnottiana Wight
32 Actephila excelsa (Dalz.) Mullet Arg
33 Actinodaphne tadulingamii
34 Actinodaphne bourdillonii Gamble
35 Actinodaphne campanulata Hook F
36 Actinodaphne malabarica Balakr
37 Actinodaphne salicina Meisner
38 Actinodaphne semicarpifolia
39 Adenanthera pavonia L.
40 Adenia hondala (Gaertn.) de. Wilde
41 Adenosma indianum (Lour.) Merr
42 Adenosma subrepens Benth
43 Adenostemma lavenia (L.) Kuntze
44 Adenostemma macrophylla (Blume) DC
45 Adrisia pauciflora Heyne in Roxb
46 Aeginetia indica L
47 Aeginetia pedunculata Wall
48 Aegle marmelos (L.) Correa
49 Aenchenrya rotundifolia Satish
50 Aerides cylindricum Lindley
51 Aerides maculosum Lindl
52 Aerides ringens (Lindl.) Fischer
53 Aerva lanata (L.) Juss
54 Aerva sanguinolentata (L.) Bl
55. Aeschymone aspera L
56 Aeschynanthus perottetii A DC
57 Aeschynomene americana Linn
58 Aeschynomene indica L
59 Aglaia alaegnoidea (Juss.) Benth
60 Aglaia apiocarpa Hiern
61 Aglaia barberi Gamble
62 Aglaia lawii (Wt.) Sald
63 Aglaia malabarica Sasi
64 Aglaia perviridis Hiern in Hook F
65 Aglaia simplicifolia Harns
66 Aglaia tomentosa Teijsm & Binn
67 Aganope thyrsiflora (Benth.)
68 Aganosma cymosa (Roxb.) G Don
69 Agave americana L
70 Ageratina adenophora (Sprengel) King & Robinson
71 Ageratum conisoides L
72. Ageratum houstonianum Miller
73. Agrostistachys borneensis Becc.
74. Agrostistachys indica Dalz
75 Ailanthus triphysa Alston
76. Alangium salvifolium (L F) Wangerin
77 Albizia chinensis (Osb) Merril
78 Albizia lebbeck (L.) Willd
79 Albizia odoratissima (L F) Benth
80 Albizia procera (Roxb.) Benth
81 Aleurites moluccana (L.) Willd
82 Allamanda cathartica L
83. Allmania nodiflora (L.) R Br
84. Allophyllus cobbe (L.) Raeusch
85. Allophyllus concanicus Radlk
86. Allophyllus serratus (Roxb.) Kurz
87 Allophyllus serrulatus Radlk
88 Alloteropsis cimicina (L.) Stapf
89 Alocasia formicata Schott
90 Alocasia macrorrhizos (L.) G Don
91. Alpinia calcarata Rose
92. Alpinia galanga (L.) Sw
93. Alpinia malaccensis (Burm F) Rose
94. Alpinia nigra (Gaertn.) Burtt
95. Alpinia smithiae Sabu & Mangaly
96. Alseodaphne semicarpifolia Nees
97. Alstonia scholaris (L.) R Br
98. Alstonia venenata R Br
99 Alternanthera paronychioides St
100. Alternanthera pungens Kunth
101 Alternanthera sessilis (L.) R Br
102. Alternanthera tenella Colla
103. Alysicarpus bupleurifolius (L.) DC
104 Alysicarpus heterophyllus (Benth Ex.Baker) Jafty & Ali
105. Alysicarpus monilifer (L.) DC
106. Alysicarpus vaginalis (L.) DC
107. Amaranthus spinosus L
108. Amaranthus viridis L
109. Amischophacelus axillaris (L.) Rao & Kumar
110. Ammania baccifera L
111 Ammomum microstephanum Baker
112. Amomum cannicarpum (Wt.) Benth
113 Amomum involucratum Benth
114 Amomum muricatum Bedd
115. Amomum pterocarpum Thw
116. Amorphophallus commntatus Engl
117. Amorphophallus hohenackeri (Scott) Engl
118. Amorphophallus nicolsianus Sivadas
119. Amorphophallus paeoniifolius (Dennst.) Nicols
120 Ampelocissus indica (L.) Planch
121. Ampelocissus latifolia (Roxb.)
122. Anacardium occidentale L
123 Anacolosa densiflora Bedd
124. Anagallis pumila Sw
125 Anamirta cocculus (L.) Wight & Arn
126. Anaphalis aristata DC
127 Anaphalis beddomei
128 Anaphalis lawii (Hook F) Gamble

Contd....

Appendix 3.5.2.1 Contd..

129 *Anaphyllum barnesii Fischer*

130 *Anaphyllum wightii*

131 *Ancistrocladus heyneanus Wall ex Graham*

132 *Andrographis aphinis Nees*

133 *Andrographis atropurpurea (Dennet) Alston*

134 *Andrographis elongata (Vahl) T Anders*

135 *Andrographis explicatai Gamble*

136 *Andrographis lineata Wall Ex. Nees*

137 *Andrographis macrobotrys Nees*

138 *Andrographis neesiana Wt*

139 *Andrographis paniculata (Burm f) Wall Ex Nees*

140 *Andrographis producta Gamble*

141 *Aneilema montanum (Wight) Clarke*

142 *Aneilema ovalifolium (Wight) Hook.F*

143\. *Aneilema scaberrimum (Bl.) Kunth*

144 *Angelonia biflora Benth.*

145 *Aniseia martinicensis (Jacq) Choisy*

146 *Anisochilus argenteus Gamble*

147 *Anisochilus carnosus (L.F) Wall*

148 *Anisochilus dysophylloides Benth*

149 *Anisochilus robustus Hook F*

150 *Anisochilus sericens Benth*

151 *Anisochilus verticillatus Hook F*

152\. *Anisomeles indica (L) Kuntze*

153 *Annona squamosa L*

154 *Anodendron manubriatum Merr*

155 *Anodendron rhinosporum Thw*

156 *Anoectochilus elatus Lindl.*

157 *Anogeissus latifolia Roxb Ex Dc) Wall ex Guill*

158 *Anona glabra L*

159 *Antiaris toxicana Leech*

160 *Antidesma acidum Retz*

161 *Antidesma alexiteria L*

162 *Antidesma ghaesembilla Gaertn*

163 *Antidesma menasu Miq Ex Tul*

164 *Antidesma pubescens Roxb*

165 *Antidesma zeylanicum Lam*

166 *Aphanamixis polystachys (Wall) Parker*

167 *Aphyllorchis montana Reichb*

168 *Apluda mutica L*

169 *Apocopsis mangalorensis Henr*

170 *Apodytes dimidiata E Mayer*

171 *Aponogeton natans (L.) cosson*

172 *Aponogeton undulatus Roxb*

173 *Aporusa acuminata Thur.*

174 *Aporusa bourdillonii Stapf*

175 *Aporusa fusiformis Thw*

176 *Aporusa lindleyana (Hight) Baill*

177 *Aralia malabarica Bedd.*

178 *Archidendron clypearia (Jack)*

179 *Archidendron monadelphum (Roxb) Neilson*

180 *Ardisia gardneri (Lour) Tir veng*

181 *Ardisia blatteri Gamble*

182 *Ardisia rhomboidea Wight*

183 *Ardisia solanaceae Roxb*

184 *Ardisia sonchifolia Mez*

185 *Ardisia stonei Sasi*

186 *Areca catechu L*

187 *Arenga wightii Griff*

188 *Argostemma anupama Sivar*

189 *Argostemma courtallense Arn*

190 *Argostemma verticillatum Wall*

191 *Agrostistachys indica Dalz*

192 *Argyreia cuneata (Willd) Ker-Gawl*

193 *Argyreia daltonii Clarke*

194 *Argyreia elliptica (Roth) Choisy*

195 *Argyreia hirsuta Wiht & Arn*

196 *Argyreia imbricata (Roth) Sant & Patel*

197 *Ariopsis peltata Nimmo*

198 *Arisaema barnesii Fischer*

199\. *Arisaema leschenaultii Blum*

200 *Arisaema murayi Hook F*

201\. *Arisaema tortuosum (Wall) Schott*

202 *Aristida hystrix L f*

203 *Aristida setacea Retz*

204\. *Aristolochia indica L*

205\. *Aristolochia krisagathra Shiv & Pradeep*

206\. *Aristolochia tagala Cham*

207\. *Artabotrys hexapetalus (L.F.) Bhandare*

208\. *Artabotrys zeylanicus Hook F. & Thomas*

209\. *Artanema longifolium (L) Vatke*

210\. *Artemisia nilagirica (Clarke) Pamp*

211\. *Artemisia parviflora Buch-Ham*

212\. *Arthraxon cartratus (Griff) Naray*

213 *Arthraxon lanceolatus Hochst*

214 *Arthraxon lancifolius (Trin)*

215\. *Arthraxon meeboldii Stapf*

216\. *Arthraxon nudus Hochst*

217\. *Arthraxon quartinianus (A Rich) Nash*

218\. *Artocarpus gomezianus Wall Ex Tree*

219\. *Artocarpus heterophylus Lam*

220 *Artocarpus hirsutus Lam*

221 *Arundina graminifolia Hochr*

222\. *Arundinella ciliata (Roxb) Nees*

223\. *Arundinella leptochloca Hook f*

224\. *Arundinella mesophylla Nees*

225\. *Arundinella nervosa (Roxb) Nees*

226\. *Arundinella pumila Stend*

227 *Arundinella purpurea Hochst*

228 *Arundinella setosa Trin*

229\. *Asclepias curassavica L*

230\. *Asparagus gonoclados Baker*

231 *Asparagus racemosus Willd*

232\. *Aspidopterys canarensis Dalz.*

233 *Asyneuma fulgens (Wall) Briq*

234\. *Asystasia chelonoides Nees*

235\. *Asystasia dalzelliana Santapan*

236\. *Asystasia gangetica (L) T*

237\. *Asystasia travancorica Bedd*

238\. *Atalantia racemosa Wight & Arn*

239 . *Atalantia wightii Tanaka*

240\. *Atlantia missionis Oliv*

241\. *Atuna travancorica Kosterm*

242\. *Atylosia albicana (Wight & Arn) Benth*

243\. *Atylosia goensis (Dalz) Dalz*

244 *Atylosia lineata Wight & Arn*

245 *Atylosia rugosa Wight & Arn*

246 *Atylosia scarabaeoides (L) Benth*

247 *Atylosia trinervia (DC) Gamble*

248 *Averrhoa bilimbi L*

249 *Averrhoa carambola L*

250 *Avicennia officinalis L*

251 *Axonoponus compressus (Sw)*

252 *Baccaurea courtallensis (Wight) Muell-rg*

253\. *Bacopa hamiltoniana (Benth) Wettst*

254 *Bacopa monneiri (L) Pennel*

255 *Balanophora abbreviata Blums*

256 *Balanophora fungosa Forst & Forst.F*

257 *Baliospermum solanifolium (J Burm) Suresh & Nicols*

258 *Bambusa bambos (L) Voss*

Contd....

259 Barleria acuminata Nees
260 Barleria courtallica Nees
261 Barleria cristata L
262 Barleria involucrata Nees.
263 Barleria lawii T. Anders
264 Barleria mysorensis Heyne
265 Barleria prionitis L
266 Barringtonia acutangula (L.) Gaertn
267 Barringtonia racemosa (L.) Spreng
268 Basella alba L
269 Bauhinia accuminata L
270 Bauhinia malabarica (Roxb.)
271. Bauhinia phoenicea Heyne ex. W & A
272 Bauhinia racemosa (Lamk.)
273 Bauhinia scandens (L.)
274 Bauhinia tomentosa L
275 Begonia albo-coccinea Hook
276 Begonia fallax DC
277 Begonia floccifera Bedd
278 Begonia malabarica Linn
279 Begonia subpeltata Wight
280 Begonia trichocarpa Dalz
281 Beilschmiedia bourdillonii Brandis
282 Beilschmiedia wightii (Nees) Benth.
283 Belosynapsis vivipara (Dalz.) Fischer
284 Bentinckia codapanna Berry
285 Berrya cordifolia (Willd.)
286 Bhesa indica (Bedd.) Ding Hou
287 Bidaria indica Rahman & Wilcock
288 Bidaria montana (Roxb.) Rahman
289 Bidens biternata (Lour.) Merrila Sherff.
290 Bidens pilosa
291 Biophytum candolleanum Wight
292 Biophytum intermedium Wight
293 Biophytum reinwardtii (Zucc.) Koltzrch in Peters
294 Biophytum sensitivum
295 Bischofia javanica Bl
296 Bixa orellana L
297 Blachia calycina
298 Blachia denudata Benth
299 Blachia reflexa Benth
300 Blachia umbellata (Willd.) Bail
301 Blainvillea acmella (L.)
302 Blepharispermum petiolare DC
303 Blepharistemma memboanifolia (Miq.)
304 Blepharistemma serratum
305 Blumea alata (D. Don) DC
306 Blumea barbata DC
307 Blumea belangeriana DC
308 Blumea hieracifolia (D Don) DC
309 Blumea lacera (Burm F) DC
310 Blumea lanceolaria (Roxb.) Druce
311 Blumea membranacea Wallich ex DC
312 Blumea mollis (D. Don) Merr
313 Blumea oxydonta DC
314 Blumea virens Wall
315 Blyxa aubertii Rixh
316 Blyxa echinosperma (Clarke) Hook. F
317. Blyxa octandra (Roxb.) Planch
318. Boehmeria glomerulifera Miq.
319 Boehmeria macrophylla Hornem
320. Boerhaavia diffusa L.
321 Boerhavia chinensis Asach
322 Boerhavia erecta L
323 Boerhavia repens L
324 Boesenbergia pulcherrima O Ktze
325. Bombax ceiba L
326 Bombax insigne Wall
327. Bombax scopulorum Dunn
328. Bonamia semidigyna
329. Borassus flabellifer L
330. Bothriochloa insulta A Camera
331. Bothriochloa pertusa (L.) A camus
332. Bougainvillea Spp
333. Brachiana miliiformis A chase
334. Brachiana remota Haines
335. Brachiana reptans Gard
336. Brachiaria brizantha Staff
337. Brachiaria eruciformis (Smith) Griseb
338 Brachiaria ramosa (L.) Stapt
339. Brachiaria semiundulata Stapt
340. Brachycorythis iantha Sunmerh
341. Brachycorythis splendida Summerh
342. Brassica juncea (L.) Cosson
343. Breynia retusa (Deennrt) Alston
344. Breynia vitis-idaea (Burm f) Fischer
345. Bridelia airy-shawii P T Linn
346. Bridelia crenulata Roxb
347. Bridelia scandens (Roxb.) Willd
348. Brownea capitella Jacq
349. Brucea sumatrana Roxb
350. Brugiera gymnorhiza (L.)
351. Brugmansia suaveolens Bercht & Persl.
352. Buchanania axillaris (Desr.) Rammoorthy
353 Buchanania lanceolata Wight
354 Buchanania lanzan Spreng
355 Buchnera hispida Buch Ham Ex Don
356 Buddleja asiatica Lour
357 Bulbophyllum aureum J J Sm
358 Bulbophyllum elegantulum J J Sm
359 Bulbophyllum fischeri Seidenf.
360 Bulbophyllum fusco-purpurenum Wight
361. Bulbophyllum kaitiense Reichb
362 Bulbophyllum neilgherrense Wight
363. Bulbophyllum tremulum Wight
364. Bulbophyulum fimbriatum Reichb
365 Bulbostylis barbata (Rolth) Clarke
366 Bulbostylis densa Hand
367 Bulbostylis pubenila (Poir.) Kunth
368. Burmannia coelestis D Don
369. Butea parviflora Roxb
370. Butea purpurea (Benth Ex Baker) Blatter
371 Caesalpinia bonduc (L.) Roxb
372. Caesalpinia cucullata Roxb
373 Caesalpinia decapetala (Roth.)
374. Caesalpinia nymenocarpa Hattink
375 Caesalpinia mimosoides Lam
376 Caesalpinia pulcherrima (L.) SW
377 Caesalpinia sappan L
378 Caesalpinia spicata Dalz
379. Caesaria bourdillonii Mukh
380. Caesaria coriaceae Thw
381. Cajanus cajan (L.) Millsp
382. Cajanus goensis Dalz
383. Cajanus heynei Vander Massen
384. Cajanus lineatus Vander Massen
385. Cajanus scarabaeoides (L.) Thouars
386. Caladium bicolor (Ait.) Vent
387. Calamus brandisii Becc
388. Calamus gamblei Becc
389. Calamus pseudotenuis Becc
390. Calamus rotang L
391. Calamus thwaitesii Becc & Hook F

Contd....

392 *Calamus travancoricus* Bedd.
393 *Calamus vattayila* Renuka
394 *Calanthe masuea* (D. Don) Lindl
395 *Calanthe triplicata* Ames
396 *Calapagonium mucunoides* Desv
397 *Callicarpa tomentosa* (L.) Murray
398 *Callipedium assimile* A. Camus
399 *Callipedium filiculme* (Hook.F.)
400 *Callipedium huegelii* (Hack.) A. Camus
401 *Callistemon citrinus* (curtis) Stapf
402 *Calophyllum austroindicum* Kosterm
403 *Calophyllum calaba* L.
404 *Calophyllum inophyllum* L
405 *Calophyllum polyantum* Wall
406 *Calotropis gigantea* (L.) R. Br.
407 *Calycopteris floribunda* (Roxb.) Poiret
408 *Camellia sinensis* (L.) Kuntze
409 *Cananga odorata* (Lam.) ook.F.&Thomas
410 *Canarium strictum* Roxb.
411 *Canavalia cathartica* Thours
412 *Canavalia gladiata* Wt.&Arn.
413 *Canavalia mollis* Wight&Arn
414 *Canavalia rosea* (SW.) DC
415 *Cannabis sativa* L
416 *Canscora decussata* Schutes
417 *Canscora diffusa* (Vahl) R Br
418 *Canscora perfoliata* Lam
419 *Canscora roxburghii* Arn E Miq
420 *Cansjera rheedii* Gmel
421 *Canthium angustifolium* Roxb
422 *Canthium coromandelicum* (Burm.F.) Alston
423 *Canthium discoccum* (Gaertn.) eijs&Binn
424 *Canthium ficiforme* Hook F
425 *Canthium nilgherrense* Wight
426 *Canthium parviflorum* Lam
427 *Canthium rheedei* DC.
428 *Canthium travancoricum* Hook. F
429 *Capparis brevispira* DdC
430 *Capparis fusifera* Dunn
431 *Capparis moonii* Wt
432 *Capparis parviflora* Hook.F Thomas
433 *Capparis rheedei* DC
434 *Capparis tenera* Dalz
435 *Capparis zeylanica* L
436 *Caralia brachiata* (Lour) Merril
437 *Carcum tuberosus* Clarke
438 *Cardamine africana* L
439 *Cardamine trichocarpa* Hochst
440 *Cardiospermum helicacabum* L
441 *Carex baccans* Nees
442 *Carex filicina* Nees
443 *Carex jackiana* Bootl
444 *Carex lenta* D.Don
445 *Carex leucantha* Arn
446. *Carex ligulata* Nees
447 *Carex longicruris* Nees.
448 *Carex mysorus* Nees
449. *Carex phacota* Spring.
450 *Carex wightiana*
451 *Careya arborea* Roxb
452. *Carica papaya* L
453 *Carissa inermis* Vahl
454 *Caryota urens* L
455 *Cascabela thevetia* (L) Lippold
456 *Cascuta chinensis* Lam
457 *Cascuta reflexa* Roxb
458. *Casearia ovata* (Lamk) Wild
459. *Casearia rubescens* Dalz
460. *Casearia tomentosa* Roxb
461. *Cassia absus* L
462. *Cassia alata* L
463. *Cassia fistula* L
464. *Cassia grandis* L
465. *Cassia hirsuta* L
466. *Cassia intermedia* B D Sharma et al.
467. *Cassia javanica* L
468. *Cassia kleinii* Wight & Arn
469. *Cassia mimosoides* L
470. *Cassia montana* Aeyne ex Roth
471. *Cassia occidentalis* L
472. *Cassia siamea* Lam
473. *Cassia sophera* L
474. *Cassia surattensis* Burm.F
475. *Cassia timoriensis* DC
476. *Cassia tora* L
477. *Cassine paniculata* lobr Callen
478. *Casuarina equisetifolia* Forst.
479. *Catharanthus pusillus* (Murray) G. Don
480. *Catharanthus roseus* (L.) G. Don.
481. *Catunaragam spinosa* (Thumb.) Tirveng
482. *Cayratia japonica* (Thumb) Gagn
483 *Cayratia pedata* (Lam) Juss
484 *Cayratia tenuifolia* (W&A) Gajnep
485 *Cayratin carnosa* Gaynep
486 *Celastrus paniculatus* Willd
487 *Celosia pulchella* MCq
488. *Celtis philippensis* Blanco var. wightii
489. *Celtis tetrandra* Roxb
490. *Centella asiatica* (L) Urban in Martins
491. *Centipeda minima* (L) A Braun
492. *Centotheca lappaceae* (L) Desv
493. *Centotheca latifolia* (Osbeck) Trin
494. *Centranthera indica* (L.) Gamble
495. *Centrosema pubescens* Benth
496. *Centrosema virginianum* (L.) Benth.
497 *Cerasiocarpum bennettii* Cogn
498. *Cerbera odallam* Gaertn
499. *Ceropegia beddomei* Hook.F
500. *Ceropegia candelabrum* L
501. *Ceropegia ensifolia* Bedd.
502. *Ceropegia hirsuta* Wight & Arn
503. *Ceropegia intermedia* Wight
504. *Ceropegia maculata* Bedd
505. *Ceropegia metziana* Miq
506. *Ceropegia pusilla* Wight&Arn
507. *Ceropegia uniflora* Anilkumar
508. *Cestrum nocturnum* L
509 *Chassalia curviflora* Thw
510 *Chassalia ophiexyloides* (Wall) Craib
511. *Cheirostylis flabellata* Wight
512. *Cheirostylis parvifolia* Lindl
513. *Chenomorpha fragrans* (Moon)Alston
514. *Chenomorpha grandiflora*
515. *Chenopodium ambrosioides* L
516. *Chilocarpus atrovirens* (G. Don.) Blume
517. *Chilocarpus denudatus* Blume
518. *Chionachne koenigii* Thw
519. *Chionanthus linocieroides* (Wight)
520 *Chionanthus malabaricus* Bedd
521. *Chionanthus mala-elengi* (Dennsnnst) Green
522. *Chionanthus ramiflora* Roxb
523. *Chionanthus roxburghii* Srivast & Kapoor
524. *Chionanthus spinarum* L

Contd....

Appendix 3.5.2.1 Contd...

525. *Chionanthus zeylanica* L
526 *Chloris barbata* Sw.
527 *Chlorophytum attenuatum* (Wight) Booker
528 *Chlorophytum heynei* Rottler
529 *Chlorophytum laxum* R Br
530 *Chlorophytum nimmonii* Dalz
531 *Christisonia bicolor* Gard
532 *Christisonia tubulosa* (Wight) Benth ex Hook.F
533 *Christosonia calcarata* Wight
534 *Christosonia neilgherrica* Gard
535 *Chromolaena odorata* (L.) King&Robinson
536 *Chrozophora rottleri* A. Juss
537 *Chrysophyllum cainito.* L
538 *Chrysophyllum roxburghii* G Don
539 *Chrysopogan asper* Blatt
540 *Chrysopogan fulvous* Chiov
541 *Chrysopogen aciculatus* (Retz.) Trin
542 *Chrysopogen hackelii* (Hook.F) Fischer
543 *Chrysopogen zeylanicus* Thw
544 *Chukkrasia mollisima* (Wall.) Gagn
545 *Chukrasia tabularis* A. Juss
546 *Cieba pentandra* L.
547 *Cinnamomum keralaense* Kosterm
548 *Cinnamomum macrocarpum* Hook
549 *Cinnamomum malabatrum* (burmf.)
550 *Cinnamomum perrottettii* Meisner
551 *Cinnamomum riparium* gamble
552 *Cinnamomum stocksii* Meisner
553 *Cinnamomum sulphuratum* Nees
554 *Cinnamomum verum* Prest
555. *Cinnamomum wightii*
556 *Cipadessa baccifera* (Roth.) Miq
557 *Cissampelos pariera* L
558 *Cissus discolor* Bl.
559 *Cissus glauca* Roxb
560 *Cissus glyptocarpa* (T) Planch
561 *Cissus heyneana* Planch
562 *Cissus javanica* DC
563 *Cissus latifolia* Lamk
564 *Cissus quadrangularis* L.
565 *Cissus repens* Lam.
566 *Cissus trilobata* Lam
567. *Citharexylum subserratum* Sw
568. *Citrullus lanatus* (Thumb) Matsumara
569. *Clamus hookerianum* Becc.
570. *Clausena austroindica* Stone
571. *Clausena dentata* (Willd.) Roem
572. *Clausena heptaphylla* (Roxb.) Wight & Arn.
573. *Clausena indica* (Dalz.) Oliver
574. *Cledion spiciflorum* (Burm.F.)
575. *Cleistachne sorghoides* Benth
576 *Cleistanthus collinus* (Roxb.) Benth.
577 *Cleistostoma tenuiplium* (L.) Grosy
578 *Clematis gouriana* (Roxb.) ex. DC.
579. *Clematis munroiana* Wight
580. *Clematis smilacifolia* Wall
581. *Cleome burmanii* Wight & Arn.
582. *Cleome gynandra* L.
583. *Cleome monophylla* L.
584. *Cleome speciosa* Raffin.
585 *Cleome viscosa*
586. *Clerodendron indicum* (L.) Kuntze
587. *Clerodendron inerme* (L.) Gaertn.
588 *Clerodendron serratum* (L.) Moon
589 *Clerodendrum paniculatum* L.
590. *Clerodendrum philippinum* Schauer
591 *Clerodendrum viscosum* vent
592 *Clidemia hirta* (L.) D Don
593 *Coccinia grandis* (L.) J Voight
594 *Cocculus laurifolius* DC
595 *Cochlospermum religiosum* Alston
596 *Cocos nucifera* L
597 *Coelachne simpliciuscula* Benth
598 *Coelogyne breviscapa* Lindl
599 *Coelogyne nervosa* Rich
600 *Coffea canephora* Pierre ex Froehner var Robusta
601 *Coffea crassifolia* Gamble
602 *Coffea travancorensis* Wall
603 *Coixlacryma-jobi* L
604 *Coldenia proumbens* L
605 *Colebrookea oppositifolia* Sm
606 *Coleus barbatus* (Andr.) Benth
607 *Coleus malabaricus* Benth
608 *Colocasia esculentata* (L.) Schott
609 *Combretum albidum* G Don
610 *Combretum latifolium* Bl
611 *Commelina attenuata* J Koening
612 *Commelina benghalensis* L
613 *Commelina diffusa* Barm F
614 *Commelina ensifolia* R Br
615 *Commelina erecta* L
616 *Commelina imberbis* Ehrenb
617 *Commelina maculata* Edgew
618 *Commelina paludosa* Blume
619 *Connarus monocarpus* L
620 *Connarus sclerocarpus* (W&A) Schellenb
621 *Connarus wightii* Hook F
622 *Conoropus chidymus* (L.) Smith
623 *Conyza aegyptiaca* Ait
624 *Conyza bonariensis* (L.) Cronq
625 *Conyza japonica* (Thumb.) Less
626 *Conyza leucantha* (D Don) Ludlow
627 *Conyza stricta* Willd
628 *Corchorus aestuans* L
629 *Corchorus capsularis* L
630 *Corchorus olitorius* L
631 *Corchorus trilocularis* L
632 *Cordia cylindristachya* Room.&Scnult
633 *Cordia octandra* A.DC. (Exincted)
634. *Cordia wallichi* G. Don.
635. *Corypha umbraculifera* L.
636. *Coscinium fenestratum* (Gaertn.) Colebr
637. *Cosmostigma racemosum* (Roxb.) Wight
638. *Costus peduncularis* (Lindl.) Reichb.F
639 *Costus speciosus* (J. Koem) Smith
640 *Cottonia peduncularis* (Lindl.) Reichb F
641 *Couroupita guianensia* Auld
642. *Crassocephalum crepidioides* S Moore
643 *Crataeva magna* (Lour.) DC
644. *Crateaeva nurvala* Ham
645 *Crepis acaulis* (Kurz) Hook.F
646. *Crinum latifolium* L.
647. *Crotalaria barbata* Graham ex Wight&Arn
648. *Crotalaria calycina* Schrank
649. *Crotalaria clerkei* Gamble
650. *Crotalaria evolouloides* Wigtht ex Wight&Arn
651. *Crotalaria fysonii* Gamble
652. *Crotalaria grahamiana* Wt.&Arn
653. *Crotalaria heyneana* Grah.
654. *Crotalaria humifusa* Graham ex Benth
655. *Crotalaria juncea* L
656. *Crotalaria laevigata* Lamk

Contd....

657 *Crotalaria multiflora* Benth.
658 *Crotalaria mysorensis* Roth
659 *Crotalaria nana* Burm F
660 *Crotalaria obtecta* Graham ex Wight
661 *Crotalaria ovalifolia* Wall
662 *Crotalaria pallida* Dryand Var acutifolia
663 *Crotalaria pallida* Dryand Var peilider
664 *Crotalaria peduncularis* Graham ex Wight
665 *Crotalaria retusa* L
666 *Crotalaria salicifolia* Heyne ex Wight&Arn
667 *Crotalaria scabra* Gamble
668 *Crotalaria scabrella* Wt &Arn
669 *Crotalaria semperflorens* Vent
670 *Crotalaria sericea* Retz
671 *Crotalaria shevaroyensis* Gamble
672 *Crotalaria subperfoliata* Wight ex Wight&Arn
673 *Crotalaria triquetra* Dalz
674 *Crotalaria umbellata* WQt
675 *Crotalaria verrucosa* L
676 *Crotalaria walkeri* Arn
677 *Crotalaria wightiana* Graham ex Wight
678 *Croton bonplandianus* Baillon
679 *Croton caudatus* geiseler
680 *Croton klotzenanus* (Wight) Thw
681 *Croton laccifer* L
682 *Croton malabaricus* Bedd
683 *Croton tiglium* L
684 *Croton zeylanicus* Muell-Art
685 *Cryptocarya beddomei* (Gamble)
686 *Cryptocarya bourdillonii* Gamble
687 *Cryptocaryne retrospiralis* (Roxb.) Kunth
688 *Cryptolepis buchanani* R. Br.
689 *Cucumella silentvalleyii* Manilan et al
690 *Cucumis prophetarum* L
691 *Cucumis sativus* L
692 *Cullenia exarillata* Robyns
693. *Curculigo orchioides* Gaertner
694. *Curculigo trichocarpa* Bennet
695. *Curcuma angustifolia* Roxb
696. *Curcuma amada* Roxb.
697 *Curcuma aromatica* Salish
698 *Curcuma coriaceae*
699 *Curcuma ecalcarata*
700 *Curcuma haritha* Mangaly&Sabu
701 *Curcuma montana* Rosc.
702. *Curcuma peethapushpa* Sasi & Sivar
703 *Curcuma petiolata* Roxb.
704 *Curcuma pseudomontana* Grah
705. *Curcuma zedoaria* (Chrishmanu) Roscoe
706 *Cyanotis arachnoidea* Clarke
707. *Cyanotis arcotensis* Rao
708 *Cyanotis cristata* (L.) D. Don
709. *Cyanotis fasciculata* Schultes F
710 *Cyanotis pilosa* Schulates.F
711 *Cyanotis tuberosa* (Roxb.) Schult
712 *Cyanotis villosa* (Sprengel) Schultes f
713 *Cyathocalyx zeylanicus* Champ Ex Hook F &Thomas
714 *Cyathula prostrata* (L.) Blume
715 *Cycas circinalis* L
716 *Cyclea arnotii* Meirs
717 *Cyclea fissicalyx* Dunn
718 *Cyclea peltata* (Poir) Hook.F & Thomas
719 *Cymbidium aloifolium* (L.) Sw.
720 *Cymbidium ensifolium* (L) Sw
721 *Cymbopogas caesius* Staff
722. *Cymbopogas travancorensis* N
723. *Cymbopogen citratus* (OC) Staff
724. *Cymbopogen flexuosus* Wats
725. *Cynanchum callialatum* Buch Ham Ex Wight&Arn
726 *Cynodon dactylon* (L) Pres
727 *Cynoglossum zeylanicum* Thub
728. *Cynometra travancorica* Bedd
729 *Cyperus castaneous* Willd
730 *Cyperus cephalotes* Vahl
731 *Cyperus compressus* L
732 *Cyperus corymbosus* Rottts
733. *Cyperus cuspidatus* Kunth
734 *Cyperus defformis* L
735. *Cyperus diffusus* Vahl
736 *Cyperus digitatus* Roxb
737 *Cyperus distance* L F
738. *Cyperus exaltatus* Retz
739. *Cyperus haspan* L
740. *Cyperus iria* L
741. *Cyperus malaccensis* lam
742. *Cyperus natans* Vahl
743 *Cyperus oatesii* Clarke
744 *Cyperus pangorei* Rottb
745 *Cyperus pilosus* Vahl
746 *Cyperus platystylis* R Br
747 *Cyperus procerus* Rottb
748. *Cyperus pygmacus* Rottb
749 *Cyperus rotuendus* L
750. *Cyperus tenuiculmis* Boeck
751. *Cyperus tinuispica* Steud
752. *Cyperus zollingeri* Steud
753. *Cyrtococcum deccanense* N.I. Bor
754. *Cyrtococcum longipes* A. Camus
755. *Cyrtococcum muricaturs* (Retz.) Bor
756. *Cyrtococcum oxyphyllum* (Stend.) Stapf
757. *Cyrtococcum patens* (L.) A. Camus
758. *Cyrtococcum trigonum* A Camus
759. *Dactyloctenium aegypticum* (L.) P Beauv.
760. *Dactyospermum montanum* Light
761. *Dactyospermum ovalifolium* Wight
762. *Dactyospermum protensum* Wight
763. *Dalbergia beddomei* Thoth
764. *Dalbergia horrida* Mabb
765. *Dalbergia latifolia* Roxb
766. *Dalbergia malabarica*
767. *Dalbergia pseudo-sisso* Miq
768. *Dalbergia sissoides* Grah
769. *Dalbergia travancorica*
770. *Dalbergia volublis* Roxb
771. *Dalbergia pinnata*
772. *Dalechampia velutina*
773. *Daphniphyllum neilgherrense*
774. *Datura arborea* L
775. *Datura metel* L
776. *Datura stramonium* Linn
777. *Debregesia ceylanica* Hook.F
778. *Debregesia longifolia* (Burm f) Wedd
779. *Decalepis hamiltonii*
780 *Delonix regia* (Hook) Ref
781 *Dendrobium macrostachyum* Lindl
782 *Dendrobium anamalyanum* Chandr
783. *Dendrobium aqueum* Lindl
784. *Dendrobium barbatum* Lindl
785. *Dendrobium haemoglossum* Thw
786. *Dendrobium herbaceum* Lindl
787. *Dendrobium heterocarpum* Lindl

Contd....

Appendix 3.5.2.1 Contd..

788 Dendrobium heyneanum Lindl
789 Dendrobium lawianum Lindl
790 Dendrobium microbulon
791 Dendrobium nanum Hook.F
792 Dendrobium nutantiflorum Hawees
793 Dendrobium ovatum (Wild.) Kraenzl
794 Dendrobium panduratum Lindl
795. Dendrobium wightii Hawkes&Heller
796 Dendrocnide sinuata (Blume) Chew
797 Dendrophothoe falcata (L.F.) Etting
798 Dendrophthoe elasticus (Desr.) Danser
799 Dendrophthoe memecylifolia
800 Dendrophthoe neelgherrensis Tieghem
801. Dendrophthoe trigona Danser
802. Dentella repens (L.) J.R
803. Dentella travancorensis Wall.
804. Derris brevipes (Benth) Baker in Hook.f.
805 Derris canarensis (Dalz.) baker in Hooker F
806 Derris scandens (Roxb.) Benth.
807 Derris thothathrii Bennett.
808. Derris benthamii (Thu.) Enum
809. Derris brevipes var. brevipes
810. Derris brevipes var. coriaceae
811. Derris brevipes var. travancorica
812. Derris indica (Lam) Bennet
813. Derris thothathrii
814 Derris thyrsiflora Benth
815. Derris trifoliata Lour
816. Desmodium racemosum
817 Desmodium alysicarpoides Van. Meeulien
818 Desmodium dichotomum (Willd.) DC
819. Desmodium ferrugineum Wall
820. Desmodium gangeticum (L.) DC
821. Desmodium heterocarpon (I.) DC
822. Desmodium heterophyllum (Willd.) DC
823. Desmodium laxiflorum DC
824. Desmodium laxum DC
825. Desmodium microphyllum (Thump) DC
826. Desmodium motorium (Hoult.) Merr
827. Desmodium pryonii DC
828. Desmodium pulchellum (L.) Benth
829. Desmodium repandum (Vahl.) DC
830. Desmodium rufescens DC
831. Desmodium styracifolium (Osbeck.) Merr
832. Desmodium triangulare (Retz.) Merr.
833. Desmodium triflorum (L.) DC
834 Desmodium triquetrum (L.) DC
835 Desmodium uncinatum (Jacq.) DC
836. Desmodium velutinum (Willd.) DC
837 Desmodium zonatum Moq.
838 Desmos lawii (Hook.F.&Thoms) Safford
839 Desmos pannosus (Datz) Safford
840 Desmos viridiflorus (Bedd) Safford
841 Dianella ensifolia (L.) DC
842 Dicaelospermum ritchiei Clarke
843 Dicanthium filiculme
844 Dichaetaria wightii Nees
845 Dichanthium annulatum Staff.
846 Dichanthium foulkesii Jain & Desh
847 Dichanthium oliganthum Cope
848. Dichapetalum gelonioides Eng
849. Dichrocephala integrifolia (L.F)
850 Dicliptera cuneata nees
851. Dicliptera foetida (Forsk.) Baltt
852 Dictyospermum ovalifolium
853 Didymocarpus fischeri Gamble
854. Didymocarpus gambleanus
855. Didymocarpus humboldtianus Gardn.
856. Didymocarpus innominatus Burtt
857. Didymocarpus macrostachya
858. Didymocarpus meeboldii
859. Didymocarpus missionis
860. Didymocarpus ovalifolia Wight
861. Didymocarpus tomentosus Wihgt
862. Didymocarpus repens
863. Didyplosandra andersonii
864. Didyplosandra bolumpattiana
865. Digeria muricata (L.) Mar
866. Digitaria bicornis Roem
867. Digitaria griffithii Henr
868. Digitaria longiflora (Retz.) Pres.
869. Digitaria radicosa (Pers.) Miq.
870. Digitaria setigera Roth ex Roem
871. Digitaria ternata (A Rich) Staff
872. Digitaria wallichiana Stapf
873. Digitoria ciliaris (Retz.) Kaeler
874. Dillenia pentagyna Roxb
875. Dillenia bracteata
876. Dimeria connivens Hack
877. Dimeria copeana
878. Dimeria deccanensis Bor
879. Dimeria fischeri Gamble
880. Dimeria fuscescens Trim
881 Dimeria hohenackeri
882. Dimeria idukkiensis Ravi ex Anilkumar
883. Dimeria jainii
884. Dimeria kanjirapallilana K.C. Jacob
885. Dimeria kurumthotticalana Jacob
886. Dimeria lawsonii (Hook f.) Fisher
887. Dimeria mooneyi Raizada
888. Dimeria ornithopoda Trin
889. Dimeria thwaitesii Hack
890. Dimocarpus longan Lour
891. Dimorphocalys lawianus (Muell-Aug) Hook.F
892. Dimorphocalyx beddomei
893. Dimorphocalyx glabellus
894. Dimorphocalyx lawiamsi
895. Dioscorea bulbifera L
896. Dioscorea hispida Dennsted
897. Dioscorea pentaphylla L
898. Dioscorea tomentosa J Koenig
899. Diospyros alata
900. Diospyros assimilis Bedd
901. Diospyros bourdillonii Brandis
902. Diospyros buxifolia (Bl) Hiern
903. Diospyros candolleana Wight
904. Diospyros crumenata Thw
905. Diospyros ebenum Koen
906 Diospyros ferrea (Willd) Barkh
907 Diospyros ghatensis Ramesh & Franceschi
908. Diospyros hirsuta L F
909. Diospyros humilis
910. Diospyros malabarica (Desr) Kostel
911. Diospyros montana Roxb
912. Diospyros nilagirica Bedd
913. Diospyros ovalifolia Wight
914. Diospyros paniculata Dalz
915. Diospyros pruriens Dalz
916. Diospyros sulcata
917. Diospyros sylvatica Roxb
918. Diospyros toposia Buch-Ham
919. Diplocentrum congestrum Wight
920. Diplocentrum recurvum Lindl

Contd....

Appendix 3.5.2.1 Contd..

921. *Diplocentrum wallichii Hook. F*
922. *Diploclisia glaucescens (Bl.) Diels.In Engl*
923. *Diplocyclos palmatus (l.) C. Jeffrey*
924 *Dipteracanthus prostatus (Poiret) Nees*
925. *Dipterocarpus bourdilloni Brandis in Hook.*
926. *Dipterocarpus indicus Bedd.*
927 *Dioscorea oppositifolia L.*
928. *Disoxylum malabaricum Bedd.*
929. *Disperis neilgherrense Wight*
930 *Disporum leschenaultianum*
931 *Dispsacus leschenaultii*
932. *Dodonaca viscosa (L.) Jacq*
933. *Dodoncea angustifolia L.F.*
934 *Dolichandrone arcuata*
935. *Dolichandrone atrovirens*
936. *Dolichos trilobus L.*
937 *Dopatnum junceum (Roxb.) Buch-Ham*
938 *Dopatrium nudicaule (Willd.) Benth*
939. *Dorstenia indica Wall*
940 *Dracaena terniflora Roxb.*
941 *Drosera burmanii Vahl*
942 *Drosera indica L*
943 *Drosera peltata Smith ex Willd*
944 *Drymaria cordata (L.) Willd.*
945. *Drypetes confertiflora pax & Hotfm.*
946. *Drypetes elata (Bedd.) Airy shaw*
947 *Drypetes malabarica (Bedd.) Airy Shaw*
948. *Drypetes wightii*
949. *Drypetis oblangifolia (Bedd.) Airy shaw*
950. *Dryptetes venusata Pax&Hoffn*
951. *Dumasia villosa DC*
952. *Dunbaria heynei Wright&Arn*
953. *Dysoxylum beddomei Hiern.*
954 *Dysoxylum binectariferum Hook.F*
955. *Dysoxylum ficiforme (Wight) gamble*
956 *Dysoxylum malabaricum*
957. *Dysoxylum swaminathanianum .. Anilkumar*
958. *Ecbolium viride (Forssk.) Alston*
959. *Echinochloa colona (L.) Link*
960. *Echinochloa crusgalli P. Beanu*
961. *Echinochloa stagnina (Retz.) P Beaur*
962 *Eclipta prostrata (L.)*
963 *Eebolium capense L*
964 *Ehretia canarensis (Clarke) Gamble*
965. *Ehretia indica M.R & S.M Almedia*
966. *Eichornia crassipes (C. Martins)*
967 *Elaegnus canferta Roxb*
968. *Elaegnus indica Servettaz*
969. *Elaeocarpus glandulosus Wall.*
970. *Elaeocarpus munronii (Wight) Mart. Hook F*
971. *Elaeocarpus recurvatus*
972 *Elaeocarpus serratus L*
973 *Elaeocarpus tuberculatus Roxb*
974 *Elaeocarpus venustus*
975 *Elatostema wightii Hook.F*
976 *Elatostemma lineolatum Wight*
977. *Eleocharis acutangula Schult*
978. *Eleocharis congesta D.Don*
979. *Eleocharis dulcis (Burm.F.) Trim*
980 *Eleocharis retroflexa (Poiret)*
981. *Eleocharis tetraquetra Nees*
982. *Elephantopus scaber L.*
983. *Elettaria cardamomum (L.) Maton*
984. *Eleusine indica (L.) Gaertn.*
985 *Eleutheranthera ruderalis* Sch-Bip
986 *Ellertonia rheedei* Wight
987. *Embelia adanata Bedd*
988. *Embelia ribes Burm F*
989. *Embelia tsjeriam -Cottam (Roem &Schults) DC*
990. *Emelia scabra DC*
991. *Emelia sonchifolia (L.)*
992. *Emilia ramulosa*
993. *Ensete superbum (Roxb.) Cheesman*
994. *Entada rheedei Sprengel in L*
995. *Epaltes divaricata (L.) Cass*
996. *Epipogium roseum Lindl*
997. *Epiprinus mallotiformis Croizat*
998. *Epithema carnosum (G Dan) Benth Var.hispida*
999. *Eragrostis nutans (Retz.) Nees*
1000. *Eragrostis nigra Nees*
1001. *Eragrostis pilosa (L.) P Beauv*
1002. *Eragrostis tenuifolia Hochst*
1003. *Eragrostiella bifaria Bor*
1004. *Eragrostis deccanensis*
1005. *Eragrostis tenella (L.) P Beanu*
1006. *Eragrostis uniloides (Retz.) Nees*
1007 *Eragrostis cilianesis (All.) Vign*
1008. *Eragrostis gangetica Stend*
1009. *Eragrostis atrovirens Trin*
1010. *Eragrostis japonica Trin*
1011. *Eria dalzellii (Dalz.) Lindl*
1012. *Eria exilis*
1013. *Eria mysorensis Lindl*
1014. *Eria nana A Rich*
1015. *Eria pauciflora*
1016. *Eria polystachya A Rich*
1017. *Eria pseudoclavicaulis Blatt*
1018. *Eria reticosa Wt*
1019. *Ericaulon polycephalum*
1020. *Erigeron asteroides Roxb*
1021. *Erigeron canadensis (L.)*
1022. *Erigeron karvinskianus DC*
1023. *Eriocaulon brownianum Mart*
1024. *Eriocaulon cinereum R Br*
1025. *Eriocaulon conica (Fyson) Fischer*
1026. *Eriocaulon dianae Fyson*
1027. *Eriocaulon gamblei*
1028. *Eriocaulon longicuspis Hook.F*
1029. *Eriocaulon nepalense Prescett*
1030 *Eriocaulon odoratum Dalz*
1031. *Eriocaulon parviflorum (Fyson) Ansari*
1032. *Eriocaulon pectinatum Ruhl*
1033. *Eriocaulon quinquangulare L*
1034. *Eriocaulon stellulatum*
1035. *Eriocaulon thwaitesii Koern*
1036 *Eriocaulon trilobum Bunch-Ham*
1037 *Eriocaulon truncatum Buch-Ham*
1038 *Eriocaulon vanheuckii*
1039 *Eriocaulon xeranthemum Mart*
1040 *Eriocharus spiralis (Rottb.) Roem*
1041 *Eriolaena quinquelocularis Wight*
1042. *Eris microchilos*
1043. *Erucaykib ebsufirne*
1044. *Eruicaykib sexabgykare L*
1045. *Eruicaykib vasudevanii Ansari*
1046. *Erycibe paniculata Roxb*
1047. *Erythrina stricta Roxb*
1048. *Erythrina variegata L*
1049. *Erythropalum populifolium (Arn.) Mast.in Hook F*
1050 *Erythropalum scandens Bl*

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Appendix 3.5.2.1 Contd..

1051 *Erythroxylum monogynum* Roxb
1052 *Eucalyptus globulus* Labill
1053 *Eucalyptus grandis* Hilex.Maiden
1054 *Eucalyptus tereticornis* Smith
1055 *Eucalyptus torelliana* F.V
1056 *Eudia lunu-ankeda* (Gaertn.) Merr
1057 *Eugenia bracteater* (Willd.) Roxb
1058 *Eugenia calcadensis* Bedd
1059 *Eugenia discifera*
1060 *Eugenia indica*
1061 *Eugenia rottleriana* Wight & Arn
1062 *Eugenia thawitesii* Duthie in Hook.F
1063 *Eulaia phaeothrix* (Hack.) O Ktze
1064 *Eulalia trispicata* Henr.
1065 *Eulophia epidendraea* Fischer
1066 *Eulophia hirusta*
1067 *Eulophia nuda* Lind.
1068 *Eulophia ochreata*
1069 *Eulophia pulchra* (Thou) Lindl
1070 *Eulophia sangruinea* Hook.F
1071 *Eulophia spectabilis* (Dennst.) Suresh & Nicols
1072 *Euonymus serratifolius* Bedd
1073 *Euonymus crenulatus* Wall.ex.Wight&Arn
1074 *Euonymus indicus* Heyne
1075 *Euonymus paniculatus* Wight
1076 *Euphorbia geniculata* Ortega
1077 *Euphorbia heterophylla* L
1078 *Euphorbia heyneana* Sprengel
1079 *Euphorbia hirta* L
1080 *Euphorbia nivulea* Buch-Ham
1081 *Euphorbia pulcherrima* Willd
1082 *Euphorbia rothiana* Spreng
1083 *Euphorbia thymifolia* L
1084 *Euphorbia tirucalli* L.
1085 *Euphorbia vajravelui* Binojk & Balaxr
1086 *Eurya nitida* Korthals in Temminck
1087 *Eusteralis deccanensis*
1088 *Eusteralis tomentosa* var. *gracilis*
1089 *Evolvulus alsinoides* (L.) L
1090 *Evolvulus nummularis* (L.) L
1091 *Exacum anamallayanum*
1092 *Exacum atropurpureum* Bedd
1093 *Exacum courtallense* Arn.
1094 *Exacum grande* Klack
1095 *Exacum lawii* Clarke
1096 *Exacum petiolare* Griseb
1097 *Exacum pumilum* Griseb
1098 *Exacum sessile* L.
1099 *Exacum tetragenum* Roxb
1100 *Exacum wightianum* var. *wightianum*
1101 *Excoecaria crenulata* Wight
1102 *Excoecaria robusta* Hook F
1103 *Fahrenheitia zeylanica* (Thw.) Airy show
1104 *Falcourtia ramontachi* L'Her
1105 *Ffimbristylis tenera* Schult
1106 *Ficus amplissima* Smith
1107 *Ficus amplocarpa* Govindrajalu&Masilamoney
1108 *Ficus arnottiana* (Miq.) Miq.
1109 *Ficus beddomei* King.
1110 *Ficus benghalensis* L.
1111 *Ficus callosa* Willd
1112 *Ficus costata* Ait.
1113 *Ficus coulocarpa* Mig.
1114 *Ficus dalhousiae*
1115 *Ficus drupacea* Thumb
1116. *Ficus exasperata*
1117. *Ficus glaberrima* Blume
1118. *Ficus guttata*
1119. *Ficus heterophylla*
1120 *Ficus hispida* L F
1121 *Ficus microcarpa* L F
1122. *Ficus nervosa* Heyne
1123. *Ficus racemosa* L
1124 *Ficus religiosa* L
1125. *Ficus talbotii* King
1126. *Ficus tinctoria* Forster F
1127 *Ficus travancorica* King
1128. *Ficus tsjakela* Burm F
1129. *Ficus virens* Ait var *Wightiana*
1130. *Filicium decipiens* (Wight & Arn.) Thw
1131. *Fimbristylis aestivalis* (Retz.)
1132. *Fimbristylis aggregata*
1133 *Fimbristylis angamoozhiensis* Ravi et Anilkumar
1134. *Fimbristylis aphylla* Stend
1135. *Fimbristylis argentea* Vahl
1136 *Fimbristylis bisumbellata* Bubani
1137. *Fimbristylis cinnamometorum* (Vahl) Kunth
1138. *Fimbristylis complanata* (Retz.) Link
1139. *Fimbristylis cymosa* R Br
1140. *Fimbristylis dauciformis*
1141. *Fimbristylis dichotoma* (L.) Vahl
1142. *Fimbristylis dipsaceae* Clarke
1143. *Fimbristylis dura* Merr
1144. *Fimbristylis eragrostis* (Nees) Hance
1145 *Fimbristylis falcata* (Vahl) Kunth
1146. *Fimbristylis glabra* Stend
1147. *Fimbristylis littoralis* Gardich
1148. *Fimbristylis milliaceae* (L.) Vahl
1149. *Fimbristylis monospicula*
1150. *Fimbristylis monticola* Hoist
1151. *Fimbristylis narayanii* Fischer
1152. *Fimbristylis ovata* (Burm F) Kern
1153. *Fimbristylis paupercula*
1154. *Fimbristylis pseudonarayanii* Revi.et.Anilkumar
1155. *Fimbristylis schoenoides* (Retz.). Vahl
1156. *Fimbristylis tetragona* R Br
1157. *Fimbristylis tomentosa* Vahl
1158. *Fimbristylis uliginosa* Hoist
1159. *Firmiana colorata* (Roxb.) R. Br.
1160. *Flacourtia indica* (Burm F) Merr
1161. *Flacourtia montana* Grah
1162. *Flacourtia ramontchi* L'Her
1163. *Flagellaria indica* L
1164. *Flemingia bracteata* (Roxb.) Wight
1165 *Flemingia grahamiana* W&Arn
1166 *Flemingia macrophylla* (Willd) Prain ex Merr
1167 *Flemingia nilgheriensis*
1168 *Flemingia semialata* Roxb
1169. *Flemingia strobilifera* (L.) R Br Ex Ait
1170. *Flemingia wallichi* Wight&Arn
1171. *Flickingeria nodosa* Seidenf
1172. *Floria vitifolia* (L.) Mattei
1173. *Floscopa scandens* Lour
1174. *Fragraea ceylanica* Thumb
1175. *Fuirena ciliaris* (L) Roxb
1176. *Fuirena ponmudiensis* Ravi-Anilkumar
1177. *Fuirena umbellata*
1178. *Furcraea foetida* (L) Hawerth
1179. *Galinsoga parviflora* Cav

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Appendix 3.5.2.1 Contd..

1180 *Galphinia glauca* Cav.
1181. *Garcinia cowa* Roxb
1182. *Garcinia gummi-gutta* (L.) Robson
1183. *Garcinia indica*
1184. *Garcinia mangostana* L.
1185 *Garcinia morella* (Gaerh.) Desv
1186 *Garcinia spicata* (Wight&Arn) Hook.F
1187 *Garcinia talbotii*
1188. *Garcinia travancorica*
1189. *Garcinia wightii* T.
1190 *Gardneria ovata* Wall.
1191. *Garnotia arborum*
1192. *Garnotia arundinaceae* Hook.F
1193. *Garnotia courtallensis* Thw.
1194 *Garnotia elata* Janowski
1195 *Garnotia exarıstata* Gould
1196 *Garnotia tenella* (Mig.) Jan
1197 *Garuga pinnata* Roxb
1198 *Gastrochilus bigibbus* O. Ktze
1199 *Gastrochilus calceolaris* D.Don
1200. *Gastrochilus indicus* Garay
1201. *Geissapis cristata* Wight&Arn.
1202. *Gemphrena serrata* L.
1203. *Gendarussa vulgaris* Nees
1204 *Gendarussa wynaadensis*
1205. *Geodorum densiflorum* (Lam.) Schltr
1206. *Geodyera procera* Hook.F
1207 *Geophila herbaceae* (Jacq.) K. Schum
1208. *Geophila repens* (L.) Johnston
1209. *Girardinia diversifolia* (Link.) Friis
1210. *Gliricidia sepium* (Jacq.) Kunth.ex. Walp
1211 *Glinus oppositifolius* (L.) A.DC
1212. *Glinus portulacastrum* L.
1213. *Globba marantina* L.
1214. *Globba ophioglosa* Wight
1215. *Glochidioin neilgherrense*
1216. *Glochidion arboreum*
1217. *Glochidion bourdillonii* Gamble
1218 *Glochidion ellipticum* Wight
1219 *Glochidion ellipticum var. ralphii*
1220 *Glochidion johnstonei* Hook. F
1221. *Glochidion malabaricum* Bedd
1222 *Glochidion tomentosum* Dalz
1223. *Glochidion velutinum* Wight
1224. *Glochidion zeylanicum* (Gaertner) A. Juss.
1225. *Gloriosa superba* L.
1226. *Gluta travanconca* Bedd.
1227. *Glycosmis angustifolia* Lindl
1228. *Glycosmis cymosa* (Kurz.) Narayan swami
1229. *Glycosmis macrocarpa* wt.
1230. *Glycosmis mauritiana* (Lam.) Tanaka
1231 *Glycosmis pentaphylla* (Retz.) DC
1232 *Glyphochloa arcuminata*
1233. *Glyphochola forticulata* (W.D Clayton)
1234. *Glyptopetalum grandiflorum*
1235 *Glyptopetalum lawsonii*
1236 *Glyptopetalum zeylanicum* Thw
1237. *Gmelina arborea* Roxb
1238 *Gnaphalium indicum* L.
1239. *Gnaphalium polycaulon* Pers.
1240. *Gnaphilium pulvinatum* Detile
1241 *Gnetum edule* (Willd.) Bl
1242 *Gnetum ula* Brongen
1243 *Gnidia glauca* Gamble
1244 *Gociania microcarpa* DC
1245. *Goldfussia tristis*
1246. *Gomphandra tetrandra* Sleumer
1247. *Gomphestemma heyneanum* Wall
1248. *Gomphia serrata* (Gaertn.) Kanis
1249. *Gomphiandra coriaceae* Wight
1250. *Gomphostemma eriocarpon* Benth
1251. *Gomphostemma heyneanum var rottleri*
1252. *Gomphostemma keralensis* Vivek
1253. *Gomphrena celosiodes* Martins
1254. *Gomphrena globosa* L
1255. *Gomphrena serrata* L
1256. *Goniogyna hirta* (Willd.) Ali
1257. *Goniothalamus rhyncantherus* Dunn
1258. *Goniothalamus wightii* Hook.F & Thoms
1259. *Gordonia obtusa* Wall ex Wight&Arn
1260. *Grangea madraspatana* (L.) Poir
1261. *Grewia abutilifolia* Vent ex A L juss
1262. *Grewia barberi* Drunm
1263. *Grewia disperma* Rottler ex Sprengel
1264. *Grewia gamblei*
1265. *Grewia glabra* Bl
1266. *Grewia heterotricha*
1267. *Grewia hirsuta* Vahl
1268. *Grewia laevigata* Vahl
1269. *Grewia lanceaefolia* Roxb
1270. *Grewia lawsoniana* J.R Drummn
1271. *Grewia nervosa* (Lour.) Paniqr.
1272. *Grewia obtusa* Wall ex Dunn
1273. *Grewia oppositifolia* Buch Hary
1274. *Grewia serrulata* DC
1275. *Grewia tiliifolia* Vahl
1276. *Grewia umbellifera* Bedd
1277. *Griffithella hookeriana* (Tul.) Garm
1278. *Guazuma ulmifolia* Lum
1279. *Gymnacranthera canarica* Warb
1280. *Gymnacranthera eugenifolia* (A.DC) Sinclair
1281. *Gymnacranthera fraquharriana* Warb
1282. *Gymnema kandalense* Sant
1283. *Gymnema montanum*
1284. *Gymnema sylvestre* (Retz.) R. Br
1285. *Gymnopetalum wightii* Arn.
1286. *Gymnostachum febrifugam* Benth
1287. *Gymnostachyum canescens* (Nees)
1288. *Gymnostachyum latifolium* T Anders
1289. *Gymnostachyum polyanthum* Wight
1290. *Gynura aurantiaca* (Blume) DC
1291. *Gynura lycopersicifolia* DC
1292. *Gynura nitida* DC
1293. *Gynura pseudo-China* (L.) DC
1294. *Gynura travancorica* W.W Smith
1295. *Habenaria multicaudata*
1296. *Habenaria barnesii*
1297. *Habenaria hollandiana*
1298 *Habenaria ovalifolia*
1299. *Habenaria rariflora*
1300. *Habenaria roxburghii*
1301. *Hackelochloa granularis* O ktz
1302. *Haldinia cordifolia* (Roxb.) Ridsd
1303. *Haplanthodes nilgherryensis* (Wt.) Majumdar
1304. *Haplanthodes plumosa*
1305. *Haplanthodes verticillatus*
1306. *Haplothismia exannulata*
1307. *Harpullia arborea* (Blanco) Radlk
1308. *Hebenaria barnesii* Summerh
1309. *Hebenaria clawisii* Hook F
1310. *Hebenaria crinifera* Lindl
1311. *Hebenaria heyneana* Lindl
1312. *Hebenaria malintana* (Blance) Merr.
1313. *Hebenaria multicaudata* Sed gw

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Appendix 3.5.2.1 Contd..

1314 *Hebenaria ovalifolia* Wt
1315 *Hebenaria periyarensis* Sasi
1316 *Hebenaria perrottetiana* A. Rich
1317 *Hebenaria plantaginea* Lindl
1318 *Hebenaria rariflora* A. Rich
1319 *Hebenaria viridifolia* (SW.) R Br
1320 *Hebeneria crifera* Lindl.
1321 *Hebeneria digitata* Lindl
1322 *Hebeneria longicornicolata* Lindl
1323. *Hebeneria perrottetiana* A. Rich
1324 *Hedoylis pinifolia* Wall.
1325 *Heduotis ovatifolia* Cav
1326 *Hedychium coronarium* Koenig
1327 *Hedychium flavescens* Carey
1328 *Hedychium venustum* Wight
1329 *Hedyotis affinis* Roem&Schult
1330 *Hedyotis albo-nervia*
1331 *Hedyotis anamalayana* (Gamble) R. Rao
1332 *Hedyotis articularis* R.Br
1333 *Hedyotis articularis sub sp santa pani*
1334 *Hedyotis auricularia* L
1335 *Hedyotis brachypoda* (DC.) Sivar. & Biju
1336 *Hedyotis buxifolia*
1337 *Hedyotis corymbosa* (L.) Lam
1338. *Hedyotis diffusa* Willd
1339 *Hedyotis equalata*
1340 *Hedyotis herbaceae* L
1341 *Hedyotis hygrophila* (bremek) Bennet
1342 *Hedyotis membranaceae* Thw
1343 *Hedyotis nitida* Wight&Arn.
1344. *Hedyotis pruinosa* Wight&Arn.
1345. *Hedyotis ramarowii*
1346. *Hedyotis stylosa* R. Br. Ex. Wight
1347 *Hedyotis swertioides* Hook F.
1348 *Helicanthes elastica* (Desr.) Danser
1349. *Helichrysum buddleioides* DC
1350 *Helichrysum perianigerum* Gamble
1351 *Helicia nilagirica* Bedd.
1352 *Helicteres isora* L
1353 *Heliotropium indicum* L
1354. *Heliotropium keralense* Sivar&Manilal
1355 *Heliotropium marifolium* Retz
1356 *Helixanthera hookeriana* Danser
1357 *Helixanthera intermedia* Danser
1358 *Helixanthera lepidophylla* Danser
1359. *Helixanthera obtusata* (Schult) Danser
1360 *Helixanthera wallichiana* (Schult) Danser
1361 *Hemidesmus indicus* (L.) R Br
1362 *Hemigraphis crossandra* (Steud) Bhemek
1363 *Heracleum aquilegifolium*
1364 *Heracleum candolleanum* (Wt.&Arn.) Gamble
1365 *Heracleum courtallense*
1366 *Heracleum hookerianum*
1367 *Heracleum rigens var multi radiatum*
1368 *Heracleum sprengelianum* Wight&Arn
1369 *Heritiera papilio* Bedd
1370. *Heteropogan contortus* (L.) P Beauv
1371 *Heteropogon polystachyos*
1372 *Heteropogon schmidtii*
1373 *Heterostemma deccanense* (Talb) Swarup&Manaly
1374 *Hewittia malabarica* (L.) Suresh&Nicols
1375 *Hewittia sublobatra* Kuntze
1376 *Heydotis deurcolamensis*
1377. *Heydotis stylosa*
1378 *Hibiscus aculeatus* Roxb
1379. *Hibiscus hispidissimus* Griffth
1380. *Hibiscus lobatus* O Ktze
1381 *Hibiscus lunarifolius* Willd
1382. *Hibiscus platanifolius* Sweet
1383 *Hibiscus sreenarayanianus* Anilkumar
1384. *Hibiscus surattensis* L
1385. *Hibiscus tiliaeus* L
1386. *Hiptage benghalensis* (L) Kurz.
1387. *Holarrhena pubescens* (Buch-Ham) wall.ex G Don
1388. *Holigarna nigra*
1389. *Holigarna arnottiana* Hook F
1390. *Holigarna beddomei*
1391. *Holigarna ferriginea* March
1392. *Holigarna grahanaii* (Wight) Kurz
1393. *Holigarna nigra* Bourd
1394. *Holostemma ada-kodien* Schult
1395. *Holptelia integrifolia* (Roxb.) Planch
1396. *Holygarna ferruginea*
1397 *Homalium travancorium*
1398. *Homalium zeylanicum* (Guard) Benth
1399. *Homonia riparia* Lour
1400. *Homonoia retusa* muelt-Arg
1401 *Hopea erosa* (Bedd) van sloot
1402 *Hopea fastigiata* (Griseb) Clarke
1403. *Hopea glabra* Wight&Arn
1404. *Hopea parviflora* Bedd
1405 *Hopea ponga* (Dennst) Mabb
1406 *Hopea racophotoea*
1407. *Hopea utilis*
1408. *Hoya ovalifolia* Wight&Arn
1409. *Hoya pauciflora* Wt
1410. *Hoya retusa* Dalz
1411. *Hoya wightii* Hook F
1412. *Humboldia bourdillonii*
1413. *Humboldia brunonis*
1414. *Humboldia decurrens*
1415. *Humboldia unijuga*
1416. *Humboldtia vahliana* Wight
1417 *Hunteria zeylanica* (Retz.) Gard
1418. *Hybanthus enneaspermus* (L) F V Muell
1419. *Hydnocarpus alpina* Wt
1420. *Hydnocarpus macrocarpus* (Bedd.) van sloot
1421. *Hydnocarpus pendulus* Mani. Et al
1422. *Hydnocarpus pentandra* (Buch-Ham) kam
1423. *Hydrangea macrophylla* (Thumb)Seringe
1424. *Hydrilla alismoides* (L.) Pers
1425. *Hydrilla verticillata* (L f) Royle
1426. *Hydrocera triflora* (L) Wight&Arn
1427. *Hydrocotyle conferta* Wight
1428. *Hydrocotyle javanica* Thumb
1429 *Hydrocotyle sibthorpiodes* Lam
1430 *Hydrolea zeylanica* (L) Vahl
1431. *Hygraphila ringens* (L) R Br
1432. *Hygrophila auriculata* Heins
1433. *Hygrophila erecta* Hochr
1434. *Hygrophila salicifolia* (Vahl) Nees
1435. *Hygrophila schulli* (Ham) MR & S M Almeida
1436. *Hygroyza aristata* (Retz) Nees
1437 *Hymenodictyon oboratum* Wall
1438. *Hymenodictyon orixense* (Roxb)) Mabb
1439. *Hypericum humifusum* L
1440. *Hypericum japonicum* Thumb ex.Murray in L
1441. *Hypericum mysurense* Wt &Arn
1442. *Hypericum wightianum* Wall
1443. *Hypolytrum nemorum* (Vahl) Spreng
1444 *Hypoxis aurea* Lour

Contd....

Appendix 3.5.2.1 Contd..

1445. *Hyptis capitata Jacq.*
1446. *Hyptis rhomboidea Mart&Gal.*
1447. *Hyptis snaveolens (L.) Poit*
1448. *Ichaemum nilàgiricum Hook*
1449. *Ichnanthus vicinus Merr.*
1450 *Ichnocarpus frutescens (L.) R. Br*
1451 *Ilex denticulata Wall*
1452. *Ilex gardenriana Wight*
1453. *Ilex malabarica Bedd.*
1454. *Impatiens fruticosa*
1455. *Impatiens acaulis Arn*
1456. *Impatiens anaimudica*
1457. *Impatiens auriculata Wight*
1458 *Impatiens balsamina L.*
1459. *Impatiens campanulata Wight*
1460 *Impatiens chinensis L*
1461. *Impatiens clavicornu Turcz.*
1462. *Impatiens cochinica*
1463. *Impatiens coelotropis*
1464. *Impatiens companulata*
1465. *Impatiens cordata Wight*
1466 *Impatiens crenata*
1467 *Impatiens cuspidata Wight&Arn*
1468. *Impatiens dasysperma Wight*
1469 *Impatiens disotis*
1470 *Impatiens elegans*
1471. *Impatiens flaccida Arn*
1472. *Impatiens gardneriana Wight*
1473. *Impatiens goughii Wight*
1474. *Impatiens grandis Heyne*
1475. *Impatiens hensloviana Arn.*
1476 *Impatiens herbicola Hook.F.*
1477 *Impatiens inconspicua Benth*
1478 *Impatiens jerdoniae*
1479 *Impatiens johnii*
1480 *Impatiens kleiniformis*
1481 *Impatiens kulamavensis*
1482. *Impatiens latifolia L*
1483. *Impatiens lawii*
1484. *Impatiens lenta*
1485. *Impatiens leptura Hook.F.*
1486. *Impatiens leschenaultii*
1487. *Impatiens levingei Gamble*
1488. *Impatiens ligulata*
1489. *Impatiens longiracemosa Boivin ex. Baillon*
1490. *Impatiens lucida Heyne*
1491. *Impatiens macrocarpa*
1492. *Impatiens maculata Wight*
1493 *Impatiens minor (DC) Suresh in Nicols*
1494. *Impatiens modesta Wight*
1495. *Impatiens munnarensis*
1496. *Impatiens nataliae*
1497 *Impatiens pallidiflora*
1498 *Impatiens pandata*
1499 *Impatiens parasitica Bedd*
1500 *Impatiens parvifolia*
1501 *Impatiens phoenicea*
1502. *Impatiens platyadena*
1503. *Impatiens pulcherrima Dealz*
1504 *Impatiens rivulicola*
1505. *Impatiens rufescens*
1506. *Impatiens rupicola Hook.F*
1507. *Impatiens scabriuscula*
1508. *Impatiens scapiflora Heyne ex. Roxb.*
1509 *Impatiens spicata Forsskal*
1510. *Impatiens tangachee*
1511 *Impatiens tenella*
1512. *Impatiens tomentosa Heyne ex Wight&Arn*
1513. *Impatiens travancorica*
1514. *Impatiens trichocarpa Hook.F*
1515. *Impatiens umbellata*
1516. *Impatiens uncinata*
1517. *Impatiens verecunda*
1518. *Impatiens verticillata Wight*
1519. *Impatiens viscosa Bedd*
1520. *Impatiens wightiana*
1521. *Impatiens zollingeriana Miq*
1522. *Imperata cylindrica (L.) Raeusch*
1523. *Indigofera astragalina DC*
1524. *Indigofera barberi*
1525. *Indigofera cassoides Rottl*
1526. *Indigofera colutea Merr*
1527. *Indigofera constricta (THw.) Trimen*
1528 *Indigofera galegoides DC*
1529. *Indigofera karuppiana*
1530. *Indigofera trifoliata L*
1531. *Indigofera trita L*
1532. *Indigofera wightii Graham ex Wight*
1533. *Indigofera linnaei Ali*
1534. *Indobanalia thyrsflora (Moq.) Henry&Roy*
1535. *Indoneesiella echioides (L.) Sreemadh*
1536. *Indotristicha ramosissima (Wight) Royen*
1537. *Insdigofera hirsuta L*
1538. *Iphegenia indica (L.) A Gray*
1539. *Iphigenia pallida*
1540. *Iphigenia sahyadrica*
1541. *Ipomaoea bracteata Wight*
1542. *Ipomaoea fistulosa Mart*
1543. *Ipomaoea sinensis Chorsy*
1544. *Ipomea wightii (Wall.) Choisy*
1545. *Ipomoea alba L*
1546. *Ipomoea aquatica Forsk*
1547. *Ipomoea barlerioides Benth*
1548. *Ipomoea cairica (L.) Sweet*
1549. *Ipomoea campanulata L*
1550. *Ipomoea deccana Austin*
1551. *Ipomoea eriocarpa R Br*
1552. *Ipomoea hederifolia L*
1553. *Ipomoea indica (Burm F.) Merr*
1554. *Ipomoea mauritiana Jacq.*
1555. *Ipomoea nil (L.) Roth*
1556. *Ipomoea obscura (L.) Ker Gawler*
1557. *Ipomoea pes-caprae (L.) R. Br*
1558. *Ipomoea pes-tigridis L*
1559. *Ipomoea pileata Roxb*
1560 *Ipomoea quamoclit L*
1561. *Ipomoea triloba L*
1562. *Ipomoea turbinata Lag*
1563 *Isachaemum molle*
1564 *Isachaemum nilagiricum*
1565 *Isachaemum pilosum*
1566 *Isachaemum tadulingamii*
1567 *Isachaemum thomsonianum*
1568. *Isachaemum travancorense*
1569. *Isachaemum vembanadense*
1570. *Isachne bourneorum Fischer*
1571. *Isachne fischeri*
1572. *Isachne globosa (Thumb) O Ktze*
1573. *Isachne gracilis*
1574. *Isachne kunthiana Wight&Arn*
1575. *Isachne miliaceae Roth ex Roem*
1576. *Isachne setosa Fischer*
1577. *Isachne walkeri Wight&Arn*
1578. *Ischaemum agastya malayanum*

Contd....

Appendix 3.5.2.1 Contd..

1579 *Ischaemum commutatum* Hack
1580 *Ischaemum indicum* Merr
1581 *Ischaemum mangaluricum*
1582. *Ischaemum muticum* L.
1583. *Ischaemum semisagittatum* Roxb.
1584. *Ischaemum timorense* Kunth.
1585 *Ischaemum travancorense* Stapf
1586. *Ischaemum zeylanicum* Bor.
1587 *Isonandra lanceolata* Wight
1588 *Isonandra perrottetiana* A.DC
1589 *Isonandra stocksii* Cl
1590 *Ixora alba* L
1591 *Ixora branchiata* Roxb.Ex DC
1592 *Ixora coccinea* L.
1593. *Ixora cuneifolia* Roxzb.Ex.DC
1594 *Ixora elongata* Hyne
1595. *Ixora finalaysoniana* Wall ex. Don
1596 *Ixora johnsoni* Hook.F
1597 *Ixora leucantha* Heyne ex G Dn
1598 *Ixora monticola* (Dennst.) Mabber
1599 *Ixora nigricans* R. Br. Ex Wight&Arn
1600 *Ixora notoniana*
1601 *Ixora oiktabtga* Wight
1602 *Ixora polyantha*
1603 *Ixora sessaliflora* Kurz.
1604 *Jaminum flexile* Vahl.
1605. *Janakia arayalpanthra*
1606 *Jansenella griffithiana* (Mudl.) Bor.
1607. *Jasminium angustifrlium* (L.) Willd
1608. *Jasminum adhatoda* L
1609. *Jasminum auriculatum* Vahl.
1610 *Jasminum azoricum* L
1611 *Jasminum calophyllum* Wall
1612 *Jasminum cordifolium* Wall
1613 *Jasminum cuspidatum* Rottl
1614 *Jasminum diffusa* Willd
1615 *Jasminum japanica*
1616. *Jasminum malabaricum*
1617 *Jasminum multiflorum* (Burm.F.) Andr
1618 *Jasminum procumbens* L.
1619. *Jasminum prostrata* (C.B Clarke) Gamb
1620 *Jasminum rottlerianum* Wall ex. A.DC
1621 *Jasminum santapani* Bennet
1622 *Jasminum trichotomum*
1623. *Jasminum waynandensis* (Nees.) Heyne
1624 *Jatropha curcas* L.
1625 *Jatropha gossypifolia* L
1626 *Jatropha heynei*
1627 *Jerdonia indica*
1628. *Julostylis ampumalensis*
1629 *Julostylis angustifolia* (Arn.) Thw.
1630. *Julostylis polyandra* Ravi et Anilkumar
1631 *Juncus inflexus* L.
1632 *Juncus prismatocarpus* R. Br
1633 *Justicia betonica* L
1634 *Justicia gendarusa* Bwim F
1635 *Justicia nesii*
1636 *Justicia nilgherrensis*
1637 *Justicia notha* Clarke
1638 *Justicia santhapui*
1639 *Justicia trinervia* Vahl
1640 *Juticia beddomei*
1641 *Juticia neesi*
1642. *Kalanchoe bhidei* Cooke
1643. *Kalanchoe grandiflora* Wall
1644 *Kalanchoe pinnata* (Lam.) Pers
1645 *Kalanchoe schweinfurthii* Perzig
1646. *Kamettia caryophyllata* (Roxb.) Nicols&Suresh
1647. *Kandelia candel* (L.) Druce
1648. *Kanjarum palghatense* Raman
1649. *Kingidium deliciosum*
1650. *Kingidium mysorensis* (Sold.) Satish
1651. *Kingidium niveume* Satish
1652. *Kingiodendron pinnatum* Harms
1653. *Knema attenuata* Warb
1654. *Knoxia sumatrensis* (Retz.) DC
1655. *Knoxia wightiana* Wall
1656. *Korthalsellu japonica* (Thumbs) Engl
1657 *Kunstleria keralensis* Mohanan et Nair
1658. *Kyllinga brevifolia* Rottb
1659. *Kyllinga bulbosa* Beauv
1660. *Kyllinga melanosperma* Nees
1661. *Kyllinga odorata* Vahl
1662. *Kyllinga squamulata* Vahl
1663. *Kyllinga themoralis* Dandy
1664. *Kyllinga triceps* Rottb
1665. *Lagenandra meeboldii (Engler))* Fischer
1666. *Lagenandra nairii* Rama&Rajan
1667. *Lagenandra ovates* (L.) Thw
1668. *Lagenandra toxicaria* Dalz
1669. *Lagerstroemia hirsuta* (Lam.) Willd
1670. *Lagerstroemia microcarpa* Wight
1671. *Lagerstroemia speciosa* (L.) Pers
1672. *Laggera crispata* Hepper&Wood
1673. *Lannea coromandelica* (Hoult) Merr
1674. *Lantana camara* L
1675. *Lantana indica* Roxb
1676. *Laportea crenulata* (L.) Chew
1677. *Laportea interrupta* (L.) Chew
1678. *Lasianthus accuminatus*
1679. *Lasianthus capitulatus*
1680. *Lasianthus ciliatus*
1681. *Lasianthus coffeoides*
1682. *Lasianthus jackianus*
1683. *Lasianthus parvifolius*
1684. *Lasianthus rostratus*
1685. *Lasianthus strigillosus* Hook F
1686. *Launaea acculis* (Roxb.) Babc
1687. *Laurembergia coccinea* (Blumea) Kan
1688. *Lawsonia inermis* L
1689 *Lecanthus peduncularis* Wedd
1690. *Leea asiatica* (L.) Ridsd
1691. *Leea guineensis* G Don
1692 *Leea indica*
1693. *Leea macrophylla* Roxb
1694. *Leea robusta* Roxb
1695. *Leersca hexandra* Sw
1696. *Lemna perpusilla* J Torrey
1697. *Lepianthes portulacoides* (Look.) A Dietr
1698. *Lepianthes umbellata* (L.) Ruf
1699. *Lepidagathis barberi*
1700 *Lepidagathis diffusa*
1701. *Lepidagathis incurva* Buch-Ham ex Don
1702. *Lepidagathis keralensis*
1703. *Lepidagathis mitis*
1704. *Lepidagathis pungens*
1705. *Lepidagathis rubicundus*
1706 *Lepidagathis spinosa*
1707. *Lepidium sativum* L
1708. *Lepisanthes erecta* (Thw.) Leenh
1709. *Lepisanthes tetraphylla* (Vahl.) Radlk
1710. *Lepistemon leiocalyx* Staff
1711 *Lepistemon verdcourtii*

Contd....

Appendix 3.5.2.1 Contd..

1712 *Leptacanthus amabilis*
1713. *Leptochloa uniflora Hocht*
1714. *Leptonychia candata Burrett.*
1715 *Lesianthes acuminatus Wight*
1716. *Lesianthes dichotomous Wight*
1717 *Lesianthes parvifolius Wight*
1718 *Lesianthes rostratus Wt*
1719 *Leucaena latisiliqua (L.) Gills*
1720 *Leucas aspera (Willd.) link*
1721 *Leucas biflora (Vah) R. Br*
1722 *Leucas chinensis (Retz.) R. Br*
1723 *Leucas ciliata Benth Var: alphonsae Antony*
1724 *Leucas eriostoma*
1725. *Leucas helianthemifolia*
1726. *Leucas hirta (Roth) Spreng.*
1727 *Leucas indica (L.) R. Br.*
1728 *Leucas lanceaefolia*
1729 *Leucas marrubioides Desf*
1730 *Leucas prostrata*
1731 *Leucas ternifolia*
1732 *Leucas vestita Benth*
1733 *Leucas vestita var. devicolamensis*
1734 *Leucas wightiana*
1735. *Leucas zeylanica (L.) R. Br*
1736. *Leuscas mollissima Wall*
1737 *Leuscas pubescens Benth*
1738. *Ligustrum decaisnei var. microphylla*
1739 *Ligustrum gamblei Raman*
1740 *Ligustrum perrottetti DC*
1741 *Ligustrum robustum (Roxb) Blume*
1742 *Ligustrum travancoricum*
1743 *Lilium neilgherrensis*
1744 *Lilium wallichianum Schulter*
1745 *Limnocharis flava (L.) Buchanan*
1746 *Limnophila aromatica (Lam.) Merr*
1747 *Limnophila chinensis (Osbeck) Merr*
1748. *Limnophila indica (L.) Druce*
1749. *Limnophila repens (Benth.) Benth*
1750. *Limnophilla glandulifera*
1751. *Limnopoa meeboldii*
1752 *Limnopoa tridentatus*
1753. *Lindenbergia indica (L.) O. Ktze*
1754 *Lindernia numularifolia Wats*
1755. *Lindernia anagallis (Burm.F.) Pennel*
1756. *Lindernia antipodda (L.) Alston*
1757 *Lindernia aspera Link*
1758. *Lindernia caespitosa (Bl.) Panigrahi*
1759. *Lindernia ciliata (Colsm.) Pennell.*
1760. *Lindernia crustaceae (L.) F. Muell.*
1761. *Lindernia hyssopioides (L.) Haines*
1762. *Lindernia oppositifolia (L)*
1763 *Lindernia parviflora (Roxb.) Haines*
1764 *Lindernia pusilla Boldingh*
1765 *Lindernia rotundifolia (L) Alston*
1766 *Lindernia ruellioides (Solsm) Pernnell*
1767 *Lindernia tenuifolia Link*
1768 *Lindernia viscosa (Hornem.) Merr*
1769 *Linum mysorense Heyne*
1770. *Liparis artopurpurea Lindl*
1771. *Liparis caespitosa Lindl.*
1772. *Liparis elliptica Wight*
1773 *Liparis nervosa (Thum.) Lindl*
1774. *Liparis paradox (Lind.) Reichb*
1775. *Liparis platyphylla*
1776 *Liparis viridiflora (Bl) Lindl*
1777 *Liparis walkeriae Grah*
1778 *Liparis wightiana Thw*
1779. *Liparis zeylanica Lindl*
1780. *Lipocarpha chinensis (Osbeck) Kern*
1781. *Lipocarpha sphacebta Kunth*
1782. *Litchi chinensis Sonner*
1783. *Litosanthus venulosus*
1784 *Litsea beddomei Hook F*
1785 *Litsea bourdilonii Gamble*
1786 *Litsea coriacea (Heyne ex Heisner) Hook F*
1787. *Litsea deccanensis Gamble*
1788 *Litsea floribunda (Blume) Gamble*
1789 *Litsea glabrata Hook F*
1790. *Litsea insignis Gamble*
1791. *Litsea keralana*
1792. *Litsea laevigata (Nees) Gamble*
1793. *Litsea ligustrina Hook.F*
1794. *Litsea mysorensis*
1795. *Litsea nigrescens*
1796. *Litsea oleoides (Meissn) Hook F*
1797. *Litsea stocksii Hook*
1798. *Litsea travancorica Gamble*
1799. *Litsea venulosa (Meisner) Hook F*
1800. *Litsea wightiana Hook F*
1801. *Litsea wightiana var wightiana*
1802. *Lobelia alsinoides Lam*
1803. *Lobelia dichotoma Miq*
1804. *Lobelia heyneana Roth ex. Roem&Scholt*
1805. *Lobelia leschenaultiana (Presl) Skottish*
1806 *Lobelia nicotianifolia Roth ex Roem & Schult*
1807. *Lobelia zeylanica L*
1808. *Loesenenella obtusifolia A C Smith*
1809. *Loesneriella arnottiana (Wt) A.C*
1810. *Loesneriella bourdillonii (Gamble) Ramam*
1811 *Lonicera leschenaultii*
1812. *Lophatherum gracilis Brogn*
1813. *Lophopetalum wightianum Arn*
1814. *Ludwigia adscendens (L) H. Hara*
1815. *Ludwigia hyssopifolia (Don.) Exell*
1816. *Ludwigia octovalvis (Jacq.) Raven*
1817. *Ludwigia prennis L*
1818. *Luffa aegyptiaca Mild*
1819. *Luffa acutangula (L) Roxb*
1820. *Luisia abrahamii*
1821. *Luisia birchea (A Rich) Blume*
1822. *Luisia evengelinae Blatt*
1823. *Luisia zeylanica Lindl*
1824. *Luvunga eleutherandra Dalz*
1825. *Lycianthes larvis (Dunal) Bitter*
1826. *Lysimachia procumbens Bando*
1827. *Macaranga rhamnifolius Muell-Arg*
1828. *Macaranga indica Wight*
1829. *Macaranga peltata (Roxb) Muell-Arg*
1830 *Macaranga philippensis (Lam)*
1831 *Macaranga resinosus (Blanco) Merr*
1832 *Macaranga tetracoccus (Roxb) Kurz*
1833. *Macrosolen capitellatus Danser*
1834. *Macrosolen parasiticus (L) Danser*
1835. *Macuna gigantea (Willd) DC*
1836. *Macuna monosperma DC*
1837. *Madhuca bourdillonii (Gamble) H.J Lam*
1838. *Madhuca longifolia (Koen.) Machr*
1839. *Madhuca neriifolia (Moon) H J Ham*
1840. *Maesa indica (Roxb) OC*
1841. *Maesopsis eminii Engler*
1842. *Malaxis acuminata D Don*
1843. *Malaxis densiflora (A Rich) Kuntze*
1844. *Malaxis rheedei Sw*
1845. *Mallotus artovirens Muell-Arg*

Contd....

1846 *Mallotus auro-punctatus Muell-Arg.*
1847 *Mallotus beddomei Hook F*
1848 *Mallotus distans Muell-Arg*
1849. *Malvastrum coromandelianum (L.)*
1850 *Mangifera indica L*
1851 *Manihot esculenta Crantz*
1852 *Manilkara zapota (L.) Royen*
1853 *Maresdenia tirunelvelica Henry&Subra*
1854 *Margaritaria indica Airy shaw*
1855 *Mariscus clarkei*
1856 *Mariscus concinnus Schrader*
1857 *Mariscus cyperinus (Retz.) Vahl.*
1858. *Mariscus dubius (Rottb) Kuek*
1859 *Mariscus javanicus (Hoult) Merr*
1860 *Mariscus panicens (Roth) Vahl*
1861 *Mariscus squarrosus Clarke*
1862 *Mariscus sumatrensis (Retz.) Raynal*
1863 *Marisus maderaspatanus (Willd.) Rapper*
1864 *Mastixia arborea (Wight) Bedd*
1865 *Mazus pumilus (Burm f.) Steems*
1866. *Mecardonia procumbens (Mill.) Small*
1867. *Mechinella malabarica Bedd*
1868 *Medinella beeddomei Clarke in Hook. F*
1869. *Medinella fuchsiodes Gard*
1870. *Meineckia longipes Webster*
1871 *Meineckia parviflora Webster*
1872. *Meiogyne pannosa*
1873 *Meiogyne ramarowii*
1874 *Melastoma malabaricum L*
1875 *Melia azedarach L*
1876 *Melia dubia Cav*
1877 *Meliosma pinnata (Roxb.) Walp*
1878 *Meliosma simplicifolia (Roxb.) Walp*
1879. *Melochia corchorifolia L.*
1880 *Memecylon edule Roxb.*
1881 *Memecylon heyneanum Benth.Ex W&A*
1882 *Memecylon lawsonii Gamble*
1883 *Memecylon malabaricum (Clarke) Cogn In DC*
1884 *Memecylon talbotianum Brandis*
1885 *Memecylon umbellatum Burem.F*
1886. *Memecylong depressum Benth*
1887 *Memycylon angustifolium Wight*
1888. *Memycylon flavescens Gamble*
1889 *Memycylon subcordatum Cogn.*
1890. *Merremia aegyptica (L.) Urban*
1891 *Merremia dissecta (Jacq.) Hallier f.*
1892 *Merremia tridentata (L.) Hallier.f.*
1893. *Merremia turpethum (L.) Shah&Bhatt*
1894. *Merremia vitifolia (Burm.f.) Hallier f.*
1895 *Merrenia umbellata (L.) Hallier.f.*
1896 *Mesua nagassarium (Burm.F.) Kosterm*
1897 *Mesua thwaitesii Planch &Triana*
1898 *Mevia brasiliensis (Willd.ex.Juss.)Muell-Arg*
1899 *Michelia champaca L.*
1900 *Michelia nilagirica Zenk.*
1901. *Microcarpea minima (J Koenig) Merr*
1902. *Micrococca beddomei (Hook.F.) Prain*
1903 *Micrococca mercurialia (L.) Benth*
1904. *Microcos paniculata L.*
1905 *Microstegium ciliantumi (Trin) A. Camus*
1906 *Microtropis latyolia*
1907 *Microtropis stocksii Gamble*
1908 *Microtropis wallichiana Wt.*
1909 *Mikania cordata (Burm.F.) Robins*
1910 *Mikania micrantha H.R.K.*
1911. *Miliusa indica Lesch ex A.DC*
1912. *Miliusa tomentosa (Roxb.) Sinclair*
1913. *Millettia rubiginosa Wt &Arn*
1914 *Millingtonia hortensis L F*
1915 *Mimosa diplotricha (Wright)*
1916. *Mimosa invisa Mart Var invisa*
1917. *Mimosa pudica L*
1918. *Mimulus orbicularis Benth*
1919. *Mimusops elengi L*
1920. *Miquelia dentata Bedd*
1921. *Mirabilis jalapa L*
1922. *Mitracarpus verticillatus (Schum&Thonn) Vatke*
1923. *Mitracarpus villosus DC*
1924. *Mitragyna parviflora (Roxb) Korth*
1925. *Mitragyna tubulosa (A) Kuntze*
1926. *Mitrasacme indica Wight*
1927. *Mitrasacme pygmaea R Br*
1928. *Mitrephora grandiflora Bedd*
1929. *Molineria trichocarpa (Wight) Balkr*
1930. *Momordica dioica Roxb ex Willd*
1931. *Monochoria usaginalis (Burm F) persl*
1932. *Moonia heterophylla Arn*
1933. *Morinda citriflia L*
1934. *Morinda pubescens SM*
1935. *Moringa pterygosperma Gaertn*
1936. *Mucuna artopurpurea DC*
1937 *Mucuna hirsuta Wt &Arn*
1938 *Mucuna pruriens (L) DC*
1939 *Mukia leiosperma Wight*
1940. *Mukia maderaspatane (L) M. Roemer*
1941. *Mullugo pentaphylla (L)*
1942. *Mullugo stricta (L.)*
1943. *Munronia pinnata (Wall.) Harms*
1944. *Murdania nudiflora (L.) Brueck*
1945. *Murdannia dimorpha (Dalz) Brueck*
1946. *Murdannia edulis (Stokes) Faden*
1947. *Murdannia esculentata Raizada*
1948. *Murdannia glanca Brueck*
1949 *Murdannia japonica (Thumb) Foden*
1950 *Murdannia juncoides R Rao&Kammanthy*
1951 *Murdannia pauciflora Brueck*
1952. *Murdannia semiteres (Dalz) Santapur*
1953. *Murdannia simplex (Vahl.) Brenan*
1954. *Murdannia spirata (L.) Brueck.*
1955. *Murdannia wightii Rao&Kammathy*
1956. *Murdannia zeylanica (Clarke) Srueck*
1957. *Murraya paniculata (L) Jack*
1958. *Mussaenda frondosa L*
1959. *Mussaenda hirsutissima (Hook F) Hutchinson*
1960. *Mussaenda tomentosa Light*
1961 *Mussanda bellilla Ham*
1962 *Mycetia acuminata (Wight) Kuntze*
1963. *Myriactis wightii DC*
1964 *Mynophyllum oliganthum F V Muell*
1965 *Mynstica dactyloides Gasertn*
1966 *Mynstica fragrans Houtt*
1967. *Myristica malabarica Lam*
1968. *Myxospyrum serratulum Hill*
1969. *Myxospyrum smilacifolium Bl*
1970 *Najas graminea Del*
1971. *Najas indica (Willd) Cham*
1972. *Naregamia alata Wight&Arn*
1973. *Naringi crenulata (Roxb) Nicols*
1974. *Narvelia zeylanica (L) DC*
1975. *Neanotis carnosa*

Contd....

1976. *Neanotis decipiens (Hook.F).W.H.Lewis*
1977. *Neanotis indica (DC) Lewis*
1978. *Neanotis indica var. affinis*
1979 *Neanotis longiflora*
1980 *Neanotis monosperma*
1981. *Neanotis rheedi*
1982 *Negia wallichiana (Presl) Kuntze*
1983. *Nelsonia canescens (Lam.) Spreng.*
1984. *Nelumbo nucifera Gacertn*
1985. *Neolamarckia cadamba (Roxb.) Bosser*
1986. *Neolitsea cassia (L.) Kosterm.*
1987. *Neolitsea fischeri Gamble*
1988. *Neolitsea scrobiculata (Meisner) Gamble*
1989. *Neonanclea purpurea (Roxb.) Merr.*
1990. *Neonotiana wightii Lackey*
1991 *Neonotis tubulosa Mabb*
1992. *Nerium oleander L*
1993. *Nervilia aragoana Gaud*
1994. *Nervilia plicata (Andr.) Schltr.*
1995. *Nervilia prainiana Seidenf.*
1996. *Nesaea brevipes Kochne*
1997. *Nesaea lanceolata Kochne*
1998. *Neuracanthus neesianus*
1999 *Neurocalyx calycinus (R.Br Ex.Beno) Robinson*
2000 *Neuropeltis malabarica Oostr*
2001. *Nicandra physalodes (L.) Gaertn*
2002 *Nilgiranthus barbatus (Nees) Bhemek*
2003 *Nilgiranthus beddomei Bremek*
2004 *Nilgirianthus asper*
2005. *Nilgirianthus barbatus*
2006. *Nilgirianthus campanulatus*
2007. *Nilgirianthus ciliatus (Nees) Bhemek*
2008. *Nilgirianthus decurrens*
2009. *Nilgirianthus foliosus*
2010. *Nilgirianthus heyneanus (Nees) Bremek*
2011 *Nilgirianthus neilgherrensis*
2012. *Nilgirianthus perrottetianus Bremek*
2013. *Nilgirianthus punctatus Bremek*
2014 *Nilgirianthus urceolaris*
2015. *Nilgirianthus wightianus*
2016 *Nogra dalzellii*
2017. *Nostolachima crassifolia*
2018. *Nothapodytes nimmoniana (Graham) Manilal*
2019. *Nothopegia beddomei*
2020. *Nothopegia colebrookeana (Wt.) Bl.*
2021. *Nothopegia heyneana (Hook.F.) Gamble*
2022. *Nothopegia racemosa (Dalz.) Raman*
2023. *Nothopegia travancorica Bedd.Ex.Hook.F*
2024 *Notonia grandiflora Wall*
2025. *Nymphea nouchali Burm F*
2026 *Nymphoides hydrophylla (Lour.) O Ktze*
2027. *Nymphoides indica (L.) Kuntze*
2028 *Nymphoides krishnakesara*
2029 *Nymphoides macrospermum*
2030 *Nymphoides sivarajanii*
2031. *Oberonia anamalayana Joseph*
2032. *Oberonia arnottiana Wight*
2033. *Oberonia bicornis Lindl.*
2034. *Oberonia brachyphylla Blatt.*
2035 *Oberonia brunoniana Wight*
2036 *Oberonia chandrasekharanii Nair et al*
2037 *Oberonia ensiformis (Smith) Lindl.*
2038 *Oberonia longibracteata Lindl*
2039 *Oberonia rayarii Ansari&Babler*
2040 *Oberonia proudlockii King&Panth*
2041. *Oberonia sebastiana Shetty&Vivek*
2042. *Oberonia verticillatai Wight*
2043. *Oberonia wightiana Lindl*
2044. *Oboronia chandrasekharanii Nair*
2045. *Oboronia denticulata Wt*
2046. *Oboronia recuria Lindl*
2047. *Oboronia santapaum Kapad*
2048. *Oboronia thwaitesi Hook.F*
2049. *Ochlandra scriptoria Fischer*
2050. *Ochlandra travancorica (Bedd.) Benth*
2051. *Ochlandra wightii Fischer*
2052. *Ochna obtusata DC*
2053. *Ochreinauclea missionis (Wall.ex.G.Don.) Ridsdale*
2054. *Ocimum americanum L*
2055. *Ocimum grattissimum L*
2056. *Octotropis travancorica Bedd*
2057 *Oeceoilades pulchra (Thou) Clements*
2058. *Olax imbricata Roxb*
2059. *Olea dioica Roxb*
2060. *Olea glandulifera Wall.*
2061. *Ophiopogon intermedius D Don*
2062. *Ophiorrhiza brunonis Wt &Arn*
2063. *Ophiorrhiza eriantha Wight*
2064. *Ophiorrhiza grandiflora Wight*
2065. *Ophiorrhiza mungos L*
2066. *Ophiorrhiza pectinata Arn*
2067. *Ophiorrhiza rugosa Wall*
2068 *Oplismenus burmanii (Retz) P Beawv*
2069 *Oplismenus compositus (L) P Beanv*
2070. *Opuntia vulgaris Miller*
2071. *Oreocnide integrifolia (Gand.) Miq*
2072. *Ormocarpum cochinchinensis (Lour)Merr*
2073. *Ormosia travancorica Bedd*
2074. *Oropetium thomaeum Trin*
2075. *Orophea erythrocarpa Bedd*
2076. *Orophea malabarica Sasi&Sivar*
2077. *Orophea thomsonii Bedd*
2078. *Orophea uniflora Hook F & Thomas*
2079. *Oroxylum indicum (L) Vent*
2080. *Orthosiphon aristatus (Bl.) Miq*
2081. *Orthosiphon thymiflorus (Roth) Sleesen*
2082. *Oryza meyeriana (Zoll & Mor) Baill*
2083. *Oryza officinalis Wall*
2084. *Oryza rufipogon Griff*
2085. *Oryza sativa L*
2086. *Osbeckia brachystemon Nand*
2087. *Osbeckia gracilis Bedd*
2088. *Osbeckia leschenaultiana DC*
2089. *Osbeckia virgata D Don ex Wight&Arn*
2090. *Osbeckia wynaadensis Cl*
2091 *Osbeckia zeylanica L F*
2092 *Osbekia aspera (L) Blume Var travancorica*
2093. *Osbekia aspera Var wightianat*
2094. *Osbekia muralis Nand*
2095 *Otonephelium stipulaceum (Bedd) Radtk*
2096. *Ottelia alismoides (L) Pers*
2097. *Ottochola nodosa Dandy*
2098. *Oxalis corniculata L*
2099. *Oxalis latifolia Kunth*
2100. *Oxyceros rugulosus 9Thw) Tirvengadam*
2101. *Pachystoma pubescens Bl*
2102. *Pajanelia longifolia (Willd) Schum*
2103. *Palaquium bourdillonii*
2104. *Palaquium ellіptiam (Dalz) Baill*
2105. *Palaquium ravii Sasi&Vink*
2106. *Pananus fascicularis Lamn*

Contd....

Appendix 3.5.2.1 Contd..

2107 *Pancratium triflorum* Roxb.
2108 *Pandanus thwaitesii* Martelli
2109 *Pandanus unipapillatus* Dennst
2110 *Panicum antidotale* Retz
2111 *Panicum auritum* Presl
2112 *Panicum brevifolium* L.
2113 *Panicum gardenri* Thw
2114 *Panicum maximum* Jacq
2115 *Panicum notatum* Retz
2116 *Panicum psilopodium* Trin
2117 *Panicum repens* L
2118 *Panicum sumatrense* Roth
2119 *Panicum trypheron* Schult
2120 *Paphiopedilum druryi*
2121 *Papilionanthe subulata* Garay
2122 *Paracalyx scariosa* (Roxb.) Ali
2123 *Paracroton pendulus* (Hassk) Miq
2124 *Parkia biglandulosa* Wt.&Arn
2125 *Parochetus communis* Buch-Ham
2126 *Parsonsia laboflarescens* (Dennst) Mabb
2127 *Parthonecissus neilgherensis* (Wight) Planch
2128 *Paspalidium flavidum* A. Camus
2129 *Paspalidium punctatum* A camus
2130 *Paspalum canarae* Veddk
2131 *Paspalum corjugatum* Berg
2132 *Paspalum distichum* L
2133 *Paspalum scrobiculatum* L
2134 *Passiflora edulis* Sims.
2135 *Passiflora foetida* Var *foetida* L
2136 *Passiflora foetida* Var: *hispida* (DC) Killip ex Gleason
2137 *Passiflora leschenanltii* DC
2138 *Passiflora subpeltata* Ortega
2139 *Patherium heterosporous* L
2140 *Pavetta brunonsis*
2141 *Pavetta calophylla* Bremek
2142 *Pavetta concanica*
2143 *Pavetta hispidulla* Wt &Arn
2144 *Pavetta indica* L
2145 *Pavetta nemoralis*
2146 *Pavetta siphonantha* Dalz
2147 *Pavetta tomentosa* Roxb.Ex Smith
2148. *Pavetta travancorica*
2149. *Pavetta zeylanica* (Hook.F.) Gamble
2150 *Pavonia odorata* Willd
2151 *Pecteilis gigantea* Rafin
2152 *Pedicularis zeylanica* Benth
2153 *Pedilanthus tithymaloides* (L) Poit
2154 *Peliosanthes teeta* Andr
2155 *Pellionia heyneana* Wedd
2156 *Peltophorum pterococarpum* (Dt) Baker&Heyne
2157 *Pennisetum hohenackeri* Hoch
2158 *Pennisetum pedicellatum* Trin
2159 *Pennisetum polystachyon* (L) Schult
2160 *Pennisetum purpureum* Schum
2161 *Pentanema indicum* (L) Willense
2162 *Peperomia blanda* (Jacq) Kunth
2163 *Peperomia dindigulensis* Miq
2164 *Peperomia pellucida* (L.) HBR
2165 *Peperomia portulacoides*
2166 *Peperomia tetraphylla* (Forsk.) Hook
2167 *Peperomia wightiana* Miq
2168 *Pergularia daemia* (Forsk.) Chirv
2169 *Peristrophe montanta* Ness
2170 *Peristylus aristalus* Lindl
2171. *Peristylus densus* (Lindl) Sant &Kapad
2172. *Peristylus goodyeroides* (D Don) Lindl
2173. *Peristylus plantageneus* Lindl
2174 *Peristylus richardianus* Wight
2175. *Perotis indica* (L) Kuntze
2176. *Persea americana* Miller
2177 *Persea macrantha* (Nees) Kosterm
2178. *Persicaria barbata* (L) Hara
2179 *Persicaria chinensis* (L) Gross
2180. *Persicaria glabra* (Willd) M Gomez
2181 *Persicaria plebeium* R Br
2182. *Petrospermum rubiginosum*
2183 *Peucedanum anamallayanse* Cl
2184 *Phaeanthus malabaricus* Bedd
2185 *Phaseolus lunatus* L
2186. *Phaulopsis impricata* (Forsk) SW
2187. *Phelobophyllum joyporensis* Bremek
2188. *Philodota impricata* Hook
2189. *Phlebophyllum humile*
2190 *Phlebophyllum kunthiannum*
2191. *Phlebophyllum lanatum*
2192 *Phlebophyllum lawsonii* (Gamble) Bremek
2193. *Phlebophyllum spicatum* var *amomum*
2194. *Phlebophyllum spicatum* var *hypolecum*
2195. *Phlebophyllum versicolor*
2196. *Phoebe lanceolata* Nees
2197 *Phoebe wightii* Meisner
2198. *Phoenix loureirii* Kunth
2199. *Pholidota pallida* Lindl
2200. *Photinia serratifolia* (Desf) Kalkman
2201. *Phraetia elagans* Lindl
2202. *Phragmites karka* Trin
2203. *Phrynium pubinerve* Blume
2204 *Phrynium rheedi* Suresh&Nicols
2205. *Phseudanthistiria heterociliata*
2206 *Phyla nodiflora* (L) Greene
2207 *Phylanthus virgatus* Forster f
2208. *Phyllanthus macrocalyx*
2209. *Phyllanthus airy-shawii* Brunell&Roux
2210 *Phyllanthus amarus* Schum&Thom
2211 *Phyllanthus beddomei* Mohanan
2212. *Phyllanthus debilis* Klein ex Willd.
2213. *Phyllanthus emblica* L
2214. *Phyllanthus gardnerianus* (Wight) Baill
2215. *Phyllanthus kozhikodianus* Sivar &Mani
2216. *Phyllanthus macraei* Muell Arg
2217. *Phyllanthus maderaspatensis* L
2218 *Phyllanthus missiowis*
2219. *Phyllanthus narayanaswamii* Gamble
2220. *Phyllanthus pinnatus* Webster
2221 *Phyllanthus reticulatus* Poiret
2222 *Phyllanthus rheedii* Hight
2223 *Phyllanthus stipulaceae* Kumari
2224 *Phyllanthus urinaria* L
2225 *Phyllocephalum courtallense* Narayana
2226 *Phyllocephalum rangacharii* (Gamble) Narayana
2227 *Phyllocephalum scabridum* Kirkman
2228. *Phyllocephalum tenue*
2229 *Physalis angulata* L
2230 *Physalis minima* L
2231 *Physalis peruviana* L
2232. *Phytolacca octandra* L
2233. *Pilea kingii* Fischer
2234. *Pilea melastomoides* (Poir) Wedd
2235 *Pilea microphylla* (L) Liebm
2236 *Pilea wightii* Wedd

Contd....

2237 *Pimpinella candolleana* Wight&Arn
2238 *Pimpinella heyneana* (DC) Kurz
2239 *Pinanga dicksonii (Roxb.)* Bl
2240. *Piper argyrophyllum* Mig.
2241 *Piper barberi* Gamble
2242 *Piper betle* L
2243. *Piper galeatum* Cas
2244. *Piper hapnium*
2245. *Piper hookeri*
2246. *Piper hymenophyllum* Miq
2247 *Piper longum* L
2248 *Piper muilesua* Buch Ham.Ex D.Don
2249 *Piper nigrum* L.
2250 *Piper schmiditii* hook.F
2251 *Piper trichostachyon* (Miq.) C.DC
2252 *Piper trioicum* Roxb
2253 *Piper wightii* Miq.
2254 *Pisonia aculeata* L.
2255. *Pistia stratoites* L.
2256. *Pithecellobium dulce* (Roxb.) Benth
2257 *Pithecellobium monadelphum* (Roxb.) Kosterm
2258 *Pithecolobium gracils*
2259 *Pittosporum viridulum*
2260 *Pittosporum dasycaulon*
2261 *Pittosporum floribundam* W&A
2262 *Pittosporum neelgherrense* Wt&Arn
2263. *Pittosporum tetraspermum* Wt &Arn.
2264 *Plantago erosa* Wall
2265 *Plectranthus fruticosus* Wight
2266. *Plectranthus japonicus* Koidz.
2267. *Plectranthus malabaricus* Willense
2268 *Plectranthus nilghericus* Benth
2269 *Plectranthus rivularis* Wight
2270 *Plectranthus stocksii* Hook F
2271 *Plectranthus wightii* Benth
2272 *Pleocaulus sessilis*
2273 *Pleocaulus sessiloids*
2274 *Pleurostylia opposita* (Wallich) Alston in Trimen
2275. *Plumbago zeylanica* L
2276. *Plumeria rubra* L
2277 *Poa annua* L.
2278 *Podochilus malabaricus* Wight
2279. *Podostemon barberi*
2280 *Podostemum subulatus* Gardn
2281 *Poeciloneuron indicum* Bedd
2282. *Poeciloneuron pauciflorum*
2283. *Pogonatherum crinatum* (Thumb) Kunth
2284. *Pogostemon paniculatus* (Willd.) Benth
2285 *Pogostemon auricularia* (L.) Hook
2286 *Pogostemon benghalensis* (Burm F) Kuntze
2287 *Pogostemon heyneanus* Renth
2288 *Pogostemon mollis*
2289. *Pogostemon paniculatus* Benth
2290 *Pogostemon purpurascens* Dalz
2291 *Pogostemon rotundatus* Benth
2292 *Pogostemon speciosus* Benth
2293 *Pogostemon travancoricus* Bedd
2294 *Pogostemon travancoricus var devicolamensis*
2295 *Pogostemon wightii*
2296 *Polyalthia coffeoides* Hook F
2297 *Polyalthia fragrans* (Dalz) Bedd.
2298 *Polyalthia korinti* (Dunal) Benth&Hook F
2299 *Polyalthia longifolia* (Sooner.) Thw.
2300 *Polyalthia pannosus* (Dalz) Safford.
2301 *Polyalthia rufescens* Hook F
2302. *Polyalthia suberosa* (Roxb) Thw
2303. *Polycarpaea corymbosa* (L) Lamk
2304. *Polycarpea aurea* Wight&Arn
2305. *Polycarpon prostratum* (Forsskal) Asch&Schweinf
2306. *Polygala arillata* Buch.Ham
2307. *Polygala arvensis* Willd
2308. *Polygala balbothrix* Dunn
2309. *Polygala bulbo*
2310 *Polygala chinensis* L
2311. *Polygala jacobii* Chandrah
2312 *Polygala japonica* Houtt
2313. *Polygala javana* DC
2314. *Polygala persicariefolia* DC
2315. *Polygala rosmarinifolia* Wt &Arn
2316. *Polygala telephioides* Willd
2317 *Polygonum hydropiper* L
2318. *Polygonum minus* Huds
2319. *Polygonum nepalense* Meis
2320. *Polygonum pulchrum* Blume
2321. *Polypleurum dischotomum*
2322 *Polypleurum filifolium*
2323. *Polypleurum stylosum* (Wight) Hall
2324 *Polyscias acuminata* Wight&Arn
2325. *Polystachya concreta* (Jacq) Garay
2326. *Pomatocalpa spicata* Breda
2327. *Pongamia pinnata* (L) Pierre
2328. *Portulaca oleraceae* L
2329 *Portulaca pilosa* (L)
2330. *Potamogeton javanicus* Hook
2331. *Potamogeton nodosus* Poir
2332. *Pothos armatus* Fischer
2333. *Pothos crassipedunculatus*
2334. *Pothos keralensis*
2335 *Pothos scandens* L
2336. *Pothos thomsonianus* Schott
2337. *Pouzolzia articulata* Wight
2338. *Pouzolzia cymosa*
2339. *Pouzolzia meeboldii* W S Sm&Rames
2340. *Pouzolzia pentandra* (Roxb) Benn
2341. *Pouzolzia wightii* Bennett
2342. *Pouzolzia wightii caudata*
2343. *Pouzolzia wightii nilghiriensis*
2344. *Pouzolzia zeylanica* (L) Bennatt
2345 *Premna coriacea* Clarke
2346. *Premna glaberrima* Wight
2347. *Premna herbaceae* Roxb
2348. *Premna paucinervis* (Clarke) Gamble
2349. *Premna serratifolia* L
2350. *Premna villosa*
2351 *Premna wightiana*
2352 *Prismatomeris tetrandra* K Schum
2353. *Procris crenata* Robins
2354. *Propax jerdoniana*
2355. *Propax reticulata*
2356. *Pruunus ceylanica* (Wt) Mig
2357 *Pseudaida speciosa*
2358. *Pseudanthria umbellata* (Hack) Hook F
2359 *Pseudanthria viscida* (L) Wight&Aren
2360. *Pseudechinolaena polystachya* Stapf
2361 *Pseuderanthemum malabaricum* (Clarke) Gamble
2362. *Pseudoraphis spinescens* Vickery
2363. *Pseudosorghum fasciculare* A camus
2364. *Pseudotenanthera bourdillonii* Majumdar
2365. *Pseudoxytenanthera monadelpha* Sodestram

Contd....

2366 Psidium guajava L
2367 Psilanthus bridsoniae Sivar
2368 Psilotrichum nudum
2369 Psoralea corylifolia L
2370 Pstsmihyns monophylla Wt
2371 Psychotria anamallayana Bedd
2372 Psychotria barberi
2373 Psychotria bisulcata Wight&Arn
2374 Psychotria congesta Hook F
2375 Psychotria connata Wall
2376 Psychotria dalzellii
2377 Psychotria elongata (Wight) Hook F
2378 Psychotria flavida Talbot
2379 Psychotria gladulosa (Dennst)Suresh in Nicols
2380 Psycnotria johnsonii
2381 Psychotria keralensis Deb &Gang
2382 Psychotria macrocarpa Hook.F
2383 Psychotria nigra (Gaertn) Alston
2384 Psychotria nilgiriensis Deb.&Gang
2385 Psychotria nudiflora Wight&Arn
2386 Psychotria octosulcata Talbot
2387 Psychotria subintegra
2388 Psychotria truncata Wall
2389 Pterocarpus marsupium Roxb
2390 Pterospermum diversifolium Blume
2391 Pterospermum obtusifolium
2392 Pterospermum reticulatum Wt&Arn
2393 Pterospermum rubiginosum Heyne
2394 Pterygota alata (Roxb.) R Br.
2395 Pueraria phaeoloides (Roxb) Benth
2396 Pueraria tuberosa DC
2397 Pulpalia lappacea (L) Juss
2398 Pycnopora lutescens (Poir) Schind
2399 Pycrens sanguinolentus Nees
2400 Pycrens unioloides (R Br) Rub
2401 Pycreus flavidus (Retz) Koyama
2402 Pycreus polystachyos (Roth) P Beaur
2403 Pycreus pumilus (L.) Nees
2404 Pycreus puncticulatus (Vahl.) Nees
2405 Pycreus stramineus Clarke
2406 Pycreus sulcinux Cl.
2407 Quisqualis indica L
2408 Quisqualis malabarica Bedd.
2409. Radermachera xylocarpa (Roxb.)K Schum
2410 Randia brandisii Gamble
2411 Randia dumetorum (Retz) Poiret in Lam
2412 Randia gardneri (Thw.) Hook.F
2413 Ranunculus wallichianus Wight&Arn
2414 Rapanea capitellata (Wall) Mez
2415 Rapanea daphnoides
2416 Rapanea raphnoides Mez
2417 Rapanea wightiana (Wall ex DC) Mez
2418 Raphiodophora pertusa Scholt
2419 Rauuvolfia serpentina (L) Benth ex Kurz
2420 Rauvolfia densiflora (Wall) Benth
2421 Rauvolfia hookeri Srinivasan&Chirta
2422 Rauvolfia micrantha Hook F
2423 Rauvolfia tetraphylla L
2424 Rauvolfia verticillata (Lour) Baill
2425 Reinwardtiodendron anamallayanum (Bedd) Sald
2426 Reissantia grahamii (Wt.) Ding Hon
2427 Reissantia indica (Willd.) Halle
2428. Reldia bailloniana (Muell-Arg) Gamble
2429 Reldia gagreana Gamble
2430 Remusatia viviparai Scholt
2431 Rhinacanthus nasuta (L) Nees
2432. Rhododendron arboreum J
2433. Rhododendron nilagiricum
2434 Rhodomyrtus tomentosus Hassk
2435 Rhynchoglossum notonianum (Wall)Burtt
2436. Rhynchosia beddomei
2437 Rhynchosia filipes
2438. Rhynchosia heynei
2439 Rhynchosia hirta (Andr) Meikle
2440 Rhynchosia rufescens (Willd) DC
2441 Rhynchotechum permolle (Nees) Burtt
2442 Rhyncosia accutissima Thw
2443. Rhyncosia rothii Benth
2444. Rhyncospora corymbosa (L) Britton
2445. Rhyncospora rugosa (Vahl) Gale
2446 Richardia scabra L
2447. Ricinus communis L
2448 Riklienella squarrosa Raynal
2449. Robiquetia josephiana Manilal&Satish
2450 Rorippa indica (L) Hiern
2451 Rosa leschenaultiana
2452 Rostellularia japonica (Thumb) Ellis
2453 Rostellularia serpyllifolia Bremek
2454 Rotala fimbriata
2455 Rotala indica (Willd) Koehne
2456. Rotala macrandra
2457 Rotala macrandra Koehne
2458 Rotala malampuzhensis R V Nair
2459. Rotala mexicana Cham &Schlecht
2460. Rotala ritchiei (Clarke) Koehne
2461 Rotala rosea (Poiret) cook
2462 Rotala rotundifolia (D Don) Koehne
2463. Rotalia illecebroides
2464 Rothia indica (L) Druce
2465 Rotula aquatica Lour
2466 Rubia cordifolia L
2467 Rubus nivens Thumb
2468 Rubus ellipticus Smith
2469. Rubus fairholmianus Gard
2470. Rubus glomeratus bl
2471. Rubus indicus Thum
2472. Rubus niveus Thumb
2473. Ruellia tuberosa L
2474 Rumex nepalense Spreng
2475. Rungia apiculata Bedd
2476. Rungia lacta Clarke
2477 Rungia laeta
2478 Rungia latior Nees
2479 Rungia muralis Nees
2480. Rungia parviflora (Retz) Nees
2481 Rungia pectinata (L) Nees
2482 Rungia sisparensis T Anders
2483 Rungia wightiana Nees in wall
2484 Rurea minor (Gaertn) Alston
2485 Ruta graviolens L
2486 Sabia limoniacea Wall
2487 Saccharum officinarum L
2488 Saccharum spontaneum L
2489. Sacciolepis indica (L) A Chase
2490 Sacciolepis interrupta Sataff
2491. Sacciolepis myosuroides A Camus
2492. Sacrandra chloranthoides Gard
2493. Sageraea dalzellii Bedd
2494. Sageraea grandiflora Dunn
2495. Sageretia coimbatorensis
2496. Sageretia hamosa Brongn
2497 Sagina saginoides (L) Karsten

Contd....

Appendix 3.5.2.1 Contd..

2498 Sagittaria guaynensis H.B K
2499 Salacia beddomei Gamble
2500 Salacia fruticosa Heyne ex Lawson in Hook F
2501 Salacia macrosperma Wt
2502 Salacia malabarica Gamble
2503 Salacia oblenga Wall
2504 Salix tetrasperma Roxb
2505 Salvia officinalis L.
2506 Samadera indica Gaertn.
2507 Samanea saman (Jacq.) Merr
2508 Sapatholobus parviflorus O.ktze
2509 Sapindus emarginatus Vahl
2510 Sapindus laurifolia Vahl.
2511 Sapindus trifolia L
2512 Sapium insigne (Royle) Trment
2513. Saprosma corymbosium
2514 Saprosma foetens (Wight) K. Schum
2515 Saprosma fragrans
2516 Saprosma glomeratum (Gard.) Bedd
2517 Saraca asoca (Roxb.) de Willd
2518 Sarcanthus pauciflorus Wight
2519 Sarcococca coriacea Sweet
2520 Sarcococca saligna Muell-Arg
2521 Sarcostemma intermedium
2522 Sarcostigma kleinii Whit&Arn
2523 Satyrium nepalense O.Don
2524 Sauropus androgynous (L.) Merr
2525 Sauropus quadrangularis Muell-Arg
2526 Sauropus saksenianus Manilal et al
2527 Scenecio candicans
2528 Schefflera bourdillonii Gamble
2529 Schefflera capitata
2530 Schefflera chandrasekharanii
2531 Schefflera racemosa
2532 Schefflera rostrata (Wight) Hamrs
2533 Schefflera rostrata micrantha
2534 Schefflera rostrata var.rostrata
2535 Schefflera venulosa (W&A) Harms
2536 Schefflera wallichiana Harms
2537 Schimia sulcatum
2538. Schizachrium brevifolium Nees
2539 Schleichera oleosa (Lour.) Oken
2540 Schocnorchis nivea (Lind.) Schltr
2541 Schoenoplectus juncoides (Roxb.) Palla
2542 Schoenoplectus mucronatus (L.) Palla
2543 Schumannianthus virgatus (Roxb) Rolfe
2544 Scleria annularia Nees
2545 Scleria biflora Roxb.
2546. Scleria cancina (R.Br.) Benth
2547. Scleria corymbosa Roxb
2548. Scleria levis Retz
2549 Scleria lithosperma (L) Sw
2550 Scleria bergracilis (Nees) Kunth
2551 Scleria rugosa R Br
2552 Scleria terrestris (L) Fasset
2553 Scleropyrum pentandrum (Dennst) Mabberley
2554 Scolopia crenata (Wight&Arn.) D Clos
2555 Scoparia dulcis L
2556 Scurulla parasitica L
2557 Scutellaria barbata D Don
2558 Scutellaria colebrookeana Benth
2559 Scutellaria violacea Heyne
2560 Scutellaria wightiana Benth
2561 Sebastiana chamaelea (L) Muell -Arg
2562 Securinega leucopyrus Muell
2563. Securinega virosa Baill
2564. Seidenfadeniella arosea
2565 Seidenfadeniella chrysantha Satish
2566. Semecarpus anacardium L
2567. Semecarpus auriculata Bedd
2568. Semecarpus travancorica Bedd
2569. Senecio corymbosus Wall ex DC
2570. Senecio dalzellii
2571. Senecio edgeworthii
2572. Senecio intermedius
2573 Senecio neelgherryanus
2574. Senecio scandens Buch-Ham
2575. Senecio stylosus Balak
2576. Sesamum indicum L
2577. Sesamum mulayanum N C Nair
2578. Sesbania bispinosa W Wight
2579. Setaria barbata Kunth
2580 Setaria intermedia Roem&Schult
2581 Setaria palmifolia Stapt
2582 Setaria paniculifera Fourn
2583. Setaria pumila Roem
2584. Setaria verticillata (L) P Beauv
2585 Shorea roxburghii
2586. Shuteria vestita Wight&Arn
2587 Sida acuta Burm F
2588. Sida alnifolia L
2589. Sida beddomei Jacob
2590. Sida cordata (Burm F) Borss
2591 Sida cordifolia
2592. Sida fryxellii
2593. Sida glutinosa Comm
2594 Sida mysorensis Wight&Arn
2595 Sida ravii Anil kumar
2596. Sida rhombifolia S Sp retusa (L) Bross
2597 Sida scabrida Wight&Arn
2598. Siegesbeckia orientalis L
2599. Sima roubaceae
2600. Sinarundinaria walkeriana Chao&Renv
2601. Sirhookera lanceolata (Wight) Ktze
2602. Sirhookera latifolia O Ktze
2603. Smilax aspera L
2604. Smilax perfoliata Lour
2605 Smilax wightii A DC
2606. Smilax zeylanica L
2607 Smithia bigemina Dalz
2608 Smithia blanda Wall ex Wight&Arn
2609 Smithia capitata Dalz
2610 Smithia conferta Sm
2611. Smithia gracilis
2612. Smithia hirsuta Dalz
2613. Smithia racemosa Heyne
2614. Smithia sensitiva Ait
2615 Smithia setulosa
2616 Smithia venkobarowii Gamble
2617 Smithsonia straminea (Dalz) Saldanha
2618 Smithsonia viridiflora Sald
2619. Smythia bombaiensis (Dalz) Banerje&Mukarjee
2620 Soirivikys vurgubucys (L) Kunth
2621 Solanum lasiocarpum Dural
2622. Solanum americanum Mill
2623. Solanum anguivi Lamk
2624. Solanum capsicoides All
2625 Solanum ciliatum Lam
2626 Solanum erianthumD Don
2627 Solanum giganteum jacq
2628 Solanum melongena Var in sanum (L) Prain

Contd....

2629 *Solanum nigrum L*
2630 *Solanum scaforthianum Andr*
2631 *Solanum sisymbrifolium Lam*
2632 *Solanum surattense Burm F*
2633 *Solanum torvum SW*
2634 *Solanum vairum Dunsal*
2635 *Solanum violaceum Ortega*
2636 *Solena amplexicanlis (Lam.) Gandhi*
2637 *Solenocarpus indica Wt.&Arn*
2638 *Solomonia ciliata (L) DC*
2639 *Sonchus oleraceus L*
2640 *Sonchus wightianus DC*
2641 *Sonerial grandiflora R.Br*
2642 *Sonerila brunonis Wight&Arn*
2643 *Sonerila clarkei Cogn*
2644 *Sonerila devicolamensis*
2645 *Sonerila elegans*
2646 *Sonerila grandiflora*
2647 *Sonerila hadasivanii*
2648 *Sonerila hahyadrica*
2649 *Sonerila hpeciosa*
2650 *Sonerila pulneyensis*
2651 *Sonerila rheedii Whit&Arn*
2652 *Sonerila rotundifolia Bedd.*
2653. *Sonerila sahyadrica Giri&Nayar*
2654 *Sonerila sahyadrica Var. Kadavilii*
2655 *Sonerila speciosa Zenk*
2656 *Sonerila tinnevelliensis Fischer*
2657 *Sonerila travancorica*
2658 *Sonerila versicolor Wight*
2659 *Sonerila wallichii*
2660 *Sophora velutina Lindl*
2661 *Sopubia delphifolia (L.) G.Don*
2662 *Sopubia trifida Buch-Ham.ex.D Don*
2663 *Sorghum nitidum (Vahl) Pers*
2664 *Spathodea campanulata P Beauv*
2665. *Spatholobus lenticellata Hill*
2666. *Spatholobus purpureus Benth*
2667. *Spatholobus wallichii Benn.*
2668 *Spermacoce articularis L.F*
2669 *Spermacoce hispida L*
2670 *Spermacoce latifolia Aubelt*
2671 *Spermacoce mauritiana Osca Gideon ex. Verdaurt*
2672 *Spermacoce ocymoides Burm.F*
2673 *Spermacoce pusilla Wall in Roxb*
2674 *Sphaeranthuss indicus L*
2675 *Sphenodesme involucrata (Persl.) Rob*
2676 *Sphenodesme paniculata Cl.*
2677 *Spilanthes ciliata H.B.&K*
2678 *Spilanthes paniculata Wall ex DC*
2679 *Spilanthes radicans Jacq*
2680 *Spilanthus calva DC*
2681 *Spiranthes sinensis Ames*
2682 *Sphenoclea zeylanica Gaertn*
2683 *Spodiopogon rhizophorus Pilges*
2684 *Spondias indica*
2685 *Spondias pinnata (L F) Kurz*
2686 *Sporobolus diander (Retz.) P Bean*
2687 *Sporobolus indicus (L.) Kunth*
2688 *Sporobolus piliferus*
2689. *Sporobolus tenuissimus O.Ktz*
2690 *Stachyphrynium spicatum K Schum*
2691 *Stachytarpheta cayennensis (L.C. Rich) Schon*
2692 *Stachytarpheta jamaiconsis (L) Vahl*
2693 *Stachytarpheta urticaefolia (Salish) Sims*
2694. *Staurogyne glauca (Nees) Kuntze*
2695. *Staurogyne zeylanica Kuntze*
2696. *Stellaria media (L) Vill*
2697 *Stenosiphonium parviflorum Anders*
2698. *Stephania japonica (Thumb) Miers*
2699 *Stephenia wightii (Arn) Dunn*
2700 *Sterculia balanghas L*
2701 *Sterculia guttata Roxb Ex DC*
2702 *Sterculia populnifolia Roxb*
2703 *Sterculia urens roxb*
2704 *Sterculia villosai Roxb*
2705. *Stereospermum colais (Buch-Ham ex Dillwyn) Mabb*
2706. *Streblus asper Lour*
2707. *Streblus taxoides (Roth) Kurz*
2708. *Streotigtba crinita P Bean*
2709. *Streptocaulon kleinii*
2710. *Strictocardia campanulata Merr*
2711 *Striga angustifolia (D Don) Sald*
2712 *Striga asiatica (L) Kuztze*
2713 *Striga gesnerioides Vatke*
2714 *Strobilanthes candatus T Anders*
2715. *Strobilanthes decurrens Nees*
2716. *Strobilanthes warreensis Dalz*
2717. *Strobilanthes anceps Nees*
2718. *Strobilanthes asperrimus Nees*
2719. *Strobilanthes ciliatus Nees*
2720 *Strobilanthes consanguineus Clarke*
2721 *Strobilanthes cuspidatus T Anders*
2722. *Strobilanthes foliosus T Anders*
2723. *Strobilanthes gracilis Bedd*
2724 *Strobilanthes heyneanus Nees*
2725 *Strobilanthes homotropus Nees*
2726. *Strobilanthes joyporensis Bedd*
2727. *Strobilanthes kunthianus (Nees) T Anders*
2728 *Strobilanthes lawsonii Gamble*
2729. *Strobilanthes luridus Wight*
2730. *Strobilanthes micranthus Wight*
2731. *Strobilanthes pulneyensis Hook.F*
2732. *Strobilanthes rubicundus T Anders*
2733. *Strobilanthes sessilis Nees*
2734 *Strobilanthes tristis (Wight) T Anders*
2735. *Strobilanthes urceolaris Gamble*
2736 *Strobilanthes wightianus Nees*
2737 *Strombosia ceylanica Gard*
2738. *Strophanthus wightia*
2739. *Struchium sparaganophorum (L) Kuntze*
2740. *Strychnos aenea*
2741. *Strychnos colubrina L*
2742 *Strychnos dalzelli var lanceolarps*
2743. *Strychnos minor Dennst*
2744 *Strychnos nux-vomica L*
2745 *Strychnos vanpurkii Craib*
2746 *Strychnos wallichiana Stend Ex DC*
2747 *Stylocoryna canarica (Hook F) Gamble*
2748 *Stylosanthes fruticosa (Retz) Alston*
2749 *Suregada angustifolia (Muell-Arg) Airy shaw*
2750 *Swertia beddomei*
2751. *Swertia corrymbosa var grisebaehiana*
2752 *Swertia corymbosa (Griseb) Wight ex Clerke*
2753. *Swertia minor*
2754. *Swertia trichotoma*
2755. *Symphorema involucratum Roxb*
2756. *Symplacos cochinchinensis (Lour) s sp laurina Moore*
2757 *Symplacos macrophylla Wall ex A DC*
2758 *Symplocos foliosa Wight*

Contd....

2759. *Symplocos macrophylla*
2760. *Symplocos monantha Wight*
2761. *Symplocos obtusa Wall*
2762. *Symplocos pulchra Wight*
2763 *Symplocos wynadense*
2764. *Synedrella nodiflora (L.) Gaerts*
2765 *Syumplacos racemosa Roxb*
2766 *Syumplacos wynadense (Kuntze) Nooteb*
2767 *Syzygium aromaticum (L.) Merr.&Parry*
2768 *Syzygium benthamianum*
2769 *Syzygium bourdillonii (Gamble) Radbkr&Nair*
2770 *Syzygium caryophyllatum (L.) Alston*
2771 *Syzygium chavaran*
2772 *Syzygium courtallense*
2773 *Syzygium cumini (L) Skeels*
2774 *Syzygium densiflonum Wall.ex.Wight&Arn*
2775 *Syzygium hemisphericum (Wight.) Alston*
2776 *Syzygium heyneanum Wall ex.Gamble*
2777 *Syzygium jambos (L.) Alston*
2778 *Syzygium lactum (Buch-Hum) Sald&Nicol*
2779 *Syzygium laetum*
2780 *Syzygium malabaricum (Bedd.) Gamble*
2781 *Syzygium mundagam (Bourd.)*
2782 *Syzygium munronii (Wight) Chandr*
2783 *Syzygium mychendrae*
2784 *Syzygium occidentale (Bourd.) Gandhi in salt*
2785 *Syzygium palghatense*
2786 *Syzygium parameswaranii mohan&Henry*
2787 *Syzygium rama-varmae*
2788 *Syzygium rubicundum Wight&Arn*
2789 *Syzygium samarangense (Blume) Merr &Parry*
2790 *Syzygium tamilnadensis*
2791 *Syzygium travancoricum Gamble*
2792 *Syzygium zeylanicum (L.) DC*
2793 *Tabernaemontana alternifolia L*
2794 *Tabernaemontana divaricata (L.) R. Br*
2795 *Tabernaemontana gamblei Subrah&Henry*
2796 *Tabernaemontana heyneana*
2797 *Taeinostachyum beddomei*
2798 *Taeniandra micrantha*
2799 *Taeniophyllum scaberulum*
2800 *Tainia bicornis Reichb.F.*
2801 *Talictrum javanicum Blume*
2802 *Talinum portulacifolium (Forssk.) Asch Ex.Scheinf*
2803. *Tamarindus induca L.*
2804. *Tamilnadia uliginosa Tirveng&Sasthry*
2805 *Taniophyllum scaberulum Hook.F*
2806 *Tarenna alpestris (Wt.) Balakr*
2807 *Tarenna asiatica (L.) Kuntze ex Schumann*
2808 *Tarenna canarica*
2809 *Tarenna monosperma (Wt.&Arn) Raju*
2810 *Tarenna nilagirica*
2811 *Tarenna trichurensis Sasi&Sivar*
2812 *Taxillus heyneanus*
2813. *Taxillus tomentosus (Heyne ex Roth) Tieghem*
2814 *Taxilus cuneatus (heyne ex Roth) Danser*
2815 *Tectona grandis L F*
2816 *Tephrosia candida DC*
2817 *Tephrosia hirta (Buch-Ham)*
2818 *Tephrosia pulcherrima (Baker) Gamble*
2819 *Tephrosia purpurea (L.) Pers*
2820 *Tephrosia tinctoria (L.) Pers*
2821. *Tephrosia villosa (L.) Pers*
2822. *Teramnus labialis Spreng*
2823. *Teramnus mollis Benth*
2824 *Terminalia bellerica (Gaertn.) Roxb*
2825 *Terminalia catappa L*
2826. *Terminalia chebula Retz*
2827. *Terminalia crenulata Roth*
2828. *Terminalia paniculata Roth*
2829. *Terminalia travancorensis Wt &Arn*
2830. *Terniola zeylanica (Gardn.) Tul*
2831. *Ternstroemia japonica (Thub) Thumb*
2832. *Tetracora akara (Burm.F) Merr*
2833. *Tetrameles nudiflora R Br In Benn*
2834. *Tetramnus mollis Benth*
2835 *Tetrastigma canarense*
2836. *Tetrastigma leucostaphylum (Dennst)*
2837. *Tetrastigma sulcatum (Lawson) Gamble*
2838. *Teucrium tomentosum Heyne*
2839. *Teucrium wightii*
2840 *Thelasias pygmaea Lindl*
2841. *Thelepaepale ixiocephala*
2842. *Themeda cymbaria (Roxb.) Hack*
2843. *Themeda tremula Hack*
2844. *Themeda triandra Forsk*
2845 *Theriophonum infaustum N E*
2846. *Thespesia lampas (Cav.) Dalz&Gibs*
2847 *Thespesia populnea (L.) Soland*
2848. *Thithonia diversifolia A Gray*
2849. *Thottea abrahamii*
2850 *Thottea dinghoui Swarup*
2851 *Thottea idukkiana*
2852. *Thottea siliquosa (Lam.) Ding Hou*
2853. *Thumbergia alata Boj*
2854. *Thunbergia mysorensis (Wight) T*
2855. *Thunbergia bicolor*
2856. *Thunbergia erecta T Benth*
2857 *Thunbergia fragrans Roxb*
2858. *Thunbergia mysorensis*
2859 *Thunbergia tomentosa*
2860. *Tichodesma zeylanicum (Burm.F) R Br*
2861 *Tilliacora acuminata (Lam.) Miers*
2862 *Tinospora cordifolia (Willd.) Miers ex.Hook&Thomas*
2863 *Tinospora sinensis (Lour.) Merr*
2864 *Toddalia asiatica (l) Lam*
2865. *Tolypanthsu lagenifier*
2866. *Tonningia axillaris (L.) O Ktze*
2867. *Tonningia cucullata (Roth) Kuntze*
2868. *Toona ciliata Roemer*
2869. *Torenia bicolor Dalz*
2870. *Torenia courtallensis Gamble*
2871 *Torenia diffusa D Don*
2872 *Torenia hirsuta*
2873 *Torenia lindernoides Sald*
2874 *Torenia travancorica Gamble*
2875 *Tournefortia heyneana Wall ex Clarke*
2876. *Toxocarpus palghatensis*
2877. *Tragia bicolor Miq*
2878. *Tragia hispida Willd*
2879. *Tragia involucrata L*
2880. *Tragia muelleriana Pax and Hoffm*
2881 *Tragus biflorus Schult*
2882 *Traisbon accordensis Satish*
2883. *Trema orientalis (L.) Bl*
2884. *Trewia nudiflora L*
2885 *Trewia polycarpa Benth*
2886 *Trianthera portulacastrum L*

Contd....

2887 *Trias stocksii* Benth
2888 *Tribulus terrestris* L
2889 *Tricalysia apiocarpa*
2890 *Tricalysis sphaerocarpa*
2891 *Trichilia connaroides* (Wt.&Arn) Benvelzen
2892 *Trichoglottis tenera* Schltz
2893 *Tricholepis angustifolia*
2894 *Tricholepis radicans*
2895 *Trichosanthes anaimalaiensis* Bedd
2896 *Trichosanthes cucumerina* L.
2897 *Trichosanthes lobata* Roxb
2898 *Trichosanthes nervifolia* L
2899. *Trichosanthes tricuspidata* Lour
2900. *Tridax procumbens* L
2901 *Triphasia trifolia* (Burm.F.) Wilson
2902 *Tripogas wightii* Hook F
2903 *Tripogon anantaswamianus*
2904 *Tripogon bromoides* Roem&Schult
2905 *Tripogon capillatus* Janb&Spach
2906 *Tripogon jacquemontii*
2907 *Tripogon narayanii*
2908. *Tripogon pangens*
2909. *Tripogon pauperculus* Stapt
2910 *Tripogon wightii*
2911 *Triumfetta annua* L
2912 *Triumfetta pilosa* Roth
2913 *Tropidia anulosa* (Lindl) Blume
2914 *Truimfetta rhomboidea* Jacq
2915 *Truimfetta rotundifolia* Lam
2916 *Tubernaemontana heyneana* Wall
2917 *Turnera subulata* J E. Smith
2918 *Turnera ulmifolia* L.
2919 *Turpenia nepalensis* Wall
2920 *Turpenia malabarica* Gamble
2921. *Turraea villosa* Benn.
2922. *Tylophora capparidifolia* Wight&Arn.
2923 *Tylophora fasciculata* Buch-Ham
2924 *Tylophora indica* (Burmann) Merrill
2925 *Tylophora macrantha* Hook.F
2926 *Tylophora millissima* Wight&Arn
2927 *Tylophora pauciflora* Wight&Arn
2928 *Tylophora rotundifolia* Buch-Ham
2929 *Tylophora subramanii* Henry
2930. *Tylophora tetrapetala* (Dennst.) Suresh
2931. *Typha angustata* Bory&Chaub
2932 *Typhonium bulbiferum* Dalz
2933. *Typhonium flagelliforme* (Lodd) Bl
2934. *Urania lagopodioides* (L.) Desv
2935 *Urania refuscens* (Dc) Schindler
2936 *Urena lobata* L
2937 *Urena sinuata* L
2938 *Urochloa panicoides* P Beanv
2939 *Urticularia graminifolia* Vahl
2940 *Utricularia aurea* Lour
2941 *Utricularia bifida* L
2942 *Utricularia caerulea* L
2943 *Utricularia nayarii* Janarthanon&Henry
2944 *Utricularia nilginosa* Vahl
2945. *Utricularia praeterita* Taylor
2946 *Utricularia reticulata* J E. Smith
2947 *Utricularia roseo-purpurea* Stapf ex.Gamble
2948 *Utricularia scandens* Benj
2949 *Utricularia stellaria* L F
2950 *Utricularia striatula* Smith
2951 *Uvara macropoda* Hook F &Thomas
2952 *Uvaria hookeri* King
2953 *Uvaria narum* (Dunal) Wall ex Wight&Arn
2954. *Uvaria zeylanica* L
2955. *Vaccinium leschenaultii* Wight
2956 *Vaccinium nelgherrense* Wight
2957 *Vallisnaria natans* (Lour) Hara
2958. *Vanasushava pedata* (Wight) Mukh
2959 *Vanda tessellata* (Roxb) Hook F
2960 *Vanda testacea* (Lind) Reichb F
2961. *Vanda thwaitesii* Hook F
2962. *Vanilla aphylla* Bl
2963. *Vateria indica* L
2964 *Ventilago bombainesis* Dalz
2965. *Vepris bilocularis* (Wight&Arn.) Eng
2966. *Vernonia albicans* DC
2967 *Vernonia anthelmintica* (L) Willd
2968. *Vernonia arborea* Buch-Ham
2969 *Vernonia cinerea* (L) Less
2970. *Vernonia comorinensis* W W> Smith
2971 *Vernonia divergens* (Roxb) Edgew
2972. *Vernonia heynei* Bedd
2973. *Vernonia indica* Clarke
2974. *Vernonia multibracteata* Gamble
2975. *Vernonia peninsularis* (Clarke) Clarke
2976. *Vernonia ramaswamii* Hatchinson
2977 *Vernonia saligna* (DC)
2978 *Vernonia salvifolia* Wight
2979. *Vernonia travancorica* Hook F
2980 *Vetiveria zizanioides* (L) Nash
2981 *Vibrunum punctatum* Buch-Ham
2982 *Viburnum erubescens* Wall Ex DC
2983 *Vicoa indica* (L) DC
2984. *Vigna dalzelliana* (Kuntze) Verdc
2985. *Vigna grahamiana* Verdc
2986. *Vigna pilosa* Baker in Hook-F
2987. *Vigna radiata* (L) Wilgek
2988. *Vigna trilobata* (L) Verde
2989. *Vigna umbellata* (Thumb) Ohwi&Dhashi
2990. *Vigna vexillata* (L) A Rich
2991. *Viola arcuata* Blume
2992 *Viscum angulatum* Heyne ex Dc
2993. *Viscum articulatum* Burm F
2994. *Viscum heyneanum* DC
2995. *Viscum monoicum* Roxb
2996 *Viscum orientale* Wild
2997. *Viscum ramosissimum* Wight&Arn
2998. *Vitex altissima* L F
2999. *Vitex leucoxylon* L F
3000. *Vitex nigundo* L
3001. *Vitex pinnata* L
3002. *Vitis vinifera* L
3003 *Wahlenbergia hookeri* (Clarke) Tuyn
3004 *Walsura trifolia* (A Juss) Harms
3005 *Waltheria indica* L
3006 *Wattakaka volublis* (L F) Stapf
3007 *Wedelia chinensis* (Osbeck) Merr
3008 *Wedelia urticifolia* DC
3009. *Wendlandia thyrsoides* (Roem&Schult) Stend
3010 *Whlenbergia erecta* Tuyn
3011. *Willisia selaginoides* (Bedd) Warm
3012 *Wrightia arborea* (Dennst) Mabb
3013. *Wrightia tinctoria* (Roxb) R Bo
3014 *Xanthium indicum* J Koenig
3015 *Xanthophyllum arnottianum* Wight
3016 *Xanthophyllum flavescens* Roxb
3017 *Xanthophyllum rhetsa* (Roxb) DC
3018. *Xantolis tomentosa* (Roxb) Raf
3019 *Xeromphis uliginosa* Mehesw

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Appendix 3.5.2.1 Contd...

3020. *Xylia xylocarpa (Roxb.) Taub*
3021. *Xyris pauciflora Willd.*
3022. *Youngia japonica (L.) DC.*
3023. *Zanonia indica L.*
3024. *Zanthoxylum ovalifolium Wt.*
3025. *Zanthoxylum rhetsa (Roxb.) DC*
3026. *Zanthoxylum tetraspermum Wight&Arn.*
3027. *Zehneria maysorensis (Wt.&Arn.) Arn.*
3028. *Zehneria scabra (L.F.) Sound*
3029. *Zehneria thwaitesii (Schwein.F.) Jeffrey*
3030. *Zenkeria elegans Trin.*
3031. *Zenkeria sebastinei (Henry)*
3032. *Zeuxibe iongilabris (Lind.) Benth.*
3033. *Zeuxine flava Renth*
3034. *Zeylanidium olivaceum (Gardn.) Engl*
3035. *Zingiber cernnum Dalz*
3036. *Zingiber macrostachyum Dalz*
3037. *Zingiber neesanum (Grah.) Raman*
3038. *Zingiber officinale Rosc.*
3039. *Zingiber purpureum Roscoe*
3040. *Zingiber wightianum Thw*
3041. *Zingiber zerymbet (L.) J.E. Smith*
3042. *Ziziphus mauritiana Lam*
3043. *Ziziphus oenoplia (L.) Miller*
3044. *Ziziphus rugosa Lam.*
3045. *Zornia gibbosa Spanoghe*
3046. *Zornia quilonensis Ravi*

Source: Secondary data collected by KFRI

Appendix 3.5.2.2. : Algae of GKR

Sr. No.	Scientific Name	Family
1	*Anabaena vaginicola* Fritsch & Rich.form fertilissima Prasad	Osciliatoriaceae
2	*Aphanocarpus grevillei* (Hass.) Robenh.	Osciliatoriaceae
3	*Aphanocarpus pulchra* (Kutz.) Rabenh.	Osciliatoriaceae
4	*Aphanothece pallida* (Kutz.) Rabenh.	Osciliatoriaceae
5	*Aulosira fertilissima* Ghose	Osciliatoriaceae
6	*Aulosira fritschii* Bharadwaja	Osciliatoriaceae
7	*Botrycococcus braunii* Kutz.	Osciliatoriaceae
8	*Chroococcus minor* (Kutz.) Nag.	Osciliatoriaceae
9	*Cladophora fracta* (Dillw.) Kutz.	Osciliatoriaceae
10	*Closteriopsis longissima* (Lemm.) Lemm. var. *tropica* (W.West & G.S. West) W.West & G.S. West	Osciliatoriaceae
11	*Closterium accerosum* (Schronk) Ehrenb.	Osciliatoriaceae
12	*Closterium ehrenbergii* Menegh.	Osciliatoriaceae
13	*Closterium subulatum* (Kutz.) Breb.	Osciliatoriaceae
14	*Coelastrum microsporum Nag.*	Osciliatoriaceae
15	*Cosmarium buoculatum* Breb var. *hians* West & G.S. West.	Nostocaceae
16	*Cosmarium depressum* (Nag.) Lund.	Scytonemataceae
17	*Cosmarium moniliforme* (Turp.) Ralfs. var. *indentatum* Scott & Gronbl.	Scytonemataceae
18	*Cosmarium pseudoconnatum* Nordst.	Scytonemataceae
19	*Cosmarium pyramidatum* Breb.	Scytonemataceae
20	*Cylyndrocystis crassa* De Bary	Scytonemataceae
21	*Debarya costata* Randhawa	Scytonemataceae
22	*Debarya jogensis* Iyengar	Scytonemataceae
23	*Debarya madrasensis* Iyengar	Scytonemataceae
24	*Docidium baculum* Breb.	Chroococcaceae
25	*Euastrum spinulosum* Delp.	Chroococcaceae
26	*Glococystis gigas* (Kg.) Lagerh.	Chroococcaceae
27	*Gloeotaenium loitlesbergerianum* Hansg.	Chroococcaceae
28	*Gonatozygon kinhanii* (Archer) Rabh.	Stygonemataceae
29	*Gonium petorale* Mull.	Stygonemataceae
30	*Hapalosiphon intricatus* W. West & G.S. West	Cladophoraceae
31	*Hapalosiphon welwitschii* W. West & G.S. West	Cladophoraceae
32	*Lyngbya aerugineo-coerulea* (Kuntz.) Gomont.	Cladophoraceae
33	*Lyngbya lachneri* (Zimm.) Geitler	Cladophoraceae
34	*Mougeotia adnata* Iyengar.	Cladophoraceae
35	*Mougeotia gotlandica* (Clev) Wittrock	Cladophoraceae
36	*Mougeotia indica* Randhawa	Cladophoraceae
37	*Mougeotia producta* W. West & West	Cladophoraceae
38	*Navicula confervaceae Kutz.*	Cladophoraceae

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Appendix 3.5.2.2 Contd....

Sr. No.	Scientific Name	Family
39	*Netrium digitus* (Her.) Itzigs.	Cladophoraceae
40	*Oedogonium cardiacum* (Hass.) Wittro. ex. Hirn.	Cladophoraceae
41	*Oocystis elliptica* W. West	Cladophoraceae
42	*Oscillatoria amphibia* Agardh ex Gomont.	Cladophoraceae
43	*Oscillatoria boryana* Bory ex Gomont.	Cladophoraceae
44	*Oscillatoria curviceps* Agardh ex Gomont.	Cladophoraceae
45	*Oscillatoria formosa* Bory ex Gomont.	Cladophoraceae
46	*Oscillatoria geifleriana* Elenkin.	Cladophoraceae
47	*Oscillatoria pseudogeminata* Schmid.	Cladophoraceae
48	*Oscillatoria sancta* (Kuntz.) Gomont.	Cladophoraceae
49	*Pediastrum boryanum* (Turp.) Menegh.	Cladophoraceae
50	*Pediastrum tetras* (Ehr.) Ralfs. var. *tetradon* (Corda) Hansg.	Cladophoraceae
51	*Pediastrum tetras* (Ehr.) Ralfs. var. *tetras*	Cladophoraceae
52	*Phormidium ambiguum* Gomont.	Cladophoraceae
53	*Phormidium calcicola* Gardner..	Cladophoraceae
54	*Phormidium fragile* (Meneghini) Gomont.	Cladophoraceae
55	*Pinnularia conica* Gandhi	Cladophoraceae
56	*Plectonema dangeardii* Fremy	Cladophoraceae
57	*Pleurotaenium verrucosum* (Bailli) Lund.	Cladophoraceae
58	*Porphyrosiphon notarisii* (Menegh.) Kuntz. ex Gomont.	Cladophoraceae
59	*Scenedesmus bijugatis* (Rurp.) Kutz. var. *bicellularis* (Chordat) Phillip.	Cladophoraceae
60	*Scenedesmus brasiliensis* Bohlin	Cladophoraceae
61	*Scenedesmus denticulatus* Lager. var. *australis* Playfair	Cladophoraceae
62	*Scenedesmus denticulatus* Lager. var. *linearis* Hansg.	Cladophoraceae
63	*Scenedesmus obliquus* (Turp.) Kutz.	Cladophoraceae
64	*Scytonema chiastum* Geifler	Cladophoraceae
65	*Scytonema cincinnatum* Thuret ex Born & Flah.	Cladophoraceae
66	*Scytonema coactile* Mont. ex Born. & Flah.	Cladophoraceae
67	*Scytonema major* Kutz.	Cladophoraceae
68	*Sorastrum americanum* (Bohlin) Schmidle	Cladophoraceae
69	*Sorastrum spinulosum* Nag.	Cladophoraceae
70	*Spirogyra dubia* Kutz.	Cladophoraceae
71	*Spirogyra goetzii* Schmidle.	Cladophoraceae
72	*Spirogyra grossii* Schmidle.	Cladophoraceae
73	*Spirogyra jogensis* Iyengar var. *minor* Iyengar.	Cladophoraceae
74	*Spirogyra setiformis* (Roth) Kutz.	Cladophoraceae
75	*Spirogyra submaxima* Transeau.	Hydrodyctiaceae
76	*Spirogyra triplicata* (Collins) Transeau.	Hydrodyctiaceae
77	*Spirulina major* Kutz. ex Gomont.	Hydrodyctiaceae
78	*Staurastrum gracile* Ralfas.	Hydrodyctiaceae
79	*Straurastrum Sebaldi* Reinsh.	Hydrodyctiaceae
80	*Temnogametum cylindrosporum* Iyengar.	Hydrodyctiaceae

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Appendix 3.5.2.2 Contd….

Sr. No.	Scientific Name	Family
81	*Temnogametum indicum* Iyengar.	Hydrodyctiaceae
82	*Tetradon bifurcatum* (Wille) Lager.	Hydrodyctiaceae
83	*Tetradon gracile* (Reinsch) Honsg.	Hydrodyctiaceae
84	*Tetradon limneticum* Borge.	Hydrodyctiaceae
85	*Tetradon trigonum* (Nag.) Hansg.	Hydrodyctiaceae
86	*Tetrastrum straurogeniaeforme* (Schroder) Lemm.	Hydrodyctiaceae
87	*Tolypothrix tenuis* (Kutz.) Johs.emend Schmidt.	Hydrodyctiaceae
88	*Tribonema bombycinum* (Agardh). Derbes & Solier.	Scenedesmaceae
89	*Zygenma cyaneum* Czurda.	Scenedesmaceae
90	*Zygenma cyanosporum* Clev.	Scenedesmaceae
91	*Zygnemopsis hesaragattense* Iyengar.	Scenedesmaceae
92	*Zygnemopsis saravatiensis* Iyengar.	Scenedesmaceae
93	*Zygnemopsis splendens* Randhwa.	Tribonemataceae
94	*Zygonium ericetorum* Kutz.	Naviculaceae
95	*Zygonium talguppense* Iyengar.	Naviculaceae

Source :Secondary data collected by CESS

Appendix 3.5.2.3 : Fungi of GKR

1. *Aecidium travancoricum* Ramakr.
2. *Aecidium spp.*
3. *Anthostomellia hibisci* K.Ramakr.
4. *Ascroe rubra* (La Bill.) Fisch. Var. *zeylanica* (Berk.) Ed. Fisch.
5. *Asterina travancorensis* Syd.
6. *Asteroconium nothopegiae* T.S.Ramakr., Sriniv. & Sund.
7. *Bahusandha indica* Subram
8. *Beltrania rhombica* Penzig
9. *Botryodiplodia theobromae* Pat.
10. *Cercosporia boreriae* Ell. & Er.
11. *Cercosporia caladii* Cooke.
12. *Cercosporia carbonacea* Miles.
13. *Cercosporia cladosporioides* Sacc
14. *Cercosporia dioscoreae* Ellis & Mark.
15. *Cercosporia perfoliata* Ell. & Ev.
16. *Chaetomella crcinoseta* Stalk.
17. *Cirrenalia macrocephala* (Kohlm.) Meyers & Moore.
18. *Cladochytrium hyalinum* Berdan.
19. *Cladochytrium replicatum* Karling.
20. *Collerotrichum ficus* Koord.
21. *Corticium salmonicolor.*
22. *Corticium spp.*
23. *Corynespora cassicola* (Berk. & Curt.) Wei.
24. *Corynespora cassicola*
25. *Curvularia pallescens* Boedijn.
26. *Cylindrocladium scoparium* Morg.
27. *Diatrype chlorosarca* Berk. & Br.
28. *Dictyoarthrinium quadratum.*
29. *Diplodia dalbergiae.*
30. *Enterobryus cingaloboli* Rajagopalan.
31. *Erysiphe periyarensis* Ramakrishnan.
32. *Exosporium bryophilli* T.S.Ramakr.
33. *Gloeosporium alorubrum.*
34. *Gloeosporium spp.*
35. *Glomerilla cingulata* (Stoneum.) Spauld & Schrenk.
36. *Helminthosporium halodes.*
37. *Hemilia pavetticola* Maubl. & Rogers
38. *Hyphochytryum catenoides.*
39. *Hypocrella discoidea* (Berk. & Br.) Sacc.
40. *Hypoxylon rubiginosum* (Pers.) Fr. Var. *tropica* Miller.
41. *Leptothyrium theae* Petch.
42. *Lomantha pooja* Subram.
43. *Lulworthia floridans* Meyers.
44. *Lulworthia purpurea* (Wison.) Johnson.
45. *Macrophoma macrangae* Ramakr.
46. *Martesia aristata* Beach & Scots pine.
47. *Meliola clavulata* Wint.
48. *Meliola gneti* Hansford
49. *Meliola tamarindii* Syd.
50. *Mylitta lapidescens* Horaninow.
51. *Myrothesium roridum* Tode ex Fr.
52. *Necteria bulbophylli* P.Henn.
53. *Necteria gracilipes* (Tul.) Wr.
54. *Phyllachora ambigua* (Syd.) Syd.
55. *Phyllachora catervaria* (Berk.) Sacc
56. *Phyllachora coicis* P. Henn.
57. *Phyllochora connari* Syd.
58. *Phyllachora ynodontis* (sacc.) Niessl.
59. *Phyllachora cyperi* Rehm.
60. *Phyllachora dalbergiae* Niessl.
61. *Phyllachora diospyri* Ullasa.
62. *Phyllachora fallax* Sacc.
63. *Phyllachora gordoniae* Hosagoudar sp. Nov. ined
64. *Phyllachora infectoria* (sacc.) Niessl.
65. *Colletotrichum sp.*
66. *Phaeoseptoria eucalypti Hansf.*
67. *Cercospora nigricans Cooke*
68. *Cercospora careyae Ramakrishnan T.S & K.*
69. *Asperisporium pongamiae (H.Syd.) Deighton*
70. *Exobasidium cinnamomi Petch*
71. *Tilletia themedicola Mishra & Thirum.*
72. *Sphacelotheca sp*
73. *Sorosporium sp.*
74. *Cintractia minor (Clint.) Jackson*
75. *Uromyces pianhyensis P Henn.*
76. *Uromyces decoratus Syd.*
77. *Uromyces commelinae Cooke*
78. *Uromyces clingnyi Pat. & Har.*
79. *Uromyces achrous Syd.*
80. *Uredo ophiorrhizae Petch*
81. *Uredo chasaliae Petch*
82. *Stakmania formosana (Syd.) Sathe*
83. *Puccinia sp*
84. *Puccinia ruelliae Syd*
85. *Puccinia pusilla H. Syd. & P. Syd*
86. *Puccinia prataparajii Hosagoudar sp*
87. *Puccinia pachypes H Syd. & P. Syd.*
88. *Puccinia levis (Sacc. & Bizz.) Magn*
89. *Puccinia arthroaxonis -ciliaris Cum*
90. *Masseeella capparidis (Hobson) Diet.*
91. *Kuehneola spondias Hosgoudar sp.*
92. *Didymopsorella macrospora (Mundk. & Thirum.) Thirum*
93. *Dasturella divinia (Syd.) Mundk. & Khes.*
94. *Caeoma keralensis Hosagoudar sp.*
95. *Aecidium rhytismoideum Berk. & Br*
96. *Aecidium painavuensis Hosagoudar sp.*

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Appendix 3.5.2.3 Contd..

97. *Aecidium elaeocarpi-tuberculatae Hosagoudar sp.*
98. *Spaerodothis raoii Pande*
99. *Phyllachora themedae Ananth.*
100. *Phyllachora stenospora (Berk. & Br.) Sacc.*
101. *Phyllachora sikkimensis Ramkr. T.S. & K.*
102. *Phyllachora setariecola Speg.*
103. *Phyllachora sacchari P. Henn.*
104. *Phylachora pongamiae (Berk. & Br.) Petch*
105. *Phyllachora paspalicola P. Henn.*
106. *Phyllachora ischaemi Syd.*

Source: Secondary data collected by CESS

Appendix 3.5.2.4 : Bryophytes of GKR

Sr. No.	Scientific Name	Family
1	*Anthoceros* sp.	Ditrichaceae
2	*Brachymenium acuminatum* Harv. In Hook.	Dicranaceae
3	*Brachymenium bryoides* Hook.	Dicranaceae
4	*Brachymenium exile* (Dozy & Molk.) Bryol.	Leucobryaceae
5	*Bryum badhwari* Ochi	Fissidentaceae
6	*Bryum capillare* L. ex Hedw.	Calymperaceae
7	*Bryum coronatum* Schw.	Pottiaceae
8	*Calymperes* sp.	Bryaceae
9	*Claopodium assurgens* (Sull. & Lesq.) Card.	Bryaceae
10	*Diaphanodon* sp.	Bryaceae
11	*Dumortiera* sp.	Bryaceae
12	*Ectropothecium* sp.	Bryaceae
13	*Entodon chloropus* Ren. & Card.	Bryaceae
14	*Erythrodontium julaceum* (Schwaegr.) Par.	Bryaceae
15	*Fissidens involutus Wils. & Mitt.*	Bartramiaceae
16	*Fossombronia himalayensis* kash.	Orthrotrichaceae
17	*Garckea phascoides* (Hook.) C.Muell.	Trachypodaceae
18	*Homaliodendron exiguum* (Bosch. & lac.)	Pterobryaceae
19	*Hyophila involuta* (Hook.) Jaeg.	Meteoriaceae
20	*Leucobryum* sp.	Neckeraceae
21	*Leucoloma amoene* virens Mitt.	Thuidiaceae
22	*Macromitrium* sp.	Entodontaceae
23	*Meteoriopsis* sp.	Entodontaceae
24	*Metzgeria* sp.	Hypnaceae
25	*Philonotis hestata* (Dub.) Wijk & marg.	Polytrichaceae
26	*Pogonatum aloides* (Hedw.) P.Beauv.	Fossombroniaceae
27	*Pohlia* sp.	Metzegeriaceae
28	*Pterobryopsis* sp.	Aneuraceae
29	*Riccardia multifida* (L.) Dum.	Ricciaceae
30	*Riccia fluitanes* L.	Ricciaceae
31	*Riccia* sp.	Marchantiaceae
32	*Trematodon longicollis* Michx.	Anthocerotaceae

Source: Secondary data collected by CESS

Appendix 3.5.2.5 : Pteridophytes of GKR

Sr. No.	Scientific Name	Family
1	*Actinopteris radiata* (Sw.) Link.	Actinopteridaceae
2	*Adiantum aethiopicum L.*	Adiantaceae
3	*Adiantum cuneipinnulum* Nair et Ghosh	Adiantaceae
4	*Adiantum hispidulum* Sw.	Adiantaceae
5	*Adiantum incisum* Forssk.	Adiantaceae
6	*Adiantum latifolium* Lam.	Adiantaceae
7	*Adiantum lunulatum* Burm.	Adiantaceae
8	*Adiantum raddianum* Presl.	Adiantaceae
9	*Amphineuron terminans* (Hook.) Holtum	Thelypteridaceae
10	*Angiopteris evecta* (Forst.) Hoff.	Angiopteridaceae
11	*Antrophyum plantagineum* (Cav.) Kaulf.	Vittariaceae
12	*Arachnoides aristata* (Forst. f.) Tindale	Athyriaceae
13	*Arachnoides tripinnata* (Goldm.) Sledge	Dryopteridaceae
14	*Araiostegia pulchra* (Don) Copel.	Davalliaceae
15	*Asplenium aethioppicum* (Burm. f.) Becherer	Aspleniaceae
16	*Asplenium auritum* Sw.	Aspleniaceae
17	*Asplenium crinicaule* Hance	Aspleniaceae
18	*Asplenium decrescens* Kunze	Aspleniaceae
19	*Asplenium ensiforme* Wall. ex Hook. & Grev.	Aspleniaceae
20	*Asplenium formosum* Willd.	Aspleniaceae
21	*Asplenium indicum* Sledge	Aspleniaceae
22	*Asplenium iunilaterale* Lam.	Aspleniaceae
23	*Asplenium laciniatum* Don	Aspleniaceae
24	*Asplenium phyllitidis* Don	Aspleniaceae
25	*Asplenium polyodon* G. Forster.	Aspleniaceae
26	*Asplenium serricula* Fee.	Aspleniaceae
27	*Asplenium tenerum* Forst.	Aspleniaceae
28	*Asplenium tenuifolium* Don.	Aspleniaceae
29	*Asplenium unilaterale* Lam.	Aspleniaceae
30	*Asplenium unilaterale* var. *majus* (C. Chr.) Sledge	Aspleniaceae
31	*Asplenium zenkaranum* Kunze	Aspleniaceae
32	*Aspleniumpolydon* G. Forster var. *bipinnatum* (Sledge)	Aspleniaceae
33	*Athyrium hohenackeranum* (Kunze) T. Moore	Athyriaceae
34	*Athyrium nigripes* (Bl.) T. Moore	Athyriaceae
35	*Blechnum orientale* L.	Blechanaceae
36	*Bolbitis semicordata* (Baker) Ching	Lomariopsidaceae

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Appendix 3.5.2.5 Contd...

Sr. No.	Scientific Name	Family
37	*Bolbitis Xprolifera* (Bory) C. Chr.	Lomariopsidaceae
38	*Botrychium lanuginosum* Wall. ex Hook. & Grev.	Ophioglossaceae
39	*Cheilanthes bullosa* Kunze	Sinopteridaceae
40	*Cheilanthes farinosa* (Forsk.) Kaulf.	Sinopteridaceae
41	*Christella dentata* (Forssk.) Brownsey & Jermy	Thelypteridaceae
42	*Christella meeboldii* (Rosenst.) Holtt.	Thelypteridaceae
43	*Christella papilio* (Hope) Holttum	Thelypteridaceae
44	*Christella parasitica* (L.) H. Lev.	Thelypteridaceae
45	*Crypsinus montanus* Sledge	Polypodiaceae
46	*Ctenopteris subfalcata* (Bl.) Kunze	Grammitidaceae
47	*Cyathea crinita* (Hook.) Copel.	Cyatheaceae
48	*Cyathea gigantea* (Wall. ex Hook.) Holttum	Cyatheaceae
49	*Cyclosorus interruptus* (Wild.) H. Ito	Thelypteridaceae
50	*Davallia bullata* Wall. ex Hook.	Davalliaceae
51	*Dicranopteris linearis* (Burm.f.) Underwood var. sebastiana Panigrahi & Dixit	Gleicheniaceae
52	*Diplazium cognatum* (Hieron.) Sledge	Athyriaceae
53	*Diplazium dilatatum* Bl.	Athyriaceae
54	*Diplazium esculentum* (Retz.) Sw.	Athyriaceae
55	*Diplazium polypodioides* Bl.	Athyriaceae
56	*Diplazium sylvaticum* (Bory) Sw.	Athyriaceae
57	*Diplazium travancoricum* Beddome	Athyriaceae
58	*Doryopteris concolor* (Langsd. et Fisch.) Kuhn	Sinopteridaceae
59	*Drynaria quercifolia* (L.) J. Sm.	Polypodiaceae
60	*Dryoathyrium boryanum* (Willd.) Ching	Athyriaceae
61	*Dryopsis scabrosa* (Kunze) Holttum & Edwards	Dryopteridaceae
62	*Dryopteris approximata* Dldge	Dryopteridaceae
63	*Dryopteris cochleata* (Buch. Ham. ex D. Don) C. Chr.	Dryopteridaceae
64	*Dryopteris hirtipes* (Bl.) Kuntze	Dryopteridaceae
65	*Dryopteris sparsa* (Buch. Ham. ex D. Don) Kuntze	Dryopteridaceae
66	*Egenolfia appendiculata* (Willd.) J. Sm.	Lomariopsidaceae
67	*Egenolfia asplenifolia* (Bory) Fee.	Lomariopsidaceae
68	*Egenolfia keralensis* Nayar et Kaur	Lomariopsidaceae
69	*Elaphoglossum beddomei* Sledge	Lomariopsidaceae
70	*Elaphoglossum nilgiricum* Krajina ex Sludge	Lomariopsidaceae
71	*Equisetum ramosissimum* Desf.	Equisetaceae
72	*Grammitis attenuata* Kunze	Grammitidaceae
73	*Grammitis pilifera* Ravi et Joseph var. *munnarensis* Raju Antony et al.	Grammitidaceae

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Appendix 3.5.2.5 Contd...

Sr. No.	Scientific Name	Family
74	*Hemionitis arifolia (Burm.) Moore*	Hemionitidaceae
75	*Histiopteris incisa* (Thunb.) J. Sm.	Dennstaedtiaceae
76	*Huperzia hamiltonii* (Spreng) Trev.	Lycopodiaceae
77	*Huperzia hilliana* (Nessl) Holub.	Lycopodiaceae
78	*Huperzia phlegmaria* (L.) Rothmaler	Lycopodiaceae
79	*Huperzia phyllantha* (Hook. et Arn.) Holub.	Lycopodiaceae
80	*Huperzia squarrosa* (Forst.) Trev.	Lycopodiaceae
81	*Hymenophyllum denticulatum* Sw. Schrad	Hymenophyllaceae
82	*Hymenophyllum gardneri* v.d.B.	Hymenophyllaceae
83	*Hypolepis glandulifera* Brownsey et Chinnock	Dennstaedtiaceae
84	*Laxogramme involuta* (D. Don) C. Presl.	Polypodiaceae
85	*Lepisorus amaurolepidus* Sledge	Polypodiaceae
86	*Lepisorus nudus* (Hook.) Ching	Polypodiaceae
87	*Leptochilus decurrens* Bl.	Polypodiaceae
88	*Leptochilus thwaitesianus* Fee.	Polypodiaceae
89	*Leucostegia immersa* (Wall.) Presl.	Davalliaceae
90	*Lindsaea ensifolia* Sw.	Lindsaeaceae
91	*Lindsaea odorata Roxb. ex Griff.*	Lindsaeaceae
92	*Lycopodiella cernua* (L.) Pic.	Lycopodiaceae
93	*Lycopodium japonicum* Thunb.	Lycopodiaceae
94	*Lycopodium wightianum* Wall. ex Hook. et Grev.	Lycopodiaceae
95	*Lygodium flexuosum* (L.) Sw.	Shizaeaceae
96	*Macrothelypteris torresiana* (Gaudich.) Ching	Thelypteridaceae
97	*Microgonium bimarginatum* v.d.B., Hymen.	Hymenophyllaceae
98	*Microlepia rhomboidea* Prantl, Arb.	Dennstaedtiaceae
99	*Microlepia splenuncae* (L.) Moore	Dennstaedtiaceae
100	*Microlepis stigosa* (Thunb.) Presl.	Dennstaedtiaceae
101	*Microsorium membranaceum* (D. Don) Ching	Polypodiaceae
102	*Microsorium pteropus* (Bl.) Copel.	Polypodiaceae
103	*Microsorium punctatum* (L.) Copel.	Polypodiaceae
104	*Nephrolepis auriculata* (L.) Trimen.	Oleandraceae
105	*Odontosoria chinensis* (L.) J. Smith	Lindsaeaceae
106	*Oleandra musifolia* (Bl.) Presl	Oleandraceae
107	*Ophioglossum nudicaule* L.f.	Ophioglossaceae
108	*Osmunda hugeliana* Presl.	Osmundaceae
109	*Pellaea bovini* Hook.	Sinopteridaceae
110	*Phymatosorus lucidus* (Roxb. ex Grifff.) Pic.	Polypodiaceae
111	*Phymatosorus nigrescens* (Bl.) Pic.	Polypodiaceae
112	*Pityrogramma calomelanos* (L.) Link. var *calomelanos* Handb. Gew.	Hemionitidaceae

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Appendix 3.5.2.5 Contd...

Sr. No.	Scientific Name	Family
113	*Pityrogramma Calomelanos var. aureoflava* (Hook.) Weath. ex Baily	Hemionitidaceae
114	*Pneumatopteris truncata* (Poir.) Holtum	Thelypteridaceae
115	*Polystrichum moluccense* (Bl.) T. Moore	Dryopteridaceae
116	*Prosaptia contigua* (Forst. f.) Presl.	Grammitidaceae
117	*Pseudocyclosorus ochthodes* (Kunze) Holttum	Thelypteridaceae
118	*Pseudocyclosorus tylodes* (Kunze) Ching	Thelypteridaceae
119	*Psilotum nudum* (L.) P. Beauv.	Psilotaceae
120	*Pteridium aquilinum* (L.) Kuhn. v. Reis.	Dennstaedtiaceae
121	*Pteris argyraea* T. Moore	Pteridaceae
122	*Pteris aspericaulis* all. ex Ag.	Pteridaceae
123	*Pteris biaurita* L.	Pteridaceae
124	*Pteris confusa* Walker	Pteridaceae
125	*Pteris furunculata* Nair et Ghosh	Pteridaceae
126	*Pteris kleiniana* Christ	Pteridaceae
127	*Pteris longipes* D. Don	Pteridaceae
128	*Pteris quadriaurita* Retz.	Pteridaceae
129	*Pteris scabripes* Wall. ex Ag.	Pteridaceae
130	*Pyrossia lanceolata* Farewell.	Polypodiaceae
131	*Pyrossia porosa* var. *porosa* Hovenkamp.	Polypodiaceae
132	*Selaginella brachystachya* (Hook. & Grev.) Spring	Selaginellaceae
133	*Selaginella chrysocaylos* (Hook. et Grev.) Spring	Selaginellaceae
134	*Selaginella chrysorrhizos* Spring	Selaginellaceae
135	*Selaginella ciliaris* (Retz.) Spring	Selaginellaceae
136	*Selaginella delicatula* (Desv.) Alston	Selaginellaceae
137	*Selaginella inequalifolia* (Hook. et Grev.)	Selaginellaceae
138	*Selaginella intermedia* Spring	Selaginellaceae
139	*Selaginella involvens* (Sw.) Spring	Selaginellaceae
140	*Selaginella monospora* Spring.	Selaginellaceae
141	*Selaginella radicata* (Hook. & Grev.) Spring	Selaginellaceae
142	*Selaginella semicordata* (Wall.) Spring	Selaginellaceae
143	*Selaginella tenera* (Hook & Grev.) Spring	Selaginellaceae
144	*Selaginella wightii* Hieron.	Selaginellaceae
145	*Sphaerostephanos subtruncatus* (Bory) Holttum	Thelypteridaceae
146	*Sphaerostephanos unitus* (L.) Holttum	Thelypteridaceae
147	*Stegnogramma pozoi* (Lagasca) K. Iwats.	Thelypteridaceae
148	*Stenochlaena palustris* (Burm.) Beddome	Polypodiaceae
149	*Tectaria coadunata* (J. Sm.) C. Chr.	Dryopteridaceae
150	*Tectaria paradoxa* (Fee) Sledge	Dryopteridaceae

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Appendix 3.5.2.5 Contd...

Sr. No.	Scientific Name	Family
151	*Tectaria wightii* (Clarke) Ching	Dryopteridaceae
152	*Trichomanes obscurum* Blume	Hymenophyllaceae
153	*Trichomanes proliferum* Blume	Hymenophyllaceae
154	*Trichomanesplicatum* (v.d.B.) Beddome	Hymenophyllaceae
155	*Trignospora caudipinna* (Ching) Sledg	Thelypteridaceae
156	*Trignospora ciliata* (Wall. ex Benth.) Holttum	Thelypteridaceae
157	*Vittaria elongata* Sw.	Dennstaedtiaceae

Source: Secondary data collected by CESS

Appendix 3.5.2.6 : Medicinal Plants of the Sacred Groves of GKR

Sr. No.	Scientific Name	Family	Malayalam Name
1	*Abrus precatorius* L.	Papilionaceae	Kunni
2	*Achyranthes aspera* L.	Amaranthaceae	Kadaladi
3	*Achronychia pedunculata* (L.) Miq.	Rutaceae	Viduikanali
4	*Aerva lanata* (L) Juss	Amaranthaceae	Cherula
5	*Alangium salvifoliuin* (L.f.) Wang.	Alangiaceae	Azhinjil, Ankolam
6	*A lbizia lebbeck* (L.) Benth.	Mimosaceae	Nenmenivaka
7	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	Ezhilampala, Pala
8	*Anamirta cocculus* (L) Wight & Arn.	Menispermaceae	Polla, Nanchuvalli
9	*Andrographis paniculata* (Burm. f.) Wall. ex Nees	Acanthaceae	Kiriyathu
10	*Antiaris toxicaria* (Pers.) Lesch.	Moraceae	Maravuri
11	*A ristolochia indica* L.	Aristolochiaceae	Garudakodi
12	*Asparagus racemosus* Wi lld.	Liliaceae	Sathavari
13	*Azadirachta indica* A. Juss.	Meliaceae	Veppu
14	*Barringtonia acutangula* (L.) Gaertn.	Lecythidaceae	Nirpezhu
15	*Biophvtum sensitivum* (L.) DC.	Oxalidaceae	Mukkuti
16	*Buchanania lanceolata* Wight	Anacardiaceae	Kulamavu, Malamavu
17	*Callicarpa tomentosa* (L.) Murray	Verbenaceae	Cheruthekku
18	*Calophyllum apetalwn* Willd.	Clusiaceae	Cherupunna
19	*Calycopteris floribunda* Lam.	Combretaceae	Pullani
20	*Cardiospertnum halicacabitin* L.	Sapindaceae	Uzhinja
21	*Careyota urens* L.	Arecaceae	Anappana, Olattippana
22	*Centella asiatica* (L.) Urban.	Apiaceae	Kudangal
23	*Cissampelos pareira* L.	Menispermaceae	Malathangi, Padathali
24	*Clerodendrum viscosum* Vent	Verbenaceae	Peruku, Peruvelam
25	*Connarus monocarous* L.	Connaraceae	Kureel, Malathangi
26	*Costus speciosus* (Koen.) Sm.	Zingiberaceae	Anakoova, Channakoova
27	*Curculigo orchioides* Gaertn.	Liliaceae	Nilappana
28	*Cycas circinalis* L.	Cycadaceae	Entha, Intalppana
29	*Cyclea peltata* (Lam.) Hook. f & Thoms.	Menispermaceae	Padakizhangu Padathali
30	*Dioscorea bulbifera* L.	Dioscoreaceae	Kachil
31	*Diospyros candolleana* Wight.	Ebenaceae	Karimaram
32	*Evolvulus alsinoides* (L.) L.	Convolvulaceae	Kranthi
33	*Ficus arnotiana* Miq.	Moraceae	Kallarayal
34	*Ficus bengalensis* L.	Moraceae	Peral
35	*Gloriosa superba* L.	Liliaceae	Menthonni
36	*Glycosmis arborea* (Roxb.) DC.	Rutaceae	Panal
37	*Gnetum ula* Brong.	Gnetaceae	Karathodal, Ula
38	*Holigarna arnottiana* Hook. f.	Anacardiaceae	Cheru
39	*Hugonia mystax* L.	Linaceae	Mothirakkanni
40	*Hydnocarpus pentandra* (Buch.Ham) Oken	Flacourtiaceae	Marotti

Contd...

Appendix 3.5.2.6 Contd...

Sr. No.	Scientific Name	Family	Malayalam Name
41	*Inchnocarpus frutescens* (L.) R.Br.	Apocynaceae	Palvallii
42	*Lannea coromandalica* (Houtt.) Merr.	Anacardiaceae	Udi
43	*Lantana camara* L.	Verbenaceae	Arippu, Poochedi
44	*Leea indica* (Burm.f.) Merr.	Leeaceae	Maniperanti
45	*Madhuca longifolia* (Koenig.) Me Bride	Sapotaceae	Nattilippa, Kaasavu
46	*Mallotes philippensis* (Lam.) Muell. Arg.	Euphorbiaceae	Chenkolli, Kunkuma
47	*Memecylon umbellatum* Burm. f.	Melastomataceae	Kaasavu, kayampu
48	*Mesua nagassarium* (Burm. f.) Kosterm.	Clusiaceae	Nanku
49	*Mimosa pudica* L.	Mimosaceae	Thottavadi
50	*Minusops elengi* L.	Sapotaceae	Ilangi
51	*Morinda umbellata* L.	Rubiaceae	Kudal churukki
52	*Moullava spicata* (Dalz.) Nicolson	Caesalpiniaceae	Kazhangi
53	*Murraya paniculata* (L). Jacq	Rutaceae	Kattukariveppu
54	*Mussaenda laxa* (Hook. f.) Hutch. ex Gamble	Rubiaceae	Vellila
55	*Myristica malabarica* Lam.	Myristicaceae	Kattu jathi
56	*Myxopyrum serratulum* Hill	Oleaceae	Chathuramulla
57	*Naregamia alata* Wight & Arn.	Meliaceae	Nilanarakam
58	*Neolitsea cassia* (L.) Kosterm.	Lauraceae	Venkana
59	*Ocimum sanctum* L.	Laminaceae	Tulasi
60	*Olea dioica* Roxb.	Oleaceae	Edana
61	*Ophiorriziza mungos* L.	Rubiaceae	Avilpori
62	*Pavetta indica* L.	Rubiaceae	Pavatta
63	*Piper longum* L.	Piperaceae	Thippali
64	*Salacia oblonga* Wall	Hippocrateaceae	Ponkarandi
65	*Samadera indica* Gaertn.	Simaroubaceae	Karinjotta
66	*Santalum album* L.	Santalaceae	Chandanam
67	*Scoparia dulcis* L.	Scrophulariaceae	Neenankanni
68	*Smilax aspera* L.	Smilacaceae	Kareelanchi
69	*Sterculia urens* Roxb.	Sterculiaceae	Thondi
70	*Syzygium caryophyllatum* (L.) Alston.	Myrtaceae	Njara
71	*Uvaria narum* (Dunal) Wall. ex Wight & Arn.	Annonaceae	Narumpanal
72	*Vateria indica* L.	Dipterocarpaceae	Vellapayin

Source: Secondary data collected by CESS

Appendix 3.5.2.7 : Insects of GKR

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
1.	*Abisara echerius prunosa* Moore	✓					
2.	*Acalolepta cervina* Hope			✓			
3.	*Acalolepta rusticartix* Fb.						✓
4.	*Acanthophorus serraticornis* Oliv.			✓			
5.	*Acherontia styx* Westw.						✓
6.	*Acigona* sp.			✓			
7.	*Acraea terpsicore*	✓					
8.	*Acrida exaltata* Walker						✓
9.	*Acrobasis olivalis* Hampson			✓			
10.	*Adoretus bicaudatus* Arrow			✓			
11.	*Adoretus latirostris Ohaus*			✓			
12.	*Adoxophyes modertana* Walker			✓			
13.	*Aeolesthes holosericea* Fb.			✓			
14.	*Aetheomorpha malayana* Baly.			✓			
15.	*Agathia lycaenaria* Koll.						✓
16.	*Agrotera coelatalis* Walker			✓			
17.	*Altha nivea* Walker			✓			
18.	*Amblychia angeronaria* Guen.			✓			
19.	*Ampittia dioscorides* Fb.	✓			✓		
20.	*Ancylolomia chrysographella* Koll.			✓			
21.	*Anisephyra ocularia* Fabr.			✓			
22.	*Antigastra catalaunalis* Dup.			✓			
23.	*Aplochlora vivilaca* Walker			✓			
24.	*Apodera tranquebaricus*						✓
25.	*Apoderus sissu* Mshl.			✓			
26.	*Apomecyna saltator* Fb.			✓			
27.	*Apophylia sericea* Fabr			✓			
28.	*Apophylia viridis* Jacoby						✓
29.	*Appias indra siva* Swin.	✓					
30.	*Appias wardi* Moore	✓					
31.	*Araecerus fasciculatus* De Geer			✓			
32.	*Arachnomius nietneri* Saussure						✓
33.	*Archips micaceana* Walker			✓			
34.	*Arhopala centaurus*			✓			
35.	*Arhopala amantes amantes* Hewit.	✓					
36.	*Ariadne ariadne indica* Moore	✓					
37.	*Ariadne merione* Cramer	✓		✓			
38.	*Artogeia canidia* Sparrman	✓					
39.	*Artogeia rapae*	✓					
40.	*Artona zebraiea* Butler						✓

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Appendix 3.5.2.7 Contd...

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
41.	*Assara albicostalis* Walker			✓			
42.	*Asticostena alternata* Fairm.			✓			
43.	*Atractomospha crenulata* Fabr.						✓
44.	*Atractocerus emarginatus* Cash.			✓			
45.	*Attelabus octomacclatus* jekel Gewia			✓			
46.	*Atteva fabriciella*			✓			
47.	*Atyma selenophora* Koll.	✓					
48.	*Atyma perius* Lin.	✓					
49.	*Auchenorrhyncha*						✓
50.	*Aularches miliaris* L.			✓			
51.	*Aulacophora cincta* Fb.				✓		
52.	*Aulacophora nilgiriensis* Jacoby						✓
53.	*Aulacophora foveicollis* Lucas						✓
54.	*Aulacodes peribocalis* Wlk.						✓
55.	*Alaus speciosas*						✓
56.	*Badamia exclamationis* Fb.	✓			✓		
57.	*Bagous affinis* Hist.			✓			
58.	*Bagrada picta Fabr.*						✓
59.	*Balinta delinendi Distant*						✓
60.	*Barvrrhynchus planicollis Walker*		✓	✓	✓		
61.	*Barvrrhynchus rudis Senna*				✓		
62.	*Basilepta dimidicitipea Jacoby*			✓			
63.	*Basilepta fulvicornis Jacoby*			✓			
64.	*Belionata prasima* Thunt.			✓			
65.	*Belenois aurata* Fb.	✓					
66.	*Boarmia infixaria* Walker			✓			
67.	*Bocchoris danalis* Hampson			✓			
68.	*Bostra vibicalis* Led.			✓			
69.	*Brachynus stevensi* Andr.			✓			
70.	*Brahmina* Sp.			✓			
71.	*Buchenorrhyncha*		✓				
72.	*Caleta caleta* Hewitson			✓			
73.	*Caleta caleta decidia* Hewit	✓					
74.	*Calopepla leayana* Latr.			✓			✓
75.	*Campsosternus* sp.			✓			
76.	*Cassida subtilis* Ws.			✓			
77.	*Castalius rosimon* (Fabr.)	✓		✓			✓
78.	*Cataclysta glandialis* Wlk.			✓			✓
79.	*Catana parcestosa* Sicard						✓
80.	*Catopsilia pomona* (Fabr.)	✓		✓			✓

Contd...

Appendix 3.5.2.7 Contd...

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
81.	*Catopsilia pyranthe* Linn.	✓		✓			✓
82.	*Celaenorrhinus leucocera* Kollar	✓					✓
83.	*Celaenorrhinus ambareesa* Moore	✓					✓
84.	*Celestrina lavendularis* Moore			✓			
85.	*Cethosia nietneri mahratta* Moore	✓					
86.	*Ceratia lewis* Baly.			✓			
87.	*Cerosterna scabrator* Fb.			✓			
88.	*Charaxes bernardus* Fb.	✓					
89.	*Charltona consociella* Walker			✓			
90.	*Cheritra freja freja* Fb.	✓					
91.	*Chilades pandava*			✓			
92.	*Chilasa clytia* (Linn.)	✓		✓			
93.	*Chilo polychrysa* Meyrick			✓			
94.	*Chilo simplex* Butl.			✓			
95.	*Chilo sp. nr. Partellus i Swinhoe*			✓			
96.	*Chirida undecimnotata* Boh.			✓			
97.	*Chilades laius laius* Cram	✓					
98.	*Chlorophorus annularis i Fabr.*			✓			
99.	*Chlorophorus jucundus* Perr.			✓			
100.	*Chryphalus dilutus* Eich.			✓			
101.	*Cicindela belli* W. Horn.			✓			
102.	*Cicindela calligramma Schaum*			✓			
103.	*Cicindela corticata Putz.*			✓			
104.	*Cicindela haemorrhoidalis Weid*			✓			
105.	*Cicindela hamiltoniana Thoms*			✓			
106.	*Cicindela minuta*			✓			
107.	*Cirrochroa thais thais* Fb.	✓					✓
108.	*Clepsis* Sp.			✓			
109.	*Cnaphalocrocis medinalis* Guen.			✓			
110.	*Cochlochila bullita* Stall.						✓
111.	*Coccinell aracuata*						✓
112.	*Coccinella bisselata* Mus.			✓			
113.	*Coccinella transversalis* Fb.			✓			
114.	*Coccotrypes carpophagus* Horning						✓
115.	*Coelosterna scabrator* Fb.						✓
116.	*Coladenia dan dan* Fb.	✓			✓		
117.	*Colasposoma rufipes* Jacoby			✓			
118.	*Cototis amata amata* Fb.	✓					
119.	*Colotis eucharis* Fb.	✓					
120.	*Colotis danae* Fb.	✓					

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Appendix 3.5.2.7 Contd....

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
121.	*Coptocycla* sp.			✔			
122.	*Coptops aedificator* Fabr.			✔			
123.	*Coptosoma cribrarium* Fabr.						✔
124.	*Coptoterms ceylonicus* Holm.					✔	
125.	*Coptoterms heinii* Wasman					✔	
126.	*Corcyra cephalonica* (Stainton)			✔			
127.	*Corynodes peregrinus* Fuessly			✔			
128.	*Cossus cadambae Moore*						✔
129.	*Cossonus cnarensis*			✔			
130.	*Creatonotus gangis*						✔
131.	*Crocidolomia binotalis* Zeller			✔			
132.	*Crocidolomia pavonana* (Fabr.)			✔			
133.	*Crossotarsus nilgiriens*			✔			
134.	*Cryptocephalus malabaricus* Clav.			✔			
135.	*Cryptocephalus sexsignatus* Fb.			✔			
136.	*Cucubdeka ayrifascuata* var. lepida Gory			✔			
137.	*Culladia admigratella* Walker			✔			
138.	*Cupha erymanthis maja* Fruhstorfer	✔		✔			
139.	*Cyrestis thyodamas indica* Boisd.	✔					
140.	*Cyrtacanthacris tatarica* (Linn.)			✔			
141.	*Daimio bhagava bhagava* Moore			✔			
142.	*Danaus chrysippus* Linn.	✔		✔			✔
143.	*Danaus genuita genuita* Cramer	✔		✔			
144.	*Dasychira horsfieldi* Saund						✔
145.	*Dasychira mendosa* Hubn.			✔			
146.	*Daulia afralis* Walker			✔			
147.	*Daulinius conchatus* Distant						✔
148.	*Deleslea rahimani* Narendran & Anil					✔	
149.	*Delias eucharis* (Drury)	✔		✔			✔
150.	*Demarchus pubipennis* Jacoby			✔			
151.	*Desisa* sp.			✔			
152.	*Diacrotricha leucomochla* Fletcher			✔			
153.	*Diapromorpha quadripunctata* Jacoby			✔			
154.	*Diastocera wallachi* Hope			✔			
155.	*Diatraca* sp. Linn.			✔			
156.	*Diboma posticata* Gahan.			✔			
157.	*Dichocrocis punctiferalis* Guen.			✔			
158.	*Dinoderus bifoveolatus* Wollaston		✔				

Contd...

Appendix 3.5.2.7 Contd....

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
159.	*Dinoderus minutus* Fb.		✓	✓			✓
160.	*Diplacodes trivialis* (Rambur)						✓
161.	*Dirhinus alticornis*		✓		✓	✓	
162.	*Discolampa ethion vavasanus* Fruth	✓					
163.	*Discophora lepida* Moore	✓					
164.	*Dystropius* sp.			✓			
165.	*Elymnias hypermnestra caudata* Butler	✓		✓			✓
166.	*Epepeotes uncinatus*			✓			
167.	*Ephertia cautella* Walker			✓			
168.	*Epicrocis hilarella* Ragonot			✓			
169.	*Epilachna septima*			✓			
170.	*Episomus lacerta* Fst.			✓			
171.	*Epistictia reicheana* Guer.			✓			
172.	*Esamus albomarginatus* Gll			✓			
173.	*Eschata sp.nr.gelida* Walker			✓			
174.	*Estigmena chinensis*			✓			
175.	*Estigmena pardalis* Walker						✓
176.	*Euchromia polymena* Linn.			✓			
177.	*Eucommatocera vittata* White			✓			
178.	*Eucorynus crassicornis* Fb.			✓			
179.	*Eugnathus marginatus*			✓			
180.	*Eumelea rosalia* Cram.			✓			✓
181.	*Euploea core core* Cramer	✓		✓			✓
182.	*Euproctis digramma* Guer			✓			
183.	*Euproctis icilia* Stoll			✓			✓
184.	*Euproctis scintillans* Walker			✓			
185.	*Eurema blanda* Boisduval	✓		✓			✓
186.	*Eurema hecabe* Linn.	✓		✓			✓
187.	*Eurema brigitta rubella* Wallace	✓					
188.	*Eutectona machaeralis* Wlk.			✓			✓
189.	*Euthalia aconthea* Fruch.						✓
190.	*Euthalia aconthea meridionalis* Cram.	✓					
191.	*Galleria mellonella* Linn.			✓			
192.	*Gangara thyrsis thyrsis* Fabr			✓			✓
193.	*Gargela* sp.			✓			✓
194.	*Glenea multiguttata* Gur.				✓		
195.	*Glyphodes indica* Saund.			✓			
196.	*Gnathodea simplex* Gahan						✓
197.	*Gonodontis clelia* Cramer			✓			

Contd...

Appendix 3.5.2.7 Contd....

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
198.	*Graphium agamemnon agamemnon* (Linn.)			✓			✓
199.	*Graphium agamemnon menides* (Fruch.)	✓					
200.	*Graphium doson doson* (Felder)			✓			✓
201.	*Graphium sarpedon teredon* (Felder)	✓		✓			✓
202.	*Gryllotalpa africana Pallas*						✓
203.	*Grryen malabaricus Moozhiar*				✓		
204.	*Glyphodes caesalis Wlk.*						✓
205.	*Gymnopleurus sinuatus Oliv.*			✓			
206.	*Hasora chromus*	✓					
207.	*Hebomoia glaucippe australis But*	✓					
208.	*Hellula undalis Fabr.*			✓			
209.	*Hemithea sp.*			✓			
210.	*Hemygascelis longicollis Jacoby*			✓			
211.	*Herculia marthalis Walker*			✓			
212.	*Herdonia sp.*			✓			
213.	*Heterobostrychus aequalis Waterhouse*			✓	✓		✓
214.	*Heteroterms Sp.*					✓	
215.	*Hieroglyphus banian Fabr*						✓
216.	*Hispa armigera*			✓			
217.	*Holotrichia fessa*						✓
218.	*Holotrichia serrata* Fb.			✓			
219.	*Homoeosoma* sp.			✓			
220.	*Hoplasoma unicolor* Illiger						✓
221.	*Hoplopoderus echinatus*				✓		
222.	*Hoplopoderus hystrix* Fb.			✓			
223.	*Hymenia fascialis* Guen.			✓			
224.	*Hypenepharus albus* Mshll.			✓			
225.	*Hyphalsis ? incorspicua* Jacoby						✓
226.	*Hyphalsis ? discipennis* Jacoby						✓
227.	*Hypolimnas bolina* Drury	✓					✓
228.	*Hypolimnas missipus* Linn.	✓		✓			✓
229.	*Hypomecis hibemaria* Swinh.			✓			
230.	*Hypomecis pallida* Hamp.			✓			
231.	*Hypomecis subrugata*			✓			
232.	*Hyposidra talaca* Walker			✓			
233.	*Hypsa alciphron* Cram						✓
234.	*Idea malabarica malabarica* (Moore)	✓		✓			
235.	*Indalmus kirbyanus Gerst.*			✓			
236.	*Indarbela quadrinotata*		✓			✓	

Contd...

Appendix 3.5.2.7 Contd....

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
237.	*Indomias frater* Marshall			✓	✓		
238.	*Indomias practeritus*				✓		
239.	*Ixias merianne* Cram	✓					
240.	*Ixias pyrene sesia* Fb.	✓					
241.	*Jamides celeno* (Cramer)			✓			
242.	*Jamides aeliamus* Fb.	✓					
243.	*Jamides bochus bochus* Stoll	✓					
244.	*Junonia almana* Lin.	✓					
245.	*Junonia atlites* Linn.						✓
246.	*Junonia hierta* Fb.	✓					
247.	*Junonia iphita* Cramer			✓			✓
248.	*Junonia lemonias vaisya* Fruhstorfer			✓			✓
249.	*Kaniska canace evans*	✓					
250.	*Kallima horsfieldi* Kill.	✓					
251.	*Krishna strigicollis* Dist.			✓			
252.	*Laccoptera quatuorimnotata* Boh			✓			
253.	*Lacoptera quadrimaculata* Thumb.			✓			
254.	*Lacoptera quatuor decimnotata* Boh.			✓			
255.	*Laemotmetus insignis* Grouvelle				✓		
256.	*Lamida moncusalis* Walker			✓			✓
257.	*Lamprosema* sp.			✓			
258.	*Lampides boeticus Lin.*	✓					✓
259.	*Leiochrinus nilgirianus Kars.*			✓			
260.	*Leptocorisa varaicornis* Fabr.						✓
261.	*Leptispa pygmaea* Baly			✓			✓
262.	*Leptosia nina* Fb.	✓					✓
263.	*Lestes malabarica* Fraser*						✓
264.	*Lethe europa* (Fabricius)	✓		✓			
265.	*Lethe dryptes* Moore	✓					
266.	*Lethe rohria* Guerin	✓					
267.	*Leucinodes orbonalis* Guen.			✓			
268.	*Libythea lepita* Moore	✓					
269.	*Libythea murrha* Godart	✓					
270.	*Lilioceris laosensis* Pic.			✓	✓		✓
271.	*Limnoecia* sp. *Peranodes* Meyr			✓			
272.	*Lixus truncatalus*			✓			
273.	*Loxostege* sp.			✓			
274.	*Loxura atymnus* Cramer			✓			✓
275.	*Lyctusreenneas Steph.*			✓			

Contd...

Appendix 3.5.2.7 Contd...

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
276.	*Lygropia amyntusalis* Walker			✓			
277.	*Macalla nubilalis* Hampson			✓			
278.	*Macalla sp. nr eumicatalis*			✓			
279.	*Macroglossum regulus* (Boisd.)						✓
280.	*Macrochenus tigrinus* Olivier			✓			
281.	*Macrotoma spinosa* Fb.			✓			
282.	*Marasmia trapezalis* Guen.			✓			
283.	*Maruca testulalis* Geyer			✓			
284.	*Masssicus venustus* Pascoe			✓			
285.	*Mecistocerus concretus* Faust.		✓				
286.	*Mecistocerus fluctiger* Faust		✓				
287.	*Mecistocerus mollis* Faust.			✓			
288.	*Melanitis leda* Lin.	✓					✓
289.	*Melanitis phedima varaha* Moore	✓					
290.	*Micronecta lucina* Dist.						✓
291.	*Mimela xanthorrhina* Hope			✓			
292.	*Minthea rugicollis* Walker			✓			
293.	*Miresa albipuncta* Herrich-Schaffer			✓			
294.	*Miresa argentifera* Walker			✓			
295.	*Miresa bracteata* Butler						✓
296.	*Moduza procris* Cramer	✓		✓			✓
297.	*Monolepta kanarensis* Jacoby			✓			
298.	*Mycalesis anaxias* Hewit.	✓					
299.	*Mycalesis oculus* Marshall	✓					
300.	*Mycalesis patnia junonia* But.	✓					
301.	*Mycalesis perseus* Fruth.	✓					
302.	*Myelois* sp.			✓			
303.	*Myllocerus blandus* Fst.			✓			
304.	*Myllocerus cardon Mshl.*			✓			
305.	*Myllocerus discolor var. variegatus Boh.*			✓			
306.	*Myllocerus dorsatus Fb.*			✓			
307.	*Myllocerus fabricii Curer.*			✓			
308.	*Myllocerus viridanus Fb.*			✓			✓
309.	*Myocalandra exarata Boheman*			✓			
310.	*Nacoleia indicata Fabr.*			✓			
311.	*Neocollyris andrewesi W. Horn.*			✓			
312.	*Neptis hylas varmona Moore*	✓		✓			✓
313.	*Neptis jumbah Moore*	✓					
314.	*Neurothemis tullia tullia (Drury)*						✓
315.	*Nezara viridula (Linn.)*						✓

Contd...

Appendix 3.5.2.7 Contd...

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
316.	*Niphona fuscatrix* Fb.			✓			
317.	*Noorda blitealis* Walker			✓			
318.	*Nupserha madurensis* Pic.			✓			
319.	*Nupserha malabarensis* Pic.			✓			
320.	*Nymphula fluctuosalis* Zell.						✓
321.	*Nymphula depunctalis* Guen.			✓			✓
322.	*Oenospila flavifusata* Walker			✓			
323.	*Olenecamptus bilobus* Fb.			✓			
324.	*Olenecamptus lateapicta* Pic.			✓			
325.	*Olenecamptus sigraticollis* Hell.			✓			
326.	*Omphisa anastomosalis* Guen.			✓			
327.	*Onthophagus amphinasus* Arrow			✓			
328.	*Onthophagus bronzeus* Arrow			✓			
329.	*Onthophagus imperator* Cast.			✓			
330.	*Ophiusa coronata* Fabr.						✓
331.	*Ora picta* Fb.			✓			
332.	*Orasema indica* Snehalatha & Narendran			✓			
333.	*Orsotraena medus mandata* Moore	✓					
334.	*Orthaga* sp.			✓			
335.	*Orthetrum sabina* (Drury)						✓
336.	*Oryzaephilus mercator* fauvel			✓			
337.	*Oxya velox* Fabr.						✓
338.	*Oxycetonia andrewesi* Janson			✓			
339.	*Oxycarenus laetus* Kirby						✓
340.	*Pachilopta hector* (Linn.)	✓		✓			✓
341.	*Pachliopta aristolochiae* Fb.	✓		✓			✓
342.	*Pachliopta pandiyana* Moore	✓					✓
343.	*Pachyzancla aegrotalis* Zell.			✓			
344.	*Pagria kanaraensis* Jacoby			✓			
345.	*Palpoxena truncatipennis* Jacoby			✓			
346.	*Panthous bimaculatus* Dist.				✓	✓	
347.	*Pantoporia hordonia* Stoll	✓					
348.	*Papilio budha* Westwood	✓		✓			
349.	*Papilio demoleus demoleus* Linn.	✓		✓			✓
350.	*Papilio helenus daksha* (Hampson)	✓		✓			
351.	*Papilio liomedon* Moore	✓		✓			
352.	*Papilio paris tamilana* Moore	✓		✓			
353.	*Papilio polymnestor parinda* (Moore)			✓			✓
354.	*Papilio polymnestor parinda* (Cram)	✓					

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Appendix 3.5.2.7 Contd....

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
355.	*Papilio polytes* Cramer			✓			✓
356.	*Papilio polytes* Lin.	✓					
357.	*Paraleprodera triangularis* J.Thomson			✓			
358.	*Paramecops farinosa* Weid.			✓			
359.	*Parantica aglea aglea* Stoll	✓		✓			✓
360.	*Parantica nilgiriensis* Moore	✓					
361.	*Parasa bicolor*						✓
362.	*Parasa lepida* Cramer			✓			✓
363.	*Parthenos sylvia* Moore	✓					
364.	*Passandra heros* Fb.			✓			
365.	*Pelopidas mathias Fabr.*						✓
366.	*Pelopidas sibocjracea*				✓		
367.	*Peltotrachelus cognatus Marshall*			✓			
368.	*Pericallia ricini* Fabar.						✓
369.	*Pericoma gilvipes* Brun.						✓
370.	*Phaenomerus sunde* walli Boheman			✓			
371.	*Phalata phalatha* Drury	✓					
372.	*Phalera procera* Feld.			✓			
373.	*Pharsalia imitater* Pascoe			✓			
374.	*Phloeobius alternans* Wiedmann			✓	✓		
375.	*Phloeobius lutosus Jordon*			✓			
376.	*Phlyctaenodes flavofimbriata*						✓
377.	*Phyllotretta cruciferae* Goeze.			✓			✓
378.	*Pilopedes subochracea*	✓					
379.	*Pilopedes mathias*	✓					
380.	*Pionea brevialis* Walker			✓			
381.	*Placosternum dama* Fabr.						✓
382.	*Platypus andrewesi* Strohm			✓			
383.	*Platypus cavus* Strohm			✓	✓		✓
384.	*Platypus latifinis* Walker			✓			
385.	*Platypus solidus* Walker			✓	✓		
386.	*Platypus uncinatus* Blandford				✓		
387.	*Platipleura capitula* Oliv.				✓		
388.	*Pleurina brachyphyllus* Stal.			✓			
389.	*Polyura athamas* Drury	✓					
390.	*Pownesia kanerensis* Weise.			✓			
391.	*Prionomma atratum*			✓			
392.	*Prodenia littoralis* Boisd						✓
393.	*Prothyma paradoxa* W. Horn.			✓			

Contd...

Appendix 3.5.2.7 Contd....

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
394.	*Prosotas nora nora* Feld.	✓					
395.	*Protosilvanus lateritius* Reitter				✓		
396.	*Psara stuitalis* Walker			✓			
397.	*Pseudożizeeria maha ossa* Swin	✓					
398.	*Psolos fulligo subfasciatus* Mabilla	✓					
399.	*Psychoda nigripennis* Brun.						✓
400.	*Pterolophia milanava* Pac.			✓			
401.	*Pygospila tyres* Cramer			✓			✓
402.	*Pyrausta machoeralis* Walker			✓			
403.	*Pyrrhocoris apterus* Linn.						✓
404.	*Riptortus pedestris* Fabr.						✓
405.	*Rhizopertha dominica* Fb.		✓	✓			
406.	*Rhodopina sp. Myrtacea* Hampson						✓
407.	*Rhodopina nilgiria* Breun.Breuning			✓			
408.	*Sagra femorata* Drury			✓			
409.	*Sahyadrassus malabaricus* (Moore)			✓			
410.	*Scantius volucris* Gerstaeck						✓
411.	*Schoenobius bipunctifer* Walker			✓			
412.	*Scirpophaga auriflua* Zeller			✓			
413.	*Scirpophaga incertulas* Walker			✓			✓
414.	*Scirpophaga monostigma* Zeller			✓			
415.	*Scirpophaga* Sp.			✓			
416.	*Scleropteris coriaceus* Hann.						✓
417.	*Sebasmia* Sp.			✓			
418.	*Semiothisa emersaria* Fb.			✓			
419.	*Semiothisa epicharis*			✓			
420.	*Semiothisa honoria* Hamp.			✓			
421.	*Semiothisa inchoata* Wlk.			✓			
422.	*Semiothisa khassiana* Moore			✓			
423.	*Serricornia*						✓
424.	*Serixia sp.*						✓
425.	*Silvanus lewisi Reitter*			✓			
426.	*Sinoxylon anale Les.*			✓			✓
427.	*Sinoxylon atratum Les.*			✓			✓
428.	*Sinoxylon capitatum Les.*			✓			
429.	*Sinoxylon crassus Les.*						✓
430.	*Sinoxylon conigerum Gerst*						✓
431.	*Sinoxylon sp. pygmaeum Lesne.*			✓			
432.	*Sipalinus hypocrita Boh.*			✓			

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Appendix 3.5.2.7 Contd....

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
433.	*Sisyphus hirutus* Wiedemann			✓			
434.	*Somatina anthophilata* Guen			✓			
435.	*Somatina omierania* Fb.			✓			
436.	*Spialia galba* Fb.	✓					
437.	*Spindasis vulcanus vulcanus* Fb.	✓					
438.	*Spjaeridia pumilis* (Krausbauer)						✓
439.	*Sphenoptera cyaniceps* Kars.			✓			
440.	*Stephanitis typicus* Distant						✓
441.	*Stauropus alternus* Walker			✓			
442.	*Stenia minoralis* Snellen			✓			
443.	*Sternorrhyncha*		✓				
444.	*Stibara nigricornis* Fb.			✓			
445.	*Stromatium barbatum* Fab.			✓			
446.	*Suastus gremius* Fb.	✓			✓		
447.	*Surendra quercetorum* Moore			✓			
448.	*Sylepta derogata* Fabr.			✓			
449.	*Syngamia abjungalis* Wlk.			✓			
450.	*Syngamia abruptalis* Wlk.			✓			
451.	*Syngamia latimarginalis* Walker			✓			
452.	*Syntomis extensa* Walker			✓			
453.	*Tagiades gana silvia*	✓			✓		
454.	*Tagiades litigoiosa* Moschler	✓					✓
455.	*Talicada nyseus* Guerin	✓					
456.	*Tanaecia lepidea miyana* Fruh	✓		✓			✓
457.	*Tarsostenus univittatus* Rossi			✓			
458.	*Telecota augias* Linn.			✓			
459.	*Tephrina pulinda* Walker			✓			
460.	*Terastia meticulosalis* Guen.			✓			
461.	*Teredolaemus similis* Sharp			✓			
462.	*Tetragonothrox gyllennali*			✓			
463.	*Theretra oldenlandiae oldenlandiae* (Fabr.)						✓
464.	*Tillus notatus* Klug			✓			
465.	*Timandra mundissima* Wlk.			✓			
466.	*Tirumala lilmniace leopardus* Butler	✓		✓			✓
467.	*Tirumala sepentrionis dravidarum* Fruhstorfer			✓			
468.	*Tonica niviferana* ex.			✓			
469.	*Trachelizus bisulcatus* Fb.			✓			
470.	*Trachelizus politus* Senn.		✓	✓			

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Appendix 3.5.2.7 Contd....

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
471.	*Trabla vishnu* Lef.						✓
472.	*Tricondyla macrodera* chaud			✓			
473.	*Trigonocolus brachmanae* Faust.			✓			
474.	*Trigryllus bimaculatus* De geer						✓
475.	*Trilophidia* Sp.						✓
476.	*Troides minos* Cram.	✓		✓			
477.	*Trypanaeus indicus* Lewis				✓		
478.	*Trypanaeus trypeticus bombacis* Lewis						✓
479.	*Tyndis hypotialis* Swinhoe			✓			
480.	*Typhaea stercorea* Linn.			✓			
481.	*Udaspes folus* Cram.	✓					
482.	*Urentius echinus* Distant						✓
483.	*Vanessa cardui* lin.	✓					
484.	*Vanessa indica* Fruh.	✓					
485.	*Vindula erota soloma de* Nicevile	✓					
486.	*Volobilis chloropteralla*			✓			
487.	*Xenocerus retilineatus* Jord.			✓			
488.	*Xyleborus interjectus* Blandford		✓				
489.	*Xyleborus similis* Ferr.			✓			
490.	*Xyleborus maximus* Samps						✓
491.	*Xylosandrus discolor* Blandford			✓			
492.	*Xylotrechus subscutellatus* Chevr.			✓			
493.	*Ypthima ceylonica* Hewit	✓					
494.	*Ypthima baldus* Fb.	✓					
495.	*Ypthima philomela* Lin.	✓					
496.	*Ypthima ypthimoides* Moore	✓					
497.	*Zipactis saitis* Hewit	✓					

Source: Secondary data collected by KFRI

Appendix 3.5.2.8 : Amphibians of GKR

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
1.	*Bufo fergusonii* Boul.	✓					✓
2.	*Bufo melanostictus* Schneider	✓	✓	✓	✓	✓	✓
3.	*Bufo microtympanum* Boul.	✓	✓	✓	✓	✓	✓
4.	*Bufo parietalis* Boul	✓			✓		
5.	*Euphlyctis hexadactyla* (Lesson)	✓	✓	✓	✓	✓	
6.	*Euphlyctis cyanophlyctis* Schnedier		✓		✓	✓	
7.	*Gegenophis ramaswami* Taylor				✓		
8.	*Hoplobatrachus tigerinus* (Daudin)	✓			✓	✓	
9.	*Hoplobatrachus crassus* (Jerdon)				✓	✓	
10.	*Ichthyophis beddomei* Peters			✓	✓		
11.	*Ichthyophis subterrestris* Taylor	✓	✓				
12.	*Ichthyophis tricolor* Annandale	✓					
13.	*Indirana beddomei* (Gunther)	✓			✓		
14.	*Indirana leithii* (Boulenger)				✓		
15.	*Indirana leptodactyla* Boul.	✓					
16.	*Limnonectes brevipalmata* Peters	✓					
17.	*Limnonectes keralensis* (Dubois)	✓			✓		
18.	*Limnonetes limnocharis* (Boi in Weigman)	✓	✓		✓	✓	
19.	*Micrixalus fuscus* (Boul.)	✓		✓	✓		
20.	*Micrixalus nudis* Pillai	✓					✓
21.	*Micrixalus saxicola* Jerdon	✓					
22.	*Microhyla ornata* (D.&B.)	✓	✓	✓	✓	✓	
23.	*Microhyla rubra* (Jerdon)		✓	✓	✓	✓	
24.	*Micrixalus gadgili* Pillai & Patabhiraman				✓		
25.	*Nyctibatrachus major* Boul	✓			✓		
26.	*Philautus beddomii* (Gunther)	✓					
27.	*Philautus leucorhinus* (Lichtenstein & Martens)		✓	✓		✓	
28.	*Philautus nasutus* Gunther			✓	✓		
29.	*Philautus pulcherrimus* (Ahl.)			✓			
30.	*Polypedates maculatus* (Gray)	✓	✓	✓	✓	✓	✓
31.	*Ramanella variegata* Stoliczka		✓			✓	
32.	*Rana aurantiaca* Boul	✓	✓			✓	✓
33.	*Rana beddomii* (Gunther)						✓
34.	*Rana curtipes* Jerdon	✓					
35.	*Rana cyanophlyctis* Schneider						✓
36.	*Rana hexadactyla* Lesson						✓
37.	*Rana keralensis* Dubois						✓
38.	*Rana limnocharis* Boie						✓
39.	*Rana malabarica* (Bibr.)	✓	✓	✓		✓	✓

Contd...

Appendix 3.5.2.8 Contd...

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
40.	*Rana semipalmata* Boul						✔
41.	*Rana temporalis* (Gunther)	✔			✔		
42.	*Rana tigerina* Daudin			✔			✔
43.	*Rhacophorus malabaricus* Jerdon	✔	✔	✔		✔	
44.	*Tomopterna rufescens* (Jerdon)	✔		✔			
45.	*Uraectyphlus narayani* Seshachar	✔	✔	✔	✔		
46.	*Uraeotyphlus oxyurus* (Dumeril & Bibron.)						✔
47.	*Uraeotyphlus menoni* (Annandale)			✔			✔

Source: Secondary data collected by KFRI

Appendix 3.5.2.9 : Reptiles of GKR

Sr. No	Scientific Name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
1.	*Ahaetulla dispar*				✓		
2.	*Ahaetulla nasuta*	✓	✓	✓	✓	✓	✓
3.	*Ahaetulla pulverulentas*				✓		
4.	*Amphiesma stolata*	✓					✓
5.	*Atretium schistosum*	✓					
6.	*Boiga ceylonensis*						✓
7.	*Boiga forsteni*						✓
8.	*Boiga trigonata*	✓					
9.	*Bungarus caeruleus*	✓	✓	✓	✓	✓	✓
10.	*Calliophis bibronii*						✓
11.	*Calotes calotes*	✓	✓	✓	✓		✓
12.	*Calotes elliotti*	✓		✓	✓		
13.	*Calotes rouxi*	✓		✓	✓		
14.	*Calotes versicolor*	✓	✓	✓	✓	✓	✓
15.	*Chamaeleo zeylanicus*	✓		✓	✓		
16.	*Chelonia mydas*			✓		✓	✓
17.	*Chrysopelea ornata*	✓					
18.	*Cnemaspis indica*	✓					
19.	*Cnemaspis kandiana*	✓		✓			
20.	*Cnemaspis wynadensis*			✓			✓
21.	*Crocodylus palustris*	✓					
22.	*Crocodylus porosus*					✓	
23.	*Cyrtodactylus collegalensis*	✓		✓			
24.	*Dendrelaphis tristis*	✓	✓	✓	✓	✓	✓
25.	*Draco dussumieri*	✓	✓	✓	✓		✓
26.	*Echis carinatus*	✓		✓			
27.	*Elaphe helena*	✓	✓	✓	✓	✓	✓
28.	*Enhydrina schistosa*		✓	✓		✓	✓
29.	*Eretmochelys imbrecata*				✓	✓	
30.	*Eryx conicus*	✓	✓		✓	✓	✓
31.	*Geomyda silvatica*	✓		✓		✓	✓
32.	*Geochelone elegans*	✓					
33.	*Hemidactylus brooki*	✓	✓	✓	✓	✓	✓
34.	*Hemidactylus leschenaulti*	✓	✓	✓	✓		✓
35.	*Hemidactylus reticulatus*					✓	✓
36.	*Hemidactylus frenatus*	✓	✓	✓	✓	✓	✓

Contd...

Appendix 3.5.2.9 Contd...

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
37.	*Hemidactylus triedrus*			✓			
38.	*Hycodon aulicus*	✓	✓	✓	✓		
39.	*Hydrophis cyanocinctus*		✓	✓			
40.	*Hypnale hypnale*		✓	✓			
41.	*Indotestudo forstenii*	✓		✓			
42.	*Lepidochelys olivacea*					✓	✓
43.	*Lissemys punctata punctata*	✓	✓	✓	✓	✓	✓
44.	*Lycodon aulicus*	✓		✓	✓	✓	
45.	*Lycodon travancoricus*			✓			✓
46.	*Mabuya beddomii*			✓			
47.	*Mabuya bibroni*	✓					
48.	*Mabuya carinata*	✓	✓	✓	✓	✓	✓
49.	*Mabuya clavicola*			✓			
50.	*Mabuya macularius*	✓	✓	✓	✓	✓	✓
51.	*Macropisthodon plumbicolar*	✓			✓		
52.	*Melanochelys trijuga*	✓	✓	✓	✓	✓	✓
53.	*Naja naja*	✓	✓	✓	✓	✓	✓
54.	*Oligodon arnensis*	✓					
55.	*Oligodon taeniolatus*	✓		✓	✓		
56.	*Oligodon travancoricus*	✓			✓	✓	
57.	*Ophiophagus hannah*	✓	✓	✓	✓		
58.	*Ophisops leschenaulti*	✓			✓		
59.	*Otocryptis beddomii*	✓					
60.	*Pelamis platurus*		✓	✓			
61.	*Platiplectrurus madurensis*	✓					
62.	*Platiplectrurus trilineatus*	✓			✓		
63.	*Psammophilus blanfordanus*	✓	✓	✓			
64.	*Ptyas mucosus*	✓	✓	✓	✓	✓	✓
65.	*Python molurus*	✓	✓	✓	✓	✓	✓
66.	*Ramphotyphlops braminus*	✓	✓	✓	✓	✓	✓
67.	*Rhabdops olivaceus*						
68.	*Rhinophis travancoricus*						✓
69.	*Riopa punctata*	✓	✓	✓	✓		
70.	*Ristella bedomii*			✓			
71.	*Ristella rurki*	✓					
72.	*Sibynophis subpunctatus*	✓					
73.	*Sphenomorphus dussumieri*				✓		
74.	*Trimeresurus macrolepis*	✓			✓		

Contd...

Appendix 3.5.2.8 Contd...

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
75.	*Trimeresurus malabaricus*	✓	✓	✓			
76.	*Typhlops acutus*	✓	✓	✓	✓	✓	✓
77.	*Typhlops beddomei*	✓			✓		
78.	*Typhlops porrectus*	✓					
79.	*Uropeltis articeps*				✓	✓	
80.	*Uropeltis ceylanicus*						✓
81.	*Uropeltis elliotti*	✓					
82.	*Uropeltis maculatus*	✓					
83.	*Uropeltis ocellatus*	✓					✓
84.	*Uropeltis pulneynsis*	✓			✓		
85.	*Uropeltis rubrolineatus*	✓			✓		
86.	*Uropeltis woodmasoni*	✓					
87.	*Varanus bengalensis*	✓	✓	✓	✓	✓	✓
88.	*Vipera russellii*	✓	✓	✓	✓	✓	✓
89.	*Xenochrophis piscator*	✓	✓	✓	✓	✓	✓

Source: Secondary data collected by KFRI

Appendix 3.5.2.10 : Birds of GKR

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
1.	Ashy Longtailed or Wren-Warbler	*Prinia socialis socialis*	✓	✓	✓	✓	✓	✓
2.	Ashy Swallow-Shrike	*Artamus fuscus*	✓	✓	✓	✓	✓	✓
3.	Ashycrowned Finch-Lark	*Remopterix grisea*					✓	
4.	Ashycrowned or Blackbellied	*Eremopterix grisea*				✓		
5.	Ashycrowned or Blackbellied Finch-Lark	*Eremopterix grisea*		✓	✓			
6.	Asiatic Sparrow-Hawk	*Accipiter nisus nisosimilis*	✓		✓			✓
7.	Banded Crake	*Rallina eurizonoides amauroptera*		✓		✓	✓	✓
8.	Barn Owl	*Tyto alba stertens*		✓	✓	✓	✓	✓
9.	Bartailed Godwit	*Limosa lapponica*			✓			
10.	Baybacked Shrike	*Lanius vittatus vittaus*	✓					✓
11.	Baybanded Cuckoo	*Cacomantis sonneratii sonneratii*	✓		✓			✓
12.	Besra Sparrow-Hawk	*Accipter trivirgatus besra*	✓		✓			✓
13.	Blackbacked Pied Flycatcher-Shrike	*Hemipus picatus picatus*	✓					
14.	Black Bittern	*Ixobrychus flavicollis flavicollis*	✓	✓	✓	✓	✓	✓
15.	Black Drongo	*Dicrurus adsimilis macrocercus*	✓	✓	✓	✓	✓	✓
16.	Black Eagle	*Ictinaetus malayensis perniger*	✓		✓			✓
17.	Black ibis	*Pseudibis papillosa papillosa*			✓			
18.	Black-and-Orange Flycatcher	*Muscicapa nigrorufa*	✓					
19.	Black Stork	*Ciconia nigra*	✓					
20.	Black winged Kite	*Elanus caeruleus vociferus*	✓		✓			✓
21.	Black, or King Vulture	*Torgos calvus*	✓		✓			
22.	Blackbellied Finch-Lark	*Eremopterix grisea*						✓
23.	Blackbellied Tern	*Sterna acuticauda*			✓			
24.	Blackcapped Blackbird	*Turdus merula nigropileus*	✓		✓			
25.	Blackcapped Kingfisher	*Halcyon pileata*	✓		✓			
26.	Blackcrested Baza	*Aviceda leuphotes*			✓			
27.	Blackheaded Cuckoo-Shrike	*Coracina melanoptera sykesi*	✓	✓	✓	✓	✓	
28.	Blackheaded Munia	*Lonchura malacca malacca*	✓	✓	✓	✓	✓	✓

Contd...

Appendix 3.5.2.\oContd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
29.	Blackheaded or Laughing Gull	*Larus ridibundus*		✓	✓	✓	✓	✓
30.	Blackshafted Ternlet	*Sterna albifrons*			✓			
31.	Blacktailed Godwit	*Limosa lapponica lapponica*			✓			
32.	Bluebearded Bee-eater	*Merops philippinus philippinus*						✓
33.	Bluebreasted Quail	*Coturnix chinensis chinensis*	✓					
34.	Blueheaded Rock Thrush	*Monticola cinclorhynchus*	✓		✓			✓
35.	Blueheaded Yellow Wagtail	*Motacilla flava beema*	✓					✓
36.	Bluetailed Bee-eater	*Merops philippinus philippinus*		✓	✓	✓	✓	✓
37.	Bluethroat	*Erithacus svecicus*	✓	✓	✓	✓	✓	✓
38.	Bluethroated Flycatcher	*Muscicapa rubeculoides rubeculoides*	✓		✓			✓
39.	Bluewinged Parakeet	*Psittacula columboides*	✓		✓			✓
40.	Blue-eared Kingfisher	*Alcedo meninting*	✓					
41.	Blyth's Myna	*Sturnus malabaricus blythii*	✓					✓
42.	Blyth's Reed Warbler	*Acrocephalus dumetorum*	✓	✓	✓	✓	✓	✓
43.	Bonelli's Hawk-Eagle	*Hieraaetus fasciatus fasciatus*	✓					✓
44.	Booted Hawk-Eagle	*Hieraaetus pennatus*	✓					✓
45.	Bourdillon's Blackbird	*Turdus merula bourdilloni*			✓			
46.	Bourdillon's Blackheaded Babbler	*Rhopocichla atriceps bourdilloni*	✓		✓			
47.	Bourdillon's'Great Eared Nightjar	*Eurostopodus macrotis bourdilloni*	✓		✓			✓
48.	Brahminy Kite	*Haliastur indus indus*	✓	✓	✓	✓	✓	✓
49.	Brainfever bird	*Cuculus varius varius*	✓				✓	
50.	Bright Green Leaf Warbler	*Phylloscopus nitidus*	✓					
51.	Broadbilled Roller or Doller Bird	*Eurystomus orientalis laetior*						✓
52.	Broadbilled Sandpiper	*Limicola falcinellus*			✓			
53.	Broadtailed Grass-Warbler	*Acrocephalus stentoreus brunnescens*	✓					✓
54.	Bronzed Drongo	*Dicrurus aeneus aeneus*	✓	✓	✓	✓	✓	✓
55.	Bronzewinged Jacana	*Metopidius indicus*		✓	✓	✓	✓	✓

Contd...

Appendix 3.5.2. Contd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
56.	Brown Fish Owl	*Bubo zeylonensis leschenault*	✓		✓			✓
57.	Brown Flycatcher	*Muscicapa latirostris*	✓	✓	✓	✓	✓	✓
58.	Brown shrike	*Lanius cristatus cristatus*	✓	✓		✓	✓	✓
59.	Brown Wood Owl	*Strix leptogrammica indranee*	✓		✓			
60.	Brownheaded Gull	*Larus brunnicephalus*		✓	✓	✓	✓	✓
61.	Brownheaded Storkbilled Kingfisher	*Pelargopsis capensis capensis*	✓	✓	✓	✓	✓	✓
62.	Brownthroated Spinetail Swift	*Chaetura gigantea indica*	✓		✓			✓
63.	Caspian Tern	*Hydroprogne caspia caspia*		✓	✓	✓	✓	✓
64.	Cattle Egret	*Bulbulcusibis coromandus*	✓	✓	✓	✓	✓	✓
65.	Ceylon Bush-Lark	*Mirafra assamica affinis*	✓					✓
66.	Ceylon Frogmouth	*Batrachostomus moniliger*	✓		✓			✓
67.	Ceylon Green Imperial Pigeon	*Ducula aenea pusilla*	✓		✓			✓
68.	Ceylon Hoopoe	*Upupa epops ceylonensis*	✓		✓			✓
69.	Ceylon House Crow	*Corvus splendens protegatus*	✓	✓	✓	✓	✓	✓
70.	Ceylon Iora	*Aegithina tiphia multicolor*	✓	✓	✓	✓	✓	✓
71.	Ceylon Shikra	*Accipiter badius badius*	✓	✓	✓	✓	✓	✓
72.	Chestnut Bittern	*Ixobrychus cinnamomeus*	✓	✓	✓	✓	✓	✓
73.	Chestnut-headed Bee-eater	*Merops leschenaulti leschenaulti*	✓		✓			
74.	Cliff Swallow	*Hirundo fluvicola*						✓
75.	Collared Scops Owl	*Otus bakkamoena bakkamoena*	✓	✓	✓	✓	✓	✓
76.	Comb Duck	*Sarkidiornis melanotus melanotus*			✓			
77.	Common Bustard Quail	*Turnix suscitator taigoor*	✓					
78.	Common Ceylon Kingfisher	*Alcedo atthis taprobana*	✓	✓	✓	✓	✓	✓
79.	Common Hawk-Cuckoo	*Cuculus varius varius*		✓	✓	✓		✓
80.	Common Indian Nightjar	*Caprimulgus asiaticus asiaticus*						✓
81.	Common Indian or Hodgson's Rosefinch	*Carpodacus erythrinus roseatus*	✓					✓
82.	Common Myna	*Acridotheres tristis tristis*	✓	✓	✓	✓	✓	✓
83.	Common or Fantail Snipe	*Gallinago gallinago gallinago*	✓		✓			

Contd...

Appendix 3.5.2.10 Contd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
84.	Common or Small Green Bee-eater	*Merops orientalis orientalis*	✓	✓	✓	✓	✓	✓
85.	Common Pariah Kite	*Milvus migrans govinda*	✓	✓	✓	✓	✓	✓
86.	Common Sandpiper	*Tringa hypoleucos* Rostratulidae	✓		✓	✓	✓	✓
87.	Common Teal	*Anas crecca crecca*		✓	✓	✓	✓	✓
88.	Common Tern	*Sterna hirundo*			✓			
89.	Common Peafowl	*Pavo cristatus*	✓					
90.	Coorg Longtailed or Wren-Warbler	*Prinia hodgsonii albogularis*	✓	✓	✓	✓	✓	✓
91.	Coot	*Fulica atra atra*			✓			
92.	Coppersmith	*Megalaima haemacephala indica*			✓	✓	✓	✓
93.	Cotton Teal	*Nettapus coromaandelianus coromaandelianus*		✓	✓	✓	✓	✓
94.	Crag Martin	*Hirundo rupestris*						✓
95.	Crested goshawk	*Accipiter trivirgatus*			✓			
96.	Crested Honey Buzzard	*Pernis ptilorhynchus ruficollis*	✓		✓			✓
97.	Crested Serpent Eagle	*Spilornis cheela melanotis*	✓		✓			✓
98.	Cuckoo	*Cuculus canorus*						✓
99.	Curlew	*Numenius arquata*		✓	✓	✓	✓	✓
100.	Curlew-Stint	*Calidris testacea*			✓			
101.	Desert Wheater	*Oenanthe deserti deserti*			✓			
102.	Dunlin	*Calidris alpina alpina*			✓			
103.	Dusky Crag Martin	*Hirundo concolor concolor*	✓					✓
104.	Eastern Baillon's Crake or Dwarf Rail	*Porzana pusilla pusilla*		✓		✓	✓	✓
105.	Eastern Black Redstart	*Phoenicurus ochruros rufiventris*			✓			
106.	Eastern Golden Plover	*Pluviallis dominica fulva*		✓	✓	✓	✓	✓
107.	Eastern Grasshopper-Warbler	*Locustella naevia straminea*						✓
108.	Eastern Grey Heron	*Ardea cinerea rectiroster*	✓	✓	✓	✓	✓	✓
109.	Eastern Knot	*Calidris tenuirostris*			✓			
110.	Eastern Large Egret	*Ardea alba modesta*		✓	✓	✓	✓	✓
111.	Eastern Peregrine Falcon	*Falco peregrinus japonensis*						✓
112.	Eastern Purple Heron	*Ardea purpurea manilensis*		✓	✓	✓	✓	✓

Contd...

Appendix 3.5.2.1bContd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
113.	Eastern Redbreasted Flycatcher	*Muscicapa parva albicilla*	✓		✓			✓
114.	Eastern Swallow	*Hirundo rustica gutturalis*	✓	✓	✓	✓	✓	✓
115.	European Kestrel	*Falco tinnuculus tinnunculus*	✓					
116.	Fairy Bluebird	*Irena puella puella*	✓		✓			✓
117.	Forest Eagle-Owl	*Bubo nipalensis nipalensis*	✓					✓
118.	Forest Wagtail	*Motacilla indica*	✓		✓			✓
119.	Frankli's Nightjar	*Caprimulgus affinis monticola*	✓					✓
120.	Gadwall	*Anas strepera*			✓			
121.	Garganey or Bluewinged Teal	*Anas querquedula*	✓	✓	✓	✓	✓	✓
122.	Goldfronted Chloropsis or Leaf-Bird	*Chloropsis aurifrons insularis*	✓		✓			
123.	Grass Owl	*Tyto capensis longimembris*						✓
124.	Great Blackheaded Gull	*Larus ichthyaetus*		✓	✓	✓	✓	✓
125.	Great Indian Hornbill	*Buceros bicornis homrai*	✓		✓			✓
126.	Green munia	*Estrilda formosa*						✓
127.	Green Sandpiper	*Tringa ochropus*	✓	✓	✓	✓	✓	✓
128.	Greated Spotted Eagle	*Aquila clanga*	✓					
129.	Greenish Leaf Warbler	*Phylloscopus trochiloides viridanus*	✓					✓
130.	Greenshank	*Tringa nebularia*		✓	✓	✓	✓	✓
131.	Grey Hornbill	*Tockus birostris*			✓			✓
132.	Grey Junglefowl	*Gallus sonneratii*	✓		✓			✓
133.	Grey or Spottedbilled Pelican	*Pelecanus philippensis philipensis*			✓			
134.	Grey Shrike	*Lanius excubitor*						✓
135.	Grey Wagtail	*Motacilla cinerea cinerea*	✓	✓	✓	✓	✓	✓
136.	Greyfronted Green Pigeon	*Treron pompadora affinis*	✓		✓			✓
137.	Greyheaded Bulbul	*Pycnonotus priocephalus*	✓		✓			✓
138.	Greyheaded Fishing Eagle	*Icthyophaga ichthyatus*	✓		✓			✓
139.	Greyheaded Flycatcher	*Culicicapa ceylonensis ceylonensis*	✓					
140.	Greyheaded Myna	*Sturnus malabaricus malabaricus*	✓		✓			✓
141.	Greyheaded Yellow Wagtail	*Motacilla flava thunbergi*	✓	✓	✓	✓	✓	✓
142.	Gullbilled Tern	*Gelochelidon nilotica nilotica*		✓	✓	✓	✓	✓

Contd...

Appendix 3.5.2.10 Contd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
143.	Haircrested or Spangled Drongo	*Dicrurus hottentottus hottentottus*	✓		✓			✓
144.	Heartspotted Woodpecker	*Hemicircus canente canente*	✓		✓			✓
145.	Himalayan Whiterumpted Swift	*Pus pacificus*	✓					
146.	Honey buzzard	*Pernis ptylorhyncus*	✓					
147.	House Martin	*Delichon urbica*						✓
	House Swift	*Apus affinis*	✓	✓	✓	✓	✓	✓
148.	Indian Alpine Swift	*Apus melba nubifuga*	✓	✓	✓	✓	✓	✓
149.	Indian Button Quail	*Turnix tanki tanki*	✓					
150.	Indian Blackcrested Baza	*Aviceda leuphotes leuphotes*	✓		✓			✓
151.	Indian Blacknaped Blue Flycatcher	*Monarcha azurea styani*	✓		✓			✓
152.	Indian Blacknaped Oriole	*Oriolus chinensis diffusus*	✓		✓			✓
153.	Indian Blue Chat	*Erithacus brunneus brunneus*						✓
154.	Indian Blue Rock Pigeon	*Columba livia intermedia*		✓	✓	✓	✓	✓
155.	Indian Blue Rock Thrush	*Monticola solitarius pandoo*	✓					
156.	Indian Brownbreasted Flycatcher	*Muscicapa muttui muttui*	✓					✓
157.	Indian Common Wood Shrike	*Tephrodornis pondicerianus pondicerianus*	✓	✓	✓	✓	✓	✓
158.	Indian Courser	*Cursorius coromandelicus*			✓			
159.	Indian Crested Hawk-Eagle	*Spizaetus cirrhatus cirrhatus*	✓		✓			✓
160.	Indian Crested Tree Swift	*Hemiprocne longipennis coronata*	✓		✓			✓
161.	Indian Cuckoo	*Cuculus micropterus micropterus*	✓	✓	✓	✓	✓	✓
162.	Indian Darter or Snake-bird	*Anhinga rufa melanogaster*	✓	✓	✓	✓	✓	✓
163.	Indian Drongo-Cuckoo	*Surniculus lugubris dicruroides*	✓					✓
164.	Indian Edible-nest Swiftlet	*Collocalia unicolor*	✓		✓			
165.	Indian Emerald Dove	*Chalcophaps indica indica*	✓		✓			✓
166.	Indian great Horned Owl	*Bubo bubo bengalensis*	✓	✓		✓	✓	✓
167.	Indian Great Reed Warbler	*Acrocephalus stentoreus brunnescens*	✓	✓	✓	✓	✓	✓

Contd...

Appendix 3.5.2.10 Contd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
168.	Indian Grey Drongo	*Dicrurus leucophaeus longicaudatus*	✓	✓	✓	✓	✓	✓
169.	Indian Grey Tit	*Parus major mahrattarum*	✓		✓			✓
170.	Indian Hobby	*Falco severus rufipedoides*	✓					
171.	Indian House Sparrow	*Passer domesticus indicus*	✓					✓
172.	Indian Jungle Crow	*Corvus macrorhynchos culminatus*	✓	✓	✓	✓	✓	✓
173.	Indian Jungle Nightjar	*Caprimulgus indicus indicus*	✓		✓			✓
174.	Indian Kestrel	*Falco tinnunculus objurgatus*	✓	✓		✓	✓	✓
175	Indian Koel	*Eudynamys scolopacea scolopacea*	✓	✓	✓	✓	✓	✓
176	Indian Lesser Crested Sea Tern	*Sterna bengalensis bengalensis*		✓		✓	✓	✓
177	Indian Little Grebe or Dabchick	*Podiceps ruficollis capensis*	✓	✓	✓	✓	✓	✓
178.	Indian Little Green Bittern	*Butorides striatus chloriceps*						✓
179.	Indian Little Ringed Plover	*Charadrius dubius jerdoni*	✓		✓			
180.	Indian Moorhen	*Gallinula chloropus indica*		✓	✓	✓	✓	✓
181	Indian Oriole	*Oriolus oriolus kundoo*	✓	✓	✓	✓	✓	✓
182.	Indian Pitta	*Pitta brachyura brachura*	✓	✓	✓	✓	✓	✓
183.	Indian Plaintive Cuckoo	*Cacomantis passerinus*			✓			✓
184	Indian Pond Heron or Paddy Bird	*Ardeola grayii grayii*	✓	✓	✓	✓	✓	✓
185.	Indian Purple Sunbird	*Nectarinia asiatica asiatica*	✓	✓	✓	✓	✓	✓
186.	Indian Purplerumped Sunbird	*Nectarinia zeylonica sola*	✓	✓	✓	✓	✓	✓
187.	Indian Reef Heron	*Egretta gularis schistacea*		✓	✓	✓	✓	✓
188.	Indian Ring Dove	*Streptopelia decaocto decaocto*	✓					
189.	Indian Scops Owl	*Otus scops rufipennis*	✓					
190.	Indian Shag	*Phalacrocorax fuscicollis*	✓	✓	✓	✓	✓	✓
191.	Indian Smaller Egret	*Egretta intermedia intermedia*	✓	✓	✓	✓	✓	✓
192.	Indian Spotted Dove	*Streptopelia chinensis suratensis*	✓	✓	✓	✓	✓	✓
193.	Indian Stone Curlew	*Burhinus oedicnemus indicus*			✓			
194.	Indian Whiskered Tern	*Chlidonias hybrida indica*		✓	✓	✓	✓	✓

Contd...

Appendix 3.5.2.b Contd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
195.	Indian White Wagtail	*Motacilla alba dukhunensis*		✓	✓	✓	✓	✓
196.	Indian Whitebreasted Kingfisher	*Halcyon smyrnensis fusca*	✓	✓	✓	✓	✓	✓
197.	Japanese Desert Buzzard	*Buteo buteo burmanicus*	✓					
198.	Jack Snipe	*Gallinago minima*			✓			
199.	Jerdon's Chloropsis or Leaf-Bird	*Chloropsis cochinchinensis jerdoni*	✓	✓	✓	✓	✓	✓
200.	Jerdon's Imperial Pigeon	*Ducula badia cuprea*	✓		✓			
201.	Jerdon's Longtailed Nightjar	*Caprimulgus macrurus atripennis*						✓
202.	Kentish Plover	*Charadrius alexandrinus alexandrinus*			✓			
203.	Kora or Watercock	*Gallicrex cinerea cinera*		✓	✓	✓	✓	✓
204.	Lagger Falcon	*Falco biarmicus jugger*	✓					
205.	Large Cormorant	*Phalacrocorax carbo sinensis*	✓	✓	✓	✓	✓	✓
206.	Large Crested Sea Tern	*Sterna bergii velox*		✓		✓	✓	✓
207.	Large crowned Leaf Warbler	*Phylloscopus occipitalis occipitalis*	✓					
208.	Large Green Barbet	*Megalaima zeylanica inornata*	✓					✓
209.	Large Indian (Oriental)	*Glareola pratincola maldivarum*			✓			
210.	Large Indian Cuckoo-Shrike	*Coracia novaehollandiae macei*	✓	✓	✓	✓	✓	✓
211.	Large Pied Wagtail	*Motacilla maderaspatensis*	✓	✓	✓	✓	✓	✓
212.	Large Racket-tailed Drongo	*Dicrurus paradiseus*	✓	✓	✓	✓	✓	✓
213.	Large Sand Plover	*Charadrius leschenaultii leschenaultii*			✓			
214.	Largebilled Leaf Warbler	*Phylloscopuys magnirostris*	✓		✓			✓
215.	Layard's or Indian Brownbreasted				✓			
216.	Legge's Hawk-Eagle	*Spizaetus nipalensis kelaarti*	✓					
217.	Lesser Blackbacked Gull	*Larus fuscus fuscus*		✓	✓	✓	✓	✓
218.	Lesser Coucal or Crow-Pheasant	*Centropus toulou bengalensis*	✓					✓
219.	Lesser or Common Whistling Teal	*Dendrocygna javanica*	✓		✓			
220.	Lesser Whistling Teal	*Dendrocygna javanica*		✓		✓	✓	✓

Contd...

Appendix 3.5.2. Contd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
221.	Lesser Whitethroat	*Sylvia curruca (Subspecies)*						✓
222.	Little Cormorant	*Phalacrocorax niger*	✓	✓	✓	✓	✓	✓
223.	Little Egret	*Egretta garzetta garzetta*	✓	✓	✓	✓	✓	✓
224.	Little Green Heron	*Ardeola striatus chloriceps*			✓			✓
225.	Little Ring Plover	*Charadrius dubius curonicus*		✓	✓	✓	✓	✓
226.	Little Scalybellied Green Woodpecker	*Picus myrmecophoneus*	✓					✓
227.	Little Spider-hunter	*Arachnothera longirostris longirostris*	✓		✓			✓
228.	Little Stint	*Calidris minuta*			✓			
229.	Longbilled Vulture	*Gyps indicus indicus*	✓					
230.	Loten's or Maroonbreasted Sunbird	*Nectarinia zeylonica sola*	✓	✓	✓	✓	✓	✓
231.	Malabar Crested Lark	*Galerida malabarica*	✓	✓	✓	✓	✓	✓
232.	Malabar Crimsonthroated Barbet	*Megalaima rubricapilla malabarica*	✓		✓			✓
233.	Malabar Goldenbacked Threetoed Woodpecker	*Dinopium javanense malabaricum*	✓		✓			✓
234.	Malabar Goldenbacked Woodpecker	*Dinopium benghalense*	✓	✓	✓	✓	✓	✓
235.	Malabar Great black Woodpecker	*Dryocopus javensis hodgsonii*	✓		✓			✓
236.	Malabar Grey Hornbill	*Tockus griseus griseus*	✓		✓			✓
237.	Malabar Jungle Babbler	*Turdoides striatus malabaricus*	✓		✓			✓
238.	Malabar Jungle Owlet	*Glaucidium radiatum malabaricum*	✓		✓			✓
239.	Malabar Lorikeet	*Loriculus vernalis rubropygialis*	✓	✓	✓	✓	✓	✓
240.	Malabar Pied Hornbill	*Anthracoceros coronatus coronatus*						✓
241.	Malabar Pigmy Woodpecker	*Dendrocopos nanus cinereigula*	✓		✓			✓
242.	Malabar Small Minivet	*Pericrocotus cinnamomeus malabaricus*	✓	✓	✓	✓	✓	✓
243.	Malabar Trogon	*Harpactes fasciatus malabaricus*	✓		✓			✓

Contd...

Appendix 3.5.2.16Contd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
244.	Malabar Whistling Thrush	*Myiophoneus horsfieldii horsfieldii*	✓		✓			✓
245.	Malabar Wood Shrike	*Tephrodornis virgatus sylvicola*	✓		✓			✓
246.	Malay Bittern	*Gorsachius melanolophus melanolophus*		✓		✓	✓	✓
247.	Malay Pipit	*Anthus novaeseelandiae malayensis*	✓		✓			
248.	Malherbe's Goldenbacked Woodpecker	*Chrysocolaptes lucidus chersonesus*	✓		✓			✓
249.	Marsh Harrier	*Circus aeruginosus aeruginosus*	✓	✓	✓	✓	✓	✓
250.	Marsh Sandpiper	*Tringa stagnatilis*		✓	✓	✓	✓	✓
251.	Masked Booby	*Sula dactylatra melanops*			✓			
252.	Masked Wagtail	*Motacilla alba personata*			✓			
253.	Montagu's Harrier	*Circus pygargus*	✓					✓
254.	Mottled Wood Owl	*Strix ocellata ocellata*	✓	✓		✓	✓	✓
255.	Night Heron	*Nycticorax nycticorax nycticorax*	✓	✓	✓	✓	✓	✓
256.	Nilgiri Flowerpecker	*Dicaeum agile agile*	✓		✓			
257.	Nilgiri House Swallow	*Hirundo tahitica domicola*	✓					✓
258.	Nilgiri longtailed or Wren-Warbler	*Prinia subflava franklinii*	✓	✓	✓	✓	✓	✓
259.	Nilgiri Pied Bushchat	*Saxicola caprata nilgiriensis*	✓		✓			
260.	Nilgiri Pipit	*Anthus nilghriensis*	✓					
261.	Nilgiri Quaker Babbler	*Alcippe poioicephala poioicephala*	✓		✓			✓
262.	Nilgiri Speckled Piculet	*Picumnus innominatus malayorum*	✓					✓
263.	Nilgiri Verditer Flycatcher	*Muscicapa albicaudata*	✓					✓
264.	Nilgiri White-eye	*Zosterops palpebrosa nilgiriensis*	✓					
265.	Nilgiri Wood Pigeon	*Columba elphinstonii*	✓		✓			✓
266.	Openbill Stork	*Anastomus oscitans*			✓			✓
267.	Orange Minivet	*Pericrocotus flammeus flammeus*	✓		✓			
268.	Orangebreasted Green Pigeon	*Treron bicincta bicincta*						✓
269.	Orangeheaded Ground Thrush	*Zoothera citrina cyanotus*	✓		✓			✓

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Appendix 3.5.2.10 Contd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
270.	Oriental Scops Owl	*Otus sunia*	✓					
271.	Osprey or Fish Hawk	*Pandion halioetus halioetus*	✓	✓	✓	✓	✓	✓
272.	Oystercatcher	*Haematopus ostralegus*			✓			
273.	Paddyfield Warbler	*Acrocephalus agricola agricola*						✓
274.	Painted Bush Quail	*Perdicula erythrorhyncha*	✓					
275.	Painted Snipe	*Rostratula benghalensis* Glareolidae	✓	✓	✓	✓	✓	✓
276.	Pale Harrier	*Circus macrourus*	✓		✓			✓
277.	Pallas's Grass-Warbler	*Locustella certhiola rubescens*						✓
278.	Palm Swift	*Cypsiurus parvus batasiensis*	✓	✓	✓	✓	✓	✓
279.	Pamirs Lesser Sand Plover	*Charadrius monogolus atrifrons*			✓			
280.	Paradise Flycatcher	*Terpsiphone paradisi leucogaster*	✓	✓	✓	✓	✓	✓
281.	Peninsular Bay Owl	*Phodilus badius ripleyi*						✓
282.	Peninsular Chestnutbellied Nuthatch	*Sitta castanea*	✓					
283.	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*			✓			✓
284.	Pied Crested Cuckoo	*Clamator jacobinus jacobinus*	✓		✓			✓
285.	Pied Flycatcher Shrike	*Hemipus picatus picatus*	✓		✓			✓
286.	Pied Ground Thrush	*Zoothera wardii*						✓
287.	Pied Harrier	*Circus malanoleucos*	✓					
288.	Pintail	*Anas acuta*		✓	✓	✓	✓	✓
289.	Pintail Snipe	*Gallinago stenura*			✓			
290.	Plain Sand Martin	*Riparia paludicola chinnensis*			✓			
291.	Purple Moorhen or Gallinul	*Porphyrio porphyrio poliocephalus*		✓	✓	✓	✓	✓
292.	Red Munia	*Estrilda amandava amandava*			✓			✓
293.	Red Spurfowl	*Galloperdix spadicea spadicea*	✓		✓			✓
294.	Redheaded Merlin	*Falco chiquera chiquera*						✓
295.	Redshank	*Tringa totanus totanus*		✓	✓	✓	✓	✓

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Appendix 3.5.2Io Contd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
296.	Redwattled Lapwing	*Vanellus indicus indicus*	✓	✓	✓	✓	✓	✓
297.	Redwinged Crested Cuckoo	*Clamator coromandus*	✓					✓
298.	Richard's Pipit	*Anthus novaeseelandiae richardi*	✓	✓		✓	✓	✓
299.	River Tern	*Sterna aurantia*			✓			✓
300.	Roseringed Parakeet	*Psittacula krameri manillensis*	✓	✓	✓	✓	✓	✓
301.	Rosy Pastor	*Sturnus roseus*						✓
302.	Rubythroated Bulbul	*Pycnonotus melanicterus gularis*	✓		✓			
303.	Ruddy Crake	*Amaurornis fuscus zeylonicus*	✓	✓	✓	✓	✓	✓
304.	Ruff	*Philomachus pugnax*			✓			
305.	Rufous Babbler	*Turdoides striatus malabaricus*	✓		✓			✓
306.	Rufous Rock Pipit	*Anthus similis travancoriensis*	✓					✓
307.	Rufousbellied Hawk-Eagle	*Hieraaetus kienerii*	✓		✓			
308.	Rufousbellied Munia	*Lonchura kelaarti jerdoni*	✓		✓			✓
309.	Rufoustailed Finch-Lark	*Ammomanes phoenicurus testaceus*						✓
310.	Rufoustailed Flycatcher	*Muscicapa ruficauda*	✓					✓
311.	Sanderling	*Calidris alba*			✓			
312.	Sandwich Tern	*Sterna sandvicensis sandivicensis*			✓			·
313.	Saunders' Little Tern	*Sterba saundersi*		✓		✓	✓	✓
314.	Shahin Falcon	*Fakci oeregrubys oeregrubatir*	✓					
315.	Shama	*Copsychus malabaricus malabaricus*						✓
316.	Shikra	*Accipiter badius badius*			✓			
317.	Shorteared Owl	*Asio flammeus flammeus*	✓					✓
318.	Short-toed Eagle	*Circaetus gallicus gallicus*	✓					✓
319.	Short-tailed Greyheaded Yellow Wagtail	*Motacilla flava simillima*	✓					
320.	Slatyheaded scimitar Babbler	*Pomatorhinus horsfieldii travancoreensis*	✓					
321.	Small Green Barbet	*Megalaima viridis*	✓	✓	✓	✓	✓	✓
322.	Small Greenbilled Malkoha	*Rhopodytes viridirostris*	✓		✓			
323.	Small Indian Pratincole	*Glareola lactea*			✓			

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Appendix 3.5.2.10 Contd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
324.	Small Nilgiri Skylark	*Alauda gulgula australis*	✓	✓	✓	✓	✓	✓
325.	Small Sunbird	*Nectarinia minima*	✓		✓			✓
326.	Smaller White Scavenger Vulture	*Neophron percnopterus ginginianus*						✓
327.	South Indian Black backed Robin	*Saxicoloides fulicata fulicata*	✓	✓	✓	✓	✓	✓
328.	South Indian Black Bulbul	*Hypsipetes madagascariensis ganeesa*	✓					
329.	South Indian Blackheaded Oriole	*Oriolus xanthornus maderaspatanus*	✓	✓	✓	✓	✓	✓
330.	South Indian Hawk-Owl	*Ninox scutulata hirsuta*	✓	✓	✓	✓	✓	✓
331.	South Indian Redvented Bulbul	*Pycnonotus cafer cafer*	✓	✓		✓	✓	✓
332.	South Indian Small Yellownaped Woodpecker	*Picus chlorolophus chlorigaster*	✓		✓			
333.	Southern Crow-Pheasant or Coucal	*Centropus sinensis parroti*	✓	✓	✓	✓	✓	✓
334.	Southern Grackle	*Gracula religiosa indica*	✓		✓			✓
335.	Southern Green Pigeon	*Treron phoenicoptera chlorigaster*	✓		✓			
336.	Southern Grey Partridge	*Francolinus pondicerianus pondicerianus*			✓			
337.	Southern Greybacked Shrike	*Lanius schach caniceps*	✓					✓
338.	Southern Indian Roller	*Coracias benghalensis indica*	✓	✓	✓	✓	✓	✓
339.	Southern Jungle Myna	*Acridotheres fuscus mahrattensis*	✓	✓	✓	✓		✓
340.	Southern Magpie-Robin	*Copsychus saularis ceylonensis*	✓	✓	✓	✓	✓	✓
341.	Southern Redwhiskered Bulbul	*Pycnonotus jocosus fuscicaudatus*	✓		✓			✓
342.	Southern Rufous Woodpecker	*Micropternus brachyurus jerdonii*	✓		✓			✓
343.	Southern Spotted Owlet	*Athene brama brama*	✓	✓		✓	✓	✓
344.	Southern Tree Pie	*Dendrocitta leucogastra*	✓	✓				✓
345.	Southern Whitebrowed Fantail Flycatcher	*Rhipidura aureola ompressirostris*	✓	✓		✓	✓	✓
346.	Southern Yellowfronted Pied Woodpecker	*Dendrocopos mahrattensis mahrattensis*	✓		✓			

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Appendix 3.5.2. Contd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
347.	Spoonbill	*Platalea leucorodia major*			✓			
348.	Spoonbilled Sandpiper	*Limicola falcinellus*			✓			
349.	Spotbil Duck	*Anas Poecilorhyncha poecilorhyncha*						✓
350.	Spotted Babbler	*Pellorneum ruficeps ruficeps*	✓		✓			✓
351.	Spotted Munia	*Lonchura punctulata punctulata*	✓	✓	✓	✓	✓	✓
352.	Streaked Weaver bird	*Ploceus manyar flaviceps*		✓	✓	✓	✓	✓
353.	Swallow-Plover	*Glareola lactea*						✓
354.	Sykes's Striated or Redrumped Swallow	*Hirundo daurica erythropygia*	✓	✓	✓	✓	✓	✓
355.	Sykes's Tree Warbler	*Hippolais caligata rama*						✓
356.	Tailor Bird	*Orthotomus sutorius guzurata*	✓	✓	✓	✓	✓	✓
357.	Temminck's Stint	*Calidris temminckii*			✓			
358.	Terek Sandpiper	*Tringa terek*			✓			
359.	Thickbilled Flowerpecker	*Dicaeum agile agile*	✓		✓			
360.	Thickbilled Warbler	*Phragamaticola aedon aedon*						✓
361.	Threetoed Forest Kingfisher	*Ceyx erithacus erithacus*						✓
362.	Tickell's Blue Flycatcher	*Muscicapa tickelliae tickelliae*	✓		✓			✓
363.	Tickell's Flowerpecker	*Dicaeum erythtothynchos erythrorhynchos*	✓	✓	✓	✓	✓	✓
364.	Tickell's Leaf Warbler	*Phylloscopus affinis*	✓					✓
365.	Travancore Baya or Weaver Bird	*Ploceus philippinus travancoreensis*		✓	✓	✓	✓	✓
366.	Travancore Pied Kingfisher	*Ceryle rudis travancoreensis*	✓	✓	✓	✓	✓	✓
367.	Travancore Spotted Babbler	*Pellorneum ruficeps olivaceum*			✓			
368.	Travancore Streaked Fantail Warbler	*Cisticola juncidis salimalii*	✓	✓	✓	✓	✓	✓
369.	Travancore Whitebreasted Laughing thrush	*Garrulax jerdoni fairbanki*	✓					
370.	Travancore Yellowcheeked Tit	*Parus xanthogenys travancoreensis*	✓		✓			
371.	Tree Pie	*Dendrocitta vagabunda parvula*			✓	✓	✓	✓

Contd...

Appendix 3.5.2.10 Contd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
372.	Turkestan Blackheaded Wagtail	*Motacilla flava malanogrisea*	✓	✓		✓	✓	✓
373.	Turnstone	*Arenaria interpres interpres*			✓			
374.	Tytler's Leaf Warbler	*Phylloscopus tytleri*						✓
375.	Velvetfronted Nuthatch	*Sitta frontalis frontalis*	✓		✓			✓
376.	Verditer Flycatcher	*Muscicapa thalassina thalassina*	✓					✓
377.	Vigors's Yellowbacked Sunbird	*Aethopyga siparaja vigorsii*						✓
378.	Western Blossomheaded Parakeet	*Psittacula cyanocephala cyanocephala*	✓	✓	✓	✓	✓	✓
379.	Western Yellowheaded Wagtail	*Motacilla citreola werae*		✓	✓	✓	✓	✓
380.	Whimbrel	*Numenius phaeopus phaeopus*		✓	✓	✓	✓	✓
381.	White breasted waterhen	*Amaurornis phoenicurus phoenicurus*	✓	✓	✓	✓	✓	✓
382.	White Ibis	*Threskiornis aethiopica melanocephala*			✓			
383.	White Stork	*Ciconia ciconia ciconic*			✓			
384.	Whitetailed Eagle	*Haliaeetus albicila*	✓					
385.	Whitebacked or Bengal Vulture	*Gyps bengalensis*	✓					
386.	Whitebacked Munia	*Lonchura striata striata*	✓	✓	✓	✓		✓
387.	Whitebellied Blue Flycatcher	*Muscicapa pallipes*	✓		✓			
388.	Whitebellied Drongo	*Dicrurus caerulescens caerulescens*	✓					✓
389.	Whitebellied Sea Eagle	*Haliaeetus leucogaster*	✓					
390.	White-eyed Pochard	*Aythya nyroca*		✓		✓	✓	✓
391.	Whiteheaded Babbler	*Turdoides affinis affinis*		✓	✓	✓	✓	✓
392.	Whitenecked Stork	*Ciconia episcopus eouscioys*		✓	✓	✓	✓	✓
393.	Whiterumped Spinetail Swift	*Chaetura sylvatica*	✓		✓			✓
394.	Whitethroated Babbler	*Dumetia hyperythra albogularis*	✓					
395.	Whitethroated Munia	*Lonchura malabarica malabarica*	✓		✓	✓	✓	✓
396	Wiretailed Swallow	*Hirundo smithii filifera*						✓
397	Wood or Spotted Sandpiper	*Tringa glareola*	✓	✓	✓	✓	✓	✓

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Appendix 3.5.2.10 Contd...

Sr. No.	Common name	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
398.	Wood Snipe	*Capella nemoricola*			✓			
399.	Woodcock	*Scolopax rusticola rusticola*			✓			
400.	Wren-Warbler	*Prinia sylvatica sylvatica*						✓
401.	Wryneck	*Jynx torquilla torquilla*						✓
402.	Wynaad Laughing Thrush	*Garrulax delesserti delesserti*	✓					✓
403.	Yellolegged Herring Gull	*Larus argentatus heuglin*			✓			
404.	Yellow Bittern	*Ixobrychus sinensis sinensis*	✓	✓	✓	✓	✓	✓
405.	Yellowbacked Wagtail	*Motacilla flava lutea*						✓
406.	Yellowbrowed Bulbul	*Hypsipetes indicus indicus*	✓		✓			✓
407.	Yellowthroated Sparrow	*Petronia zanthocollis xanthocollis*	✓	✓	✓	✓	✓	✓
408.	Yellow-wattled Lapwing	*Vanellus malabaricus*		✓	✓	✓	✓	✓
409.	Yunnan Tree Pipit	*Anthus hodgsoni yunnanensis*	✓					

Source: Data collected by KFRI

Appendix 3.5.2.11 : Mammals of GKR

Sr. No.	Common name and Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
1.	Bandicoot rat, *Bandicota indica* (Gray & Hardwick)	✔					✔
2.	Barking deer, *Muntjacus muntjac* (Zimmermann)	✔	✔	✔	✔		✔
3.	Blacknaped hare, *Lepus nigricollis nigricollis* F. Cuvier.	✔	✔	✔	✔		✔
4.	Bonnet macaque *Macaca radiata* (E. Geoffroy)	✔	✔	✔	✔	✔	✔
5.	Brown mangoose, *Herpestes fuscus fuscus* Water house	✔		✔			✔
6.	Chital, *Axiss axis* (Erxleben)	✔		✔			
7.	Common dolphin *Diphinus delphis* Linnaeus			✔		✔	✔
8.	Common giant flying squirrel, *Petaurista petaurista* Pallas	✔	✔	✔	✔		✔
9.	Common house rat, *Ratus ratus* (Linnaeus)	✔	✔	✔			✔
10.	Common langur, *Presbytes entellus* (Dufresne)	✔		✔			
11.	Common mangoose, *Herpestes edwardsii* (E. Geoffroy Saint Hilliare)	✔	✔	✔	✔	✔	✔
12.	Day's shrew, *Suncus dayii* (Dobson)	✔		✔	✔	✔	✔
13.	Dusky striped squirrel, *Funambulus sublineatus* (Waterhouse)	✔			✔		
14.	Elephant, *Elephas maximus* Linnaeus	✔	✔	✔	✔		✔
15.	Fishing cat, *Felis viverrina* Bennet		✔	✔	✔	✔	✔
16.	Gaur, *Bos gaurus* Smith	✔	✔	✔	✔		✔
17.	Grey musk shrew, *Suncus murinus* (Linnaeus)	✔		✔	✔	✔	✔
18.	Grizzled giant squirrel, Ratufa macroura Pennant	✔					
19.	House mouse, *Mus musculus* Linnaeus	✔	✔	✔	✔	✔	✔
20.	Indian bush rat, *Golunda elioti* (Gray)	✔		✔	✔		
21.	Indian false vampire, *Megaderma lyra* (Linnaeus)	✔	✔				
22.	Indian field mouse, *Mus booduga* (Gray)	✔	✔	✔	✔	✔	
23.	Indian flying fox, *Pteropus giganteus* Brunnich	✔	✔	✔	✔	✔	✔
24.	Indian gerbile *Tatera indica* (Hardwicke)	✔	✔				
25.	Indian mole rat, *Bandicota bengalensis* (Gray & Hardwick)	✔	✔	✔	✔	✔	
26.	Indian pangolin *Manis crassicaudata* Gray	✔	✔	✔			
27.	Indian porcupine, *Hystrix indica* Kerr	✔	✔	✔	✔		✔
28.	Jackal, *Canis aureus* Linnaeus	✔	✔		✔		✔
29.	Jungle cat, *Felis chaus* Schreber	✔	✔	✔	✔	✔	✔
30.	Jungle striped squirrel, *Funambulus tristriatus* Waterhouse	✔	✔	✔	✔		
31.	The striped palm squirrel *Funambulus palmarum* (Linnaeus)	✔	✔				

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Appendix 3.5.2.11 Contd...

Sr. No.	Common name and Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
32.	Leopard cat, *Paradoxurus hermaphroditus* (Pallas)			✓	✓		✓
33.	Leopard cat, *Prionailurus bengalensis* (Kerr)	✓	✓	✓	✓		✓
34.	Leopard, *Panthera pardus* (Linnaeus)	✓	✓				
35.	Lion tailed macaque *Macaca silenusl (Linnaeus)*	✓		✓	✓		✓
36.	Malabar giant squirrel *Ratufa indica maxima* (Erxleben)	✓	✓	✓	✓		✓
37.	Malabar spiny dormouse, *Plantacanthomys lasiurus* Blyth	✓			✓		
38.	Mouse deer, *Tragulus meminna* (Erxlenben)	✓	✓	✓	✓		✓
39.	Nilgiri langur *Trachypithecus johni* (J. Fischer)	✓	✓	✓	✓		✓
40.	Nilgiri marten, *Martes gwatkinsi* (Horsfield)	✓					
41.	Nilgiri tahr, *Hemitragus hylocrius* (Ogliby)	✓			✓		
42.	Painted bat, *Kerivoula picta pillas*			✓			
43.	Ruddy mangoose, *Herpestes smithii smithii* Gray	✓	✓		✓		
44.	Rusty spotted cat, *Prionailurus rubiginosa* (Geoffroy Saint-Hilaire)				✓		
45.	Salim Ali's bat *Latidens salimali* Thonglongya	✓					
46.	Sambar, *Cervus unicolor* Kerr.	✓	✓	✓	✓		✓
47.	Short nosed fruit bat, *Cynopterus sphinx* Vahl	✓	✓	✓	✓		
48.	Slender loris, *Loris tardigradus malabaricus* Wroughton		✓	✓			
49.	Sloth bear, *Melursus ursinus* (Shaw)	✓	✓	✓	✓		
50.	Small Indian civet, *Viverricula indica* (Desmarest)	✓	✓	✓	✓		✓
51.	Small travancore flying squirrel,*Petinomys fuscocapillus* (Jerdon)	✓			✓		
52.	Smooth Indian otter, *Lutra lutra nair* F. Cuvier	✓	✓	✓	✓	✓	✓
53.	Stripenecked mangoose, *Herpestes vitticollis* Bennets	✓					
54.	The brown rat, *Rattus norvegicus* (Berkenhout)	✓			✓		
55.	The striped palm squirrel *Funambulus palmarum* (Linnaeus)			✓	✓	✓	✓
56.	Tiger, *Panthera tigris tigris* (Linnaeus)	✓	✓	✓	✓		✓
57.	Toddy cat, *Paradoxurus hermaphroditus* (Pallas)	✓	✓	✓	✓		✓
58.	Travancore rat *Rattus ranjiniae* Agarwal and Ghosal				✓		
59.	White tailed wood rat, *Rattus blanfordi* (Thomas)	✓	✓	✓	✓		
60.	Wild boar, *Sus scrofa* Linnaeus	✓	✓	✓	✓		✓
61.	Wild dog, *Cuon alpinus* (Laniger)	✓		✓	✓		✓

Source: Data collected by KFRI

Appendix 3.5.2.12. Checklist of Mammals in the region

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

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Appendix 3.5.2.12 Contd...

Sr. No.	Common name	Status	Species name	Remarks
22.	Andersen's Leaf-nosed Bat	DD	*Hipposideros pomona* (K. Andersen, 1918)	South India, Sikkim and Assam
23.	Bellary Leaf-nosed Bat	DD	*Hipposideros schistaceus* (K. Andersen, 1918)	Endemic to South India
24.	Schneider's Leaf-nosed Bat	LRnt	*Hipposideros speoris* (Schneider, 1800)	Kerala
25.	Tickell's Bat	DD	*Hesperoptenus tickelli* (Blyth, 1851)	All over India
26.	Burmese Whiskered Bat	DD	*Myotis montivagus* (Dobson, 1874)	South India
27.	Chocolate Bat	DD	*Pipistrellus affinis* (Dobson, 1871)	All over India
28.	Kelaart's Pipistrelle	LRlc	*Pipistrellus ceylonicus* (Kelaart, 1852)	All over India
29.	India Pipistrelle	LRnt	*Pipistrellus coromandra* (Gray, 1838)	All over India
30.	Dormer's Bat	LRnt	*Pipistrellus dormeri* (Dobson, 1875)	All over India
31.	Least Pipistrelle	LRlc	*Pipistrellus tenuis* (Temminck, 1840)	All over India
32.	Asiatic Greater Yellow House Bat	LRlc	*Scotophilus heathii* (Horsfield, 1831)	All over India
33.	Asiatic Lesser Yellow House Bat	LRnt	*Scotophilus Kuhlii* (Leach, 1821)	All over India
34.	Bamboo (Flat-headed, Club-footed) Bat	?	*Tylonycteris pacnypus* (Temminck, 1840)	N,S, and E India
35.	Nicobar Long-fingerd Bat	DD	*Miniopterus pusillus* (Dobson, 1876)	South India
36.	Schreibers'Long-fingered (Common Bent-wing) Bat	LRlc	*Miniopterus schreibersi* (Kuhl, 1817)	All over India
37.	Hairy-winged Bat	DD	*Harpiocephalus harpia* (Gray, 1842)	Kerala
38.	Round-eared Tube-nosed Bat	DD	*Murina cyclotis* (Dobson, 1972)	South India
39.	Hardwicke's Forest Bat	DD	*Kerivoula hardwickii* (Horsfield, 1824)	Throughout India
40.	Painted Bat	LRnt	*Kerivoula picta* (Pallas, 1767)	Throughout India
41.	Winkle-lipped Free-tailed Bat	DD	*Chaerephon plicata* (Buchanan, 1800)	Throughout India
42.	Wroughton's free tailed bat	CR	*Otomops wroughtoni* (Thomas, 1913)	Endemic to Western Ghats
43.	Egyptian Free-tailed Bat	LRnt	*Tadarida aegyptiaca* (E. Geoffroy, 1818)	Throughout India
44.	Slender Loris	--	*Loris tardigradus* (Linnaeus, 1758)	Kerala, Tamilnadu, etc.

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Appendix 3.5.2.12 Contd...

Sr. No.	Common name	Status	Species name	Remarks
45.	Bonnet Macaque	LRlc	*Macaca radiata* (E. Geoffroy, 1812)	India
46.	Lion-tailed Macaque	EN	*Macaca* silenus (Linnaeus, 1758)	Western Ghats
47.	Common Langur	LRlc	*Semnopithecus entellus* (Dufresne, 1797)	Throughout India
48.	Nilgiri langur, Hooded leaf monkey	VU	*Trachypithecus johnii* (J. Fischer, 1829)	Western Ghats in Kerala
49.	Golden Jackal	LRlc	*Canis aureus* (Linnaeus, 1758)	Throughout India
50.	Domestic Dog	--	*Canis familiaris* (Linnaeus, 1758)	
51.	Bengal (India) Fox	LRnt	*Vulpes bengalensis* (Shaw, 1800)	Throughout India
52.	Sloth Bear	VU	*Melursus ursinus* (Shaw, 1791)	Allover India
53.	Nilgiri Marten	VU	*Martes gwatkinsi* (Horsfield, 1851)	Endemic to Western Ghats Eravikulam National Park
54.	Common Otter	--	*Lutra lutra* (Linnaeus, 1758)	South India
55.	Malabar Civet	CR	*Viverra civettina* (Blyth, 1962)	Western Ghats
56.	Small Indian Civet	LRnt	*Viverricula indica* (Desmarest, 1804)	Throughout India
57.	Common palm civet, Toddy Cat	LRlc	*Paradoxurus hermaphroditus* (Pallas, 1777)	Throughout India
58.	Brown Palm Civet, Coffee Civet	VU	*Paradoxurus jerdoni* Blanford, (1885)	Western Ghats
59.	Brown mongoose	--	*Herpestes brachyurus* (Gray, 1837)	Agasthyamalai regions
60.	Grey mongoose	LRlc	*Herpestes edwardsii* (E. Geoffroy Saint-Hilaire, 1818)	
61.	Stripe-necked mongoose	LRnt	*Herpestes vitticollis* (Bennett, 1835)	Western Ghats; PTR
62.	Striped Hyaena	LRnt	*Hyaena hyaena* (Linnaeus, 1758)	Throughout India
63.	Jungle Cat	LRnt	*Felis chaus* Schreber, (1777)	Throughout India
64.	Leopard Cat	LRnt	*Prionailurus bengalensis* (Kerr, 1792)	Silent valley National Park
65.	Rusty-spotted cat	LRnt	*Prionailurus rubiginosus* (I. Geoffroy Saint-Hilaire, 1831)	Peninsular India
66.	Fishing cat	VU	*Prionailurus viverrinus* (Bennett, 1833)	Throughout India

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Appendix 3.5.2.12 Contd...

Sr. No.	Common name	Status	Species name	Remarks
67.	Leopard	VU	*Panthera pardus* (Linnaeus, 1758)	Throughout India
68.	Tiger	EN	*Panthera tigris* (Linnaeus, 1758)	All over India (Except J and K)
69.	Common Dolphin	LRnt	*Delphinus delphis* (Linnaeus, 1758)	Travancore Coast
70.	Pigmy Killer Whale, Slender Blackfish	--	*Feresa attenuata* (Gray, 1875)	World wide
71.	Short-finned Pilot Whale	LRnt	*Globicephala macrorhynchus* (Gray, 1846)	World wide
72.	Grey Dolphin	LRnt	*Grampus griseus* (G. Cuvier, 1812)	World wide
73.	Fraser's Dolphin	--	*Lagenodelphis hosei* (Fraser, 1957)	Within Indian ocean
74.	Irrawaddy Dolphin	EN	*Orcaella bievirostris* (Gray, 1866)	
75.	Killer Whale	LRnt	*Orcinus orca* (Linnaeus, 1758)	World wide
76.	False Killer Whale	LRnt	*Pseudorca crassidens* (Owen, 1846)	World wide
77.	Indo-Pacific hump-back Dolphin	EN	*Sousa chinensis* (Osbeck, 1765)	Throughout the world
78.	Pantropical spotted dolphin	--	*Stenella attenuata* (Gray, 1846)	World wide
79.	Spinner Dolphin	LRnt	*Stenella longirostris* (Gray, 1828)	World wide
80.	Bottle-nosed Dolphin	LRnt	*Tursiops truncatus* (Montagu, 1821)	World wide
81.	Finless porpoise	LRnt	*Neophocaena phocaenoides* (G. Cuvier, 1829)	Kerala coasts
82.	Pygmy Sperm Whale	LRnt	*Kogia breviceps* (Blainville, 1838)	Throughout tropical subtropical oceans
83.	Sperm Whale (Cachalot)	LRnt	*Physeter catodon* (Linnaeus, 1758)	Throughout Indian Ocean
84.	Ginkgo-toothed Beaked Whale	--	*Mesoplodon ginkgodens* (Nishiwaki and Kamiya, 1958)	Indian ocean
85.	Sei Whale	LRnt	*Balaenoptera borealis* (Lesson, 1828)	Worldwide in temperate and subtropical waters
86.	Bryde's Whale	LRnt	*Balaenoptera edeni* (Anderson, 1879)	Worldwide in tropical and subtropical waters
87.	Blue whale	CR	*Balaenoptera musculus* (Linnaeus, 1758)	World wide

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Appendix 3.5.2.12 Contd...

Sr. No.	Common name	Status	Species name	Remarks
88.	Fin Whale	LRnt	*Balaenoptera physalus* (Linnaeus, 1758)	World wide
89.	Indian Chevrotin, Mouse Deer	LRnt	*Moschiola meminna* (Erxleben, 1777)	Peninsular India
90.	Wild Boar	LRlc	*Sus scrofa* (Linnaeus, 1758)	Throughout India
91.	Spotted Deer	LRlc	*Axis axis* (Erxleben, 1777)	Throughout India
92.	Sambar	LRlc	*Cervus unicolor* (Kerr, 1792)	Throughout India
93.	Indian Muntjac, Barking Deer, Rib-faced Deer	LRlc	*Muntiacus muntjak* (Zimmemann, 1780)	Throughout India
94.	Gaur, Indian Bison	VU	*Bos gaurus* (Smith, 1827)	Western Ghats
95.	Nilgiri Tahr	EN	*Hemitragus hylocrius* (Ogilby, 1838)	Western Ghats
96.	Indian Pangolin	LRnt	*Manis* crassicaudata (Gray, 1827)	Throughout India
97.	Layard's Striped Squirrel	DD	*Funambulus layardi* (Blyth, 1849)	Western Ghats (?)
98.	Indian Palm Squirrel	LRlc	*Funambulus palmarum* (Linnaeus, 1766)	Peninsular India
99.	Dusky Striped Squirrel	DD	*Funambulus sublineatus* (Waterhouse, 1838)	Western Ghats from Coorg, South wards
100.	Jungle striped squirrel	LRnt	*Funambulus tristriatus* (Waterhouse, 1837)	Endemic to Western Ghats
101.	Indian Giant Squirrel	VU	*Ratufa indica* (Erxleben, 1777)	Peninsular India
102.	Elliot's Giant (Large) Flying Squirrel	LRnt	*Petaurista philippensis* (Elliot, 1839)	Kerala
103.	Travancore Flying Squirrel	VU	*Petinomys fuscocapillus* (Jerdon, 1847)	Western Ghats
104.	Lesser Bandicoot-rat	LRlc	*Bandicota bengalensis* (Gray and Hardwicke, 1833)	Throughout India
105.	Bandicota indica	LRnt	*Bandicota indica* (Bechstein, 1800)	Throughout India
106	Indian Bush Rat	LRlc	*Golunda ellioti* (Gray, 1837)	Throughout peninsular India
107.	Soft-furred field rat	LRlc	*Millardia meltada* (Gray, 1837)	
108.	Little Indian Field Mouse	LRlc	*Mus booduga* (Gray, 1837)	Throughout India
109.	Cook's Mouse	LRnt	*Mus cookii* (Ryley, 1914)	Western Ghats
110.	Bonhote's Mouse	EN	*Mus famulus* (Bonhote, 1898)	Endemic to Western Ghats

Contd...

Appendix 3.5.2.12 Contd...

Sr. No.	Common name	Status	Species name	Remarks
111.	House mouse	LRlc	*Mus musculus* (Linnaeus , 1758)	Indoor forms throughout India
112.	Fawn coloured mouse	LRlc	*Mus phillipsi* (Wroughton, 1912)	Peninsular India
113.	Spiny field mouse	LRlc	*Mus platythrix* (Bennett, 1832)	Peninsular India
114.	Elliot's Brown Spiny mouse	LRlc	*Mus saxicola* (Elliot, 1839)	Kerala
115.	Ranjini's Rat	VU	*Rattus ranjiniae* (Agarwal and Ghosal, 1959)	Endemic to Western Ghats
116.	Malabar Spiny Mouse (Spiny Dormouse)	LRlc	*Platacanthomys lasiurus* (Blyth, 1859)	Endemic Western Ghats

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

Source : Data collected by KFRI

Appendix 3.5.3.1 : Algae Associated with Mangroves of GKR

Sr. No.	Species	Family
1.	*Ulva fasciata*	Chlorophyta
2.	*Ulva lactuca*	"
3.	*Ulva reticulata*	"
4.	*Enteromorpha clathrata*	"
5.	*Enteromorpha intestinalis*	"
6.	*Enteromorpha flexusa*	"
7.	*Monostroma sp.*	"
8.	*Cladophora sp.*	"
9.	*Chaetomorpha linum*	"
10.	*Rhizoclorium knereri*	"
11.	*Rhizoclorium riparium*	"
12.	*Codium fragile*	"
13.	*Codium elongatum*	"
14.	*Diohotomosiphon salina*	"
15.	*Giffordia mitchellae*	Phaeophyta
16.	*Dictyotta indica*	"
17.	*Padina tetrastoromatica*	"
18.	*Spatoglossum asperum*	"
19.	*Colpomenia sinuosa*	"
20.	*Sargassum sp.*	"
21.	*Gracilaria verrucosa*	Rhodophyta
22.	*Hypena musciformis*	"
23.	*Catenalla impudica*	"
24.	*Caloglossa leprieuri*	"
25.	*Polysiphonia macrocarpa*	"
26.	*Polysiphonia ianosa*	"
27.	*Bostrychia tenella*	"
28.	*Chlorococcus turgidus*	Cyanophyta
29.	*Aphaniotheca saxicola*	"
30.	*Oscillatoria earlei*	"
31.	*Oscillatoria limosa*	"
32.	*Oscillatoria nigrovirdis*	"
33.	*Oscillatoria annae*	"
34.	*Oscillatoria pinceps*	"
35.	*Oscillatoria marttinii*	"
36.	*Oscillatoria sp.*	"
37.	*Phormidium fragile*	"
38.	*Phormidium sp.*	"
39.	*Spirulina sp.*	"
40.	*Schizothrix sp.*	"
41.	*Macrocoleus echthnoplastes*	"
42.	*Anabaena sp.*	"
43	*Calothrix crustaceae*	"

Source : Data collected by KFRI

Appendix 3.5.3.2. : Macro-invertebrate Fauna Associated with Mangroves of GKR

Sr. No.	Species	Family
1	*Heteromastus similis*	Polychaeta
2	*Euclymene annandalei*	"
3	*Perinereis sp.*	"
4	*Mercierella enigmatica*	"
5	*Dostia (Neritina) credpidularia*	Bivalia
6	*Telescopium telescopium*	"
7	*Cerithidea fluviatilis*	"
8	*Cerithidea obtusa*	"
9	*Littorina scarba*	"
10	*Assiminera nitida*	"
11	*Pythia plicata*	"
12	*Melampus ceylonicuss*	"
13	*Cassidual nucleus*	"
14	*Balanus amphitrite*	Cirripedia
15	*Tanais* sp.	Tanaidacea
16	*Aspseudes gymnophobia*	"
17	*Halmyrapseudes killaiyensis*	"
18	*Ligia exotica*	Isopods
19	*Cirolana fluviatilis*	"
20	*Sphaeroma terebrans*	"
21	*Sphaeroma annandalei*	"
22	*Pavacalliope* sp.	Amphipoda
23	*Grandidierella* sp.	"
24	*Corophium triacnonyx*	"
25	*Talorchestia* sp.	"
26	*Scylla serrata*	"
27	*Scylla tranguebarica*	"
28	*Thalamita crenata*	"

Source : Data collected by KFRI

Appendix 3.5.3.3. Fresh Water Phytoplanktons of GKR

1	Anabaena	Cyanophyceae
2	Microcysts	"
3	Oscillatoria	"
4	Synechococcus	"
5	Pediastrum	Chlorophyceae/Desmidaceae
6	Ankistrodesmus	"
7	Chlamydomonas	"
8	Xanthidium	"
9	Botryococcs	"
10	Microspora	"
11	Chlorella	"
12	Monostroma	"
11	Closterium	"
12	Treubaria	"
13	Cosmarium	"
14	Oosystis	"
15	Scenedesmus	"
16	Staurastrum	"
17	Tetraedron	"
18	Ulothrix	"
19	Bacillariophyceae	"
20	Amphiphera	"
21	Cyclotella	Asterionella
22	Diatoma	"
23	Fragillaria	"
24	Nitzschia	"
25	Melosira	"
26	Stephanodiscus	"
27	Synedra	"
28	Tabellaria	"
29	Pinnularia	Pyrrophyta
30	Gaunyaulax	"
31	Peridinium	"
32	Dinobryon	Chrysophyta
33	Chromulina	"
34	Mallomonas	"
35	Uroglena	"

Source : Data collected by KFRI

Appendix 3.5.3.4 : Fresh water fishes of GKR

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
1.	*Amblypharyngodon melettinus (Val.)*		✓	✓		✓	✓
2.	*Amblypharyngodon melettina (Val.)*						✓
3.	*Anabas testudienus*		✓	✓		✓	
4.	*Anguilla bengalensis bengalensis*	✓	✓	✓	✓		✓
5.	*Anguilla bicolar bicolar*	✓	✓	✓	✓		
6.	*Aplocheilus sp.*				✓		
7.	*Aplocheilus lineatus (Bloch)*	✓	✓	✓		✓	✓
8.	*Aplocheilus panchax*		✓	✓		✓	
9.	*Arius caelatus*		✓	✓		✓	
10.	*Baiasio travancoria (Hora and Law)*		✓	✓			✓
11.	*Barbodes carnaticus*			✓			
12.	*Barbodes sarana subnasutus*			✓			
13.	*Barilius bakeri (Day)*	✓	✓	✓	✓		
14.	*Barilius bendelisis*	✓	✓	✓			
15.	*Barilius gatensis (Val.)*	✓	✓	✓			✓
16.	*Bhavania australis (Jerdon)*	✓	✓	✓			
17.	*Caranax sangum*				✓		
18.	*Crossocheilus periyarensis*	✓					
19.	*Caranax carangus*		✓	✓		✓	
20.	*Catla catla*		✓	✓		✓	
21.	*Channa gachua*	✓			✓		
22.	*Channa marulius Ham.*	✓	✓	✓	✓	✓	✓
23.	*Channa orientalis (Schneider)*		✓	✓	✓	✓	✓
24.	*Channa striatus (Bloch)*	✓	✓	✓		✓	✓
25.	*Chanda thomassi*						✓
26.	*Cirrhinus mrigala*		✓	✓		✓	
27.	*Clarias batrachus*		✓	✓	✓	✓	
28.	*Clarias dussumieri dussumieri*	✓					✓
29.	*Cyprinus carpio communis*	✓	✓	✓			✓
30.	*Danio aequipinnatus*	✓			✓		
31.	*Danio malabaricus (Jerdon)*		✓	✓		✓	✓
32.	*Dayella malabarica*		✓	✓		✓	
33.	*Eeuryglossa orientalis*			✓			
34.	*Esomus danricus (Ham. & Buch.)*		✓	✓		✓	✓
35.	*Etroplus maculatus (Bloch)*		✓	✓	✓	✓	✓
36.	*Etroplus suratensis (Bloch)*		✓	✓	✓	✓	✓
37.	*Garra gotyla stenorhynchus (Jerdon)*		✓	✓			
38.	*Garra lamta*			✓			
39.	*Garra mcClellandi (Jerdon)*	✓	✓	✓			
40.	*Garra mullya (Sykes)*	✓	✓	✓	✓		✓
41.	*Garra surendranathinii*	✓	✓	✓			

Contd...

Appendix 3.5.3.4 Contd...

Sr. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
42.	*Gerres filamentosus*		✓	✓		✓	
43.	*Glossogobius giuris giuris* (Ham.)		✓	✓	✓	✓	✓
44.	*Glyptothorax annadalei*	✓					
45.	*Glyptothorax madraspatanum* (Day)	✓	✓	✓	✓		
46.	*Heterophneustes fossilis* (Bloch)	✓	✓	✓		✓	✓
47.	*Homaloptera* sp.		✓	✓			
48.	*Horabagrus brachysoma* (Guenther)		✓	✓		✓	
49.	*Horabagrus nigricollaris*			✓			
50.	*Horadandia attukorali britani*					✓	
51.	*Horaglanis krishnai*		✓				
52.	*Hyporhamphus limbatus i(Val.)*	✓	✓	✓	✓	✓	✓
53.	*Hypselobarbus curmuca*	✓	✓	✓			
54.	*Hypselobarbus jerdoni*		✓	✓			
55.	*Hypselobarbus kolus*		✓	✓			
56.	*Hypselobarbus kurali*	✓	✓	✓			
57.	*Hypselobarbus micropogon*			✓			
58.	*Hypselobarbus pulchellus*			✓			
59.	*Hypselobarbus thomassi*			✓			
60.	*Labeo calbasu*			✓			
61.	*Labeo rohita* (Ham.)		✓	✓			
62.	*Lepidocephalus thermalis*	✓	✓	✓		✓	✓
63.	*Lepidocephalus typus* (Raj)	✓					
64.	*Lutjanus argentimaculatus*		✓	✓		✓	
65.	*Macrognathus guentheri*		✓	✓	✓		
66.	*Macropodus cupanus* (Val.)		✓	✓		✓	✓
67.	*Macrospinosa cuja*		✓	✓		✓	
68.	*Mugil cephalus*		✓	✓		✓	
69.	*Mastacembelus armatus armatus*	✓	✓	✓	✓		✓
70.	*Mystus armatus* (Day)		✓	✓			
71.	*Mystus cavasius* (Ham.)			✓		✓	
72.	*Mystus gulio*		✓	✓		✓	
73.	*Mystus malabaricus* (Jerdon)		✓	✓			
74.	*Mystus montanus* (Jerdon)		✓	✓			
75.	*Mystus oculatus* (Val.)		✓	✓	✓	✓	✓
76.	*Mystus vittatus*		✓	✓	✓	✓	
77.	*Nandus nandus* (Ham)		✓	✓		✓	
78.	*Neomacheilus guentheri* (Day)	✓	✓	✓			
79.	*Noemacheilus keralaiensis*	✓					
80.	*Noemacheilus menni*	✓					
81.	*Noemacheilus triangularis* (Day)	✓	✓	✓			✓
82.	*Ompok bimaculatus (Bloch)*	✓	✓	✓	✓	✓	✓
83.	*Ophisternon bengalense*			✓			
84.	*Oreochromis mossambica* (Peters)	✓	✓	✓		✓	

Contd...

Appendix 3.5.3.4 Contd...

Sl. No.	Scientific name	Idukki	Kottayam	Thrissur	Pathanamthitta	Alapuzha	Ernakulam
85.	*Osteobrama bakeri (Day)*		✓	✓			
86.	*Osteocheilichthys longidorslis (Pethiyagoda and Kottelat)*			✓			
87.	*Osteocheilichthys nashii (Day)*						✓
88.	*Osteocheilichthys thomassi*			✓			
89.	*Parambassis dayi*		✓	✓		✓	
90.	*Parambassis gymnocephalus*				✓		
91.	*Parambassis thomassi (Day)*		✓	✓		✓	
92.	*Parlusciosoma daniconius (Ham.)*		✓	✓		✓	
93.	*Pristolepis marginatus (Jerdon)*		✓	✓			✓
94.	*Pristolepis malabarica*				✓		
95.	*Pseudobagras chryseus*			✓			
96.	*Psidnophis boro*	✓					
97.	*Puntius amphibius (Val.)*	✓			✓		✓
98.	*Puntius bimaculatus (Bleeker.)*			✓			
99.	*Puntius chola (Ham.)*		✓	✓			
100.	*Puntius conchonius (Ham.)*			✓			
101.	*Puntius denisonii (Day)*		✓	✓			
102.	*Puntius dorsalis*			✓			
103.	*Puntius filamentosus (Val.)*	✓	✓	✓	✓	✓	✓
104.	*Puntius melanampyx (Day.)*	✓	✓	✓	✓	✓	✓
105.	*Puntius melanostigma (Day)*			✓		✓	
106.	*Puntius ophiocephalus (Raj)*	✓					
107.	*Puntius parrah*		✓	✓		✓	
108.	*Puntius sarana subnasutus*		✓		✓	✓	✓
109.	*Puntius ticto punctatus (Day)*		✓	✓		✓	
110.	*Puntius ticto ticto (Ham. & Buch.)*	✓	✓	✓		✓	✓
111.	*Puntius vittatus (Day)*	✓	✓	✓	✓	✓	✓
112.	*Rasbora daniconius danconius*	✓			✓		✓
113.	*Sactophagus argus*		✓	✓		✓	
114.	*Salmostoma boopsis (Day)*		✓	✓	✓		✓
115.	*Sicyopterus griseus (Day)*		✓	✓		✓	
116.	*Terapon jarbua*		✓	✓		✓	
117.	*Tetradon travancoricus (Hora & Nair)*		✓	✓	✓	✓	✓
118.	*Tilapia mossambica Peters*						✓
119.	*Tor khudree (Sykes)*	✓	✓	✓			
120.	*Travancorica elongata*			✓			
121.	*Travancorica jonesi*	✓		✓			
122.	*Wallago attu (Schneider)*		✓	✓		✓	✓
123.	*Xenentodon cancila (Ham.)*	✓	✓	✓	✓	✓	✓

Source : Data collected by KFRI

Appendix 3.5.3.5 : Endemic, Rare and Endangered Fresh Water Fishes of GKR

Sr. No.	Species	Status
1	*Labeo dussumieri*	Endangered
2	*Tor khudree malabaricus*	"
3	*Horabagrus brachysoma*	"
4	*Puntius curmuca*	"
5	*P. denisonii*	"
6	*P. melanampyx*	"
7	*Wallago attu*	Vulnerable
8	*Ompok bimaculatus*	"
9	*Mystus malabaricus*	"
10	*M. keletius*	"
11	*M. montanus*	"
12	*M. oculatus*	"
13	*Pristolepis malabaricus*	"
14	*Nandus nandus*	"
15	*Ambassis thomassi*	"
16	*Dayella malabarica*	"
17	*Lepidophygopsis*	Rare and endemic
18	*Travancoria jonesi*	"
19	*Glyptothorax madraspatnam*	"
20	*G. housei*	"
21	*Homoloptera montana*	"
22	*Neocheilus triangularis*	"
23	*Botasio travancoria*	"
24	*Basilus bakeri*	"

Source : Data collected by NIO

Annexure 3.6.3.1 : Panchayt-wise Comparison of the Quality of Life Indices

Id_Code	Panchayath / Municipality	Block	Accessibility	FAF	QOL (S)	QOL (O)	QOL (C)
Alappuzha District							
1010090	Ambalapuzha	Ambalapuzha	0.880	0.034	0.619	0.582	0.601
1020090	Punnapra	Ambalapuzha	0.900	0.043	0.667	0.598	0.633
1030048	Purakkad.	Ambalapuzha	0.880	0.034	0.639	0.594	0.617
1040046	Aryad	Aryad	0.720	0.014	0.716	0.560	0.638
1050093	Mannanchery	Aryad	0.740	0.024	0.704	0.568	0.636
1060096	Mararikulam South	Aryad	0.740	0.047	0.705	0.582	0.644
1070036	Chambakulam	Chambakulam	0.830	0.045	0.611	0.589	0.600
1080042	Edathwa	Chambakulam	0.730	0.028	0.557	0.540	0.549
1090040	Kainakari	Chambakulam	0.800	0.020	0.501	0.548	0.525
1100042	Nedumudi	Chambakulam	0.800	0.043	0.707	0.595	0.651
1110038	Thakazhy	Chambakulam	0.780	0.066	0.908	0.584	0.746
1120046	Thalavady	Chambakulam	0.760	0.080	0.642	0.580	0.611
1130036	Ala	Chengannur	0.550	0.040	0.643	0.579	0.611
1140042	Budhanoor	Chengannur	0.760	0.050	0.708	0.521	0.615
1150044	Cheriyanad	Chengannur	0.780	0.093	0.694	0.571	0.633
1160050	Mannar	Chengannur	0.830	0.029	0.629	0.527	0.578
1170054	Mulakuzha	Chengannur	0.580	0.041	0.621	0.533	0.577
1180032	Pandanad	Chengannur	0.680	0.121	0.705	0.587	0.646
1190038	Puliyoor	Chengannur	0.820	0.112	0.758	0.573	0.666
1200036	Thiruvanvandoor	Chengannur	0.830	0.032	0.710	0.564	0.637
1210044	Venmani	Chengannur	0.730	0.029	0.695	0.538	0.616
1220032	Cheruthana	Haripad	0.550	0.026	0.593	0.550	0.572
1230038	Chingoli	Haripad	0.800	0.072	0.626	0.561	0.594
1240034	Haripad	Haripad	0.810	0.064	0.644	0.580	0.612
1250040	Karthikapally	Haripad	0.830	0.076	0.743	0.615	0.679
1260044	Karuvatta	Haripad	0.680	0.031	0.473	0.508	0.491
1270042	Kumarapuram	Haripad	0.810	0.096	0.834	0.597	0.716
1280044	Pallippad	Haripad	0.870	0.042	0.624	0.558	0.591
1290044	Trikkunnapuzha	Haripad	0.750	0.037	0.675	0.544	0.610
1300032	Veeyapuram	Haripad	0.720	0.031	0.604	0.569	0.587
1310078	Cherthala South	Kanjikuzhi	0.700	0.027	0.693	0.584	0.639
1320050	Kanjikuzhi	Kanjikuzhi	0.790	0.044	0.706	0.610	0.658
1330050	Mararikulam(N)	Kanjikuzhi	0.680	0.035	0.725	0.583	0.654
1340048	Muhamma	Kanjikuzhi	0.750	0.032	0.727	0.629	0.678
1350093	Thanneermukkom	Kanjikuzhi	0.740	0.035	0.690	0.593	0.642
1360054	Chennithala Tripperumthura	Mavelikkara	0.610	0.062	0.740	0.593	0.686
1370084	Chettikulangara	Mavelikkara	0.640	0.066	0.690	0.537	0.638
1380054	Mavelikkara-Thekkekara	Mavelikkara	0.680	0.043	0.670	0.572	0.643
1390087	Thazhakkara	Mavelikkara	0.680	0.055	0.640	0.598	0.651
1400072	Aroor	Pattanakkad	0.830	0.044	0.653	0.556	0.605

Contd...

Annexure 3.6.3.1. Contd...

Id_Code	Panchayath / Municipality	Block	Accessibility	FAF	QOL (s)	QOL (o)	QOL (c)
1410046	Ezhupunna	Pattanakkad	0.770	0.093	0.867	0.583	0.726
1420038	Kadakkarapilly	Pattanakkad	0.810	0.053	0.917	0.624	0.771
1430036	Kodanthuruth	Pattanakkad	0.780	0.086	0.756	0.576	0.666
1440042	Kuthiyathode	Pattanakkad	0.780	0.037	0.715	0.543	0.629
1450048	Pattanakkad	Pattanakkad	0.810	0.029	0.819	0.570	0.695
1460048	Thuravur	Pattanakkad	0.740	0.035	0.741	0.570	0.655
1470046	Vayalar	Pattanakkad	0.760	0.043	0.647	0.579	0.613
1480032	Arookutty	Thykattusery	0.760	0.038	0.873	0.550	0.712
1490046	Chennam Pallippuram	Thykattusery	0.790	0.029	0.856	0.545	0.701
1500046	Panavally	Thykattusery	0.850	0.047	0.849	0.564	0.707
1510022	Perumbalam	Thykattusery	0.770	0.025	0.890	0.561	0.726
1520044	Thykattusery	Thykattusery	0.870	0.036	0.853	0.563	0.708
1530036	Kavalam	Veliyanad	0.730	0.014	0.410	0.508	0.459
1540026	Muttar	Veliyanad	0.780	0.033	0.601	0.569	0.585
1550034	Neelamperoor	Veliyanad	0.750	0.039	0.692	0.621	0.657
1560034	Ramankari	Veliyanad	0.820	0.030	0.601	0.571	0.586
1570042	Pulimkunnu	Veliyanad	0.820	0.018	0.537	0.505	0.521
1580032	Veliyanad	Veliyanad	0.830	0.016	0.523	0.517	0.520
1590343	Alappuzha Muni.		0.890	0.051	0.667	0.600	0.634
1600052	Chengannur Muni.		0.810	0.095	0.700	0.628	0.664
1610090	Cherthala Muni.		0.760	0.064	0.657	0.582	0.619
1620126	Kayamkulam Muni.		0.860	0.108	0.773	0.583	0.678
1630056	Mavelikara Muni.		0.730	0.142	0.768	0.653	0.711
Ernakulam District							
2010050	Alangad	Alangad	0.730	0.036	0.686	0.572	0.629
2020081	Eloor	Alangad	0.810	0.133	0.730	0.595	0.662
2030048	Kadungalloor	Alangad	0.760	0.075	0.704	0.597	0.651
2040046	Karumalloor	Alangad	0.810	0.032	0.734	0.589	0.662
2050044	Varapuzha	Alangad	0.740	0.065	0.688	0.599	0.644
2060038	Ayyampuzha	Angamali	0.670	0.038	0.734	0.600	0.667
2070044	Kaladi	Angamali	0.740	0.130	0.713	0.618	0.666
2080038	Kanjoor	Angamali	0.830	0.079	0.753	0.615	0.684
2090044	Karukutty	Angamali	0.780	0.104	0.755	0.601	0.678
2100046	Malayattoor-Neeleswaram	Angamali	0.770	0.048	0.772	0.630	0.701
2110036	Manjapra	Angamali	0.740	0.051	0.785	0.581	0.683
2120038	Mookannur	Angamali	0.730	0.119	0.768	0.602	0.685
2130042	Sreemoolanagaram	Angamali	0.750	0.051	0.734	0.575	0.655
2140038	Thuravur	Angamali	0.830	0.055	0.778	0.585	0.682
2150042	Cheranelloor	Edappally	0.710	0.029	0.699	0.581	0.640
2160030	Kadamakkudy	Edappally	0.760	0.023	0.504	0.572	0.539
2170105	Thrikkakara	Edappally	0.690	0.045	0.724	0.599	0.661
2180036	Asamanoor	Koovappady	0.700	0.059	0.731	0.569	0.650
2190099	Koovappady	Koovappady	0.790	0.051	0.744	0.586	0.665
2200036	Mudakuzha	Koovappady	0.750	0.059	0.759	0.596	0.678

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Annexure 3.6.3.1. Contd...

Id_Code	Panchayath / Municipality	Block	Accessibility	FAF	QOL (s)	QOL (o)	QOL (c)
2210052	Rayamangalam	Koovappady	0.740	0.113	0.759	0.611	0.685
2220044	Vengoor	Koovappady	0.680	0.057	0.764	0.613	0.689
2230050	Kavalangad	Kothamangalam	0.780	0.093	0.697	0.589	0.643
2240034	Keerampara	Kothamangalam	0.750	0.046	0.677	0.597	0.637
2250036	Kottapady	Kothamangalam	0.740	0.083	0.638	0.642	0.640
2260052	Kuttampuzha	Kothamangalam	0.710	0.039	0.547	0.576	0.561
2270048	Nellikuzhi	Kothamangalam	0.700	0.058	0.657	0.567	0.613
2280032	Paingottur	Kothamangalam	0.690	0.044	0.695	0.579	0.637
2290026	Pallarimangalam	Kothamangalam	0.720	0.093	0.693	0.610	0.652
2300034	Pindimana	Kothamangalam	0.760	0.036	0.670	0.569	0.620
2310024	Pothanikkad	Kothamangalam	0.610	0.057	0.651	0.598	0.625
2320032	Varappetty	Kothamangalam	0.730	0.048	0.701	0.606	0.654
2330042	Amballoor	Mulanthuruthy	0.700	0.083	0.767	0.644	0.706
2340038	Chottanikkara	Mulanthuruthy	0.830	0.138	0.789	0.643	0.716
2350038	Edakkattuvayal	Mulanthuruthy	0.800	0.056	0.757	0.628	0.693
2360046	Mulanthuruthy	Mulanthuruthy	0.680	0.050	0.735	0.623	0.679
2370044	Thiruvankulam	Mulanthuruthy	0.780	0.059	0.753	0.642	0.698
2380046	Udayamperoor	Mulanthuruthy	0.740	0.071	0.767	0.644	0.706
2390032	Arakuzha	Moovatupuzha	0.680	0.109	0.613	0.608	0.611
2400034	Avoli	Moovatupuzha	0.730	0.057	0.641	0.594	0.618
2410038	Ayavana	Moovatupuzha	0.780	0.118	0.670	0.633	0.652
2420030	Kalloorkad	Moovatupuzha	0.730	0.087	0.607	0.557	0.582
2430034	Manjalloor	Moovatupuzha	0.830	0.045	0.620	0.599	0.610
2440034	Marady	Moovatupuzha	0.780	0.045	0.616	0.588	0.602
2450072	Paipra	Moovatupuzha	0.770	0.040	0.666	0.587	0.626
2460038	Valakam	Moovatupuzha	0.660	0.060	0.660	0.591	0.626
2470069	Chellanam	Palluruthy	0.780	0.039	0.440	0.584	0.512
2480042	Kumbalangi	Palluruthy	0.790	0.033	0.448	0.593	0.521
2490036	Elanji	Pambakuda	0.630	0.117	0.705	0.624	0.665
2500038	Koothattukulam	Pambakuda	0.690	0.116	0.719	0.629	0.675
2510036	Maneed	Pambakuda	0.680	0.031	0.735	0.584	0.660
2520034	Palakuzha	Pambakuda	0.680	0.112	0.673	0.601	0.637
2530040	Pampakuda	Pambakuda	0.710	0.136	0.728	0.627	0.677
2540046	Piravom	Pambakuda	0.730	0.062	0.759	0.601	0.680
2550038	Ramamangalam	Pambakuda	0.670	0.075	0.729	0.646	0.688
2560038	Thirumarady	Pambakuda	0.740	0.084	0.722	0.625	0.673
2570046	Chengamanad	Parakkadavu	0.780	0.046	0.739	0.565	0.652
2580038	Kunnukara	Parakkadavu	0.700	0.064	0.711	0.583	0.647
2590050	Nedumbassery	Parakkadavu	0.830	0.071	0.751	0.605	0.678
2600050	Parakadavu	Parakkadavu	0.700	0.042	0.736	0.561	0.649
2610046	Puthenvelikkara	Parakkadavu	0.690	0.032	0.737	0.538	0.638
2620048	Chendamangalam	Paravoor	0.710	0.033	0.684	0.590	0.637
2630044	Chittattukara	Paravoor	0.760	0.017	0.580	0.552	0.566
2640038	Ezhikkara	Paravoor	0.630	0.047	0.676	0.591	0.633
2650078	Kottuvalli	Paravoor	0.680	0.031	0.660	0.579	0.620

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Annexure 3.6.3.1. Contd...

Id_Code	Panchayath / Municipality	Block	Accessibility	FAF	QOL (s)	QOL (o)	QOL (c)
2660052	Vadakkekara	Paravoor	0.790	0.030	0.737	0.602	0.670
2670044	Aikkaranad	Vadavukode	0.710	0.092	0.717	0.643	0.680
2680046	Kunathunadu	Vadavukode	0.770	0.134	0.688	0.676	0.682
2690050	Mazhuvannur	Vadavukode	0.770	0.082	0.722	0.641	0.682
2700042	Poothrikka	Vadavukode	0.760	0.040	0.704	0.617	0.661
2710044	Thiruvaniyoor	Vadavukode	0.760	0.107	0.707	0.616	0.662
2720052	Vadavucodu	Vadavukode	0.730	0.167	0.701	0.674	0.687
2730046	Choornikkara	Vazhakkulam	0.790	0.096	0.752	0.607	0.680
2740048	Edathala	Vazhakkulam	0.740	0.047	0.740	0.577	0.659
2750048	Keezhmad	Vazhakkulam	0.760	0.072	0.761	0.584	0.673
2760048	Kizhakkambalam	Vazhakkulam	0.780	0.101	0.773	0.596	0.685
2770044	Vazhakkulam	Vazhakkulam	0.730	0.066	0.753	0.580	0.667
2780081	Vengola	Vazhakkulam	0.750	0.116	0.756	0.570	0.663
2790036	Edavanakkad	Vypin	0.780	0.023	0.627	0.575	0.601
2800090	Elamkunnapuzha	Vypin	0.840	0.033	0.641	0.595	0.618
2810030	Kuzhipilly	Vypin	0.730	0.028	0.602	0.573	0.588
2820042	Mulavukadu	Vypin	0.760	0.032	0.533	0.586	0.560
2830042	Nayarambalam	Vypin	0.820	0.043	0.614	0.587	0.600
2840044	Njarakkal	Vypin	0.760	0.023	0.674	0.590	0.633
2850084	Pallipuram	Vypin	0.770	0.039	0.571	0.588	0.580
2860042	Kumbalam	Vytila	0.850	0.042	0.475	0.605	0.540
2870078	Maradu	Vytila	0.850	0.067	0.472	0.619	0.546
2881130	Kochi Corporation		0.870	0.101	0.621	0.609	0.615
2890048	Aluva Municipality		0.890	0.280	0.748	0.636	0.692
2900066	Angamali (M)		0.750	0.091	0.737	0.598	0.668
2910102	Kalamasseri (M)		0.660	0.116	0.773	0.601	0.687
2920075	Kothamangalam (M)		0.830	0.056	0.670	0.572	0.621
2930056	Muvattupuzha (M)		0.730	0.081	0.658	0.614	0.636
2940056	Paravur Municipality		0.680	0.047	0.611	0.600	0.606
2950048	Perumbavoor (M)		0.860	0.129	0.776	0.631	0.703
2960096	Thripunithura (M)		0.800	0.090	0.480	0.610	0.545
Idukki District							
3010056	Adimali	Adimali	0.630	0.015	0.750	0.480	0.615
3020034	Byson Valley	Adimali	0.580	0.013	0.722	0.497	0.610
3030052	Konnathadi	Adimali	0.710	0.013	0.753	0.460	0.607
3040040	Pallivasal	Adimali	0.600	0.011	0.747	0.471	0.609
3050048	Vellathooval	Adimali	0.550	0.027	0.709	0.497	0.603
3060058	Elappara	Azhutha	0.660	0.011	0.774	0.574	0.674
3070032	Kokkayar	Azhutha	0.600	0.036	0.784	0.554	0.669
3080081	Kumily	Azhutha	0.690	0.042	0.789	0.591	0.690
3090054	Peerumedu	Azhutha	0.590	0.032	0.788	0.568	0.678
3100040	Peruvanthanam	Azhutha	0.720	0.012	0.740	0.544	0.642
3110102	Vandiperiyar	Azhutha	0.620	0.042	0.781	0.569	0.676
3120034	Chinnakanal	Devikulam	0.550	0.038	0.800	0.568	0.684

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Annexure 3.6.3.1. Contd...

Id_Code	Panchayath / Municipality	Block	Accessibility	FAF	QOL (s)	QOL (o)	QOL (c)
3130030	Kanthalloor	Devikulam	0.580	0.003	0.652	0.435	0.544
3140028	Marayur	Devikulam	0.580	0.010	0.705	0.468	0.586
3150174	Munnar	Devikulam	0.560	0.037	0.801	0.586	0.694
3160044	Santhampara	Devikulam	0.520	0.024	0.738	0.460	0.599
3170014	Vattavada	Devikulam	0.510	0.012	0.659	0.408	0.534
3180022	Alakkod	Elamdesam	0.690	0.076	0.653	0.605	0.629
3190040	Karimannur	Elamdesam	0.720	0.084	0.767	0.588	0.678
3200032	Kodikulam	Elamdesam	0.680	0.109	0.772	0.597	0.685
3210028	Kudayathoor	Elamdesam	0.740	0.036	0.663	0.580	0.622
3220048	Vannapuram	Elamdesam	0.780	0.049	0.765	0.616	0.691
3230042	Velliyamattom	Elamdesam	0.690	0.045	0.878	0.599	0.739
3240046	Udumbannur	Elamdesam	0.740	0.028	0.753	0.586	0.670
3250048	Arakulam	Idukki	0.670	0.052	0.766	0.616	0.691
3260056	Idukki-Kanjikuzhi	Idukki	0.630	0.004	0.553	0.484	0.519
3270042	Kamakshi	Idukki	0.690	0.024	0.765	0.600	0.683
3280032	Mariyapuram	Idukki	0.700	0.024	0.761	0.625	0.693
3290048	Wathikkudi	Idukki	0.760	0.038	0.757	0.613	0.685
3300044	Vazhathoppu	Idukki	0.700	0.050	0.770	0.622	0.696
3310038	Ayyappan Kovil	Kattappana	0.580	0.053	0.701	0.573	0.637
3320046	Chakkupallam	Kattappana	0.580	0.009	0.746	0.498	0.622
3330040	Erattayar	Kattappana	0.670	0.089	0.782	0.537	0.659
3340046	Kanchiyar	Kattappana	0.550	0.018	0.765	0.536	0.651
3350084	Kattappana	Kattappana	0.750	0.092	0.792	0.567	0.680
3360068	Upputhara	Kattappana	0.650	0.014	0.736	0.550	0.643
3370056	Vandanmedu	Kattappana	0.570	0.028	0.707	0.540	0.624
3380048	Karunapuram	Nedumkandam	0.600	0.015	0.753	0.508	0.631
3390093	Nedumkandam	Nedumkandam	0.720	0.011	0.745	0.453	0.599
3400042	Pambadumpara	Nedumkandam	0.630	0.017	0.767	0.498	0.633
3410036	Rajakkad	Nedumkandam	0.610	0.011	0.717	0.461	0.589
3420036	Rajakumari	Nedumkandam	0.680	0.025	0.760	0.517	0.638
3430034	Senapathy	Nedumkandam	0.540	0.063	0.754	0.545	0.649
3440044	Udumbanchola	Nedumkandam	0.500	0.034	0.795	0.523	0.660
3450026	Idavetti	Thodupuzha	0.770	0.048	0.778	0.618	0.699
3460030	Karimkunnam	Thodupuzha	0.780	0.041	0.789	0.624	0.706
3470030	Kumaramangalam	Thodupuzha	0.750	0.027	0.762	0.612	0.688
3480034	Manakkad	Thodupuzha	0.910	0.068	0.777	0.621	0.699
3490026	Muttam	Thodupuzha	0.730	0.057	0.773	0.624	0.699
3500030	Purapuzha	Thodupuzha	0.770	0.074	0.764	0.633	0.698
3510090	Thodupuzha (M)		0.830	0.075	0.724	0.603	0.664
Kottayam District							
4010044	Eerattupetta	Erattupetta	0.730	0.035	0.540	0.606	0.573
4020028	Melukavu	Erattupetta	0.680	0.053	0.848	0.600	0.724
4030024	Moonnilavu	Erattupetta	0.500	0.022	0.564	0.540	0.552
4040028	Poonjar	Erattupetta	0.590	0.123	0.725	0.619	0.672

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Annexure 3.6.3.1. Contd...

Id_Code	Panchayath / Municipality	Block	Accessibility	FAF	QOL (s)	QOL (o)	QOL (c)
4050040	Poonjar Thekkekara	Erattupetta	0.660	0.028	0.772	0.574	0.673
4060018	Thalanadu	Erattupetta	0.730	0.097	0.885	0.559	0.722
4070028	Thalapulam	Erattupetta	0.790	0.048	0.539	0.597	0.569
4080040	Thidanadu	Erattupetta	0.680	0.148	0.649	0.619	0.634
4090026	Thikkoi	Erattupetta	0.580	0.045	0.675	0.529	0.602
4100044	Aarpookkara	Ettumanur	0.880	0.031	0.621	0.563	0.593
4110075	Athirampuzha	Ettumanur	0.880	0.057	0.692	0.589	0.641
4120078	Aymanam	Ettumanur	0.820	0.061	0.719	0.601	0.660
4130087	Ettumanur	Ettumanur	0.880	0.052	0.694	0.612	0.654
4140081	Kumaranallur	Ettumanur	0.890	0.124	0.728	0.599	0.664
4150038	Neendur	Ettumanur	0.870	0.129	0.681	0.601	0.641
4160048	Kaduthuruthy	Kaduthuruthy	0.700	0.075	0.793	0.578	0.685
4170034	Kallara	Kaduthuruthy	0.730	0.018	0.782	0.568	0.675
4180044	Manjoor	Kaduthuruthy	0.610	0.041	0.738	0.567	0.653
4190044	Mulakkulam	Kaduthuruthy	0.830	0.053	0.747	0.574	0.661
4200038	Njeezhur	Kaduthuruthy	0.640	0.026	0.732	0.607	0.670
4210040	Thalayolaparambu	Kaduthuruthy	0.710	0.024	0.490	0.514	0.502
4220046	Velloor	Kaduthuruthy	0.860	0.055	0.690	0.585	0.638
4230087	Erumeli	Kanjirappally	0.650	0.055	0.786	0.592	0.689
4240075	Kanjirappally	Kanjirappally	0.730	0.094	0.744	0.598	0.672
4250036	Koottickal	Kanjirappally	0.530	0.007	0.563	0.483	0.523
4260040	Manimala	Kanjirappally	0.590	0.027	0.729	0.516	0.623
4270099	Mundakayam	Kanjirappally	0.700	0.057	0.712	0.583	0.647
4280048	Parathod	Kanjirappally	0.640	0.062	0.725	0.522	0.624
4290032	Bharananganam	Lalam	0.890	0.052	0.782	0.559	0.670
4300038	Kadanad	Lalam	0.670	0.093	0.663	0.573	0.618
4310040	Karoor	Lalam	0.670	0.086	0.712	0.600	0.656
4320030	Kozhuvanal	Lalam	0.700	0.109	0.578	0.578	0.578
4330034	Meenachil	Lalam	0.810	0.124	0.782	0.580	0.681
4340032	Mutholi	Lalam	0.780	0.058	0.779	0.573	0.677
4350042	Karukachal	Madappally	0.710	0.032	0.641	0.549	0.595
4360050	Kurichi	Madappally	0.730	0.053	0.777	0.624	0.701
4370050	Madappally	Madappally	0.770	0.041	0.730	0.583	0.657
4380042	Paippad	Madappally	0.690	0.071	0.697	0.583	0.640
4390046	Thrikkodithanam	Madappally	0.670	0.068	0.749	0.600	0.674
4400054	Vakathanam	Madappally	0.730	0.052	0.718	0.594	0.656
4410050	Vazhapalli	Madappally	0.700	0.067	0.696	0.599	0.648
4420052	Ayarkunnam	Pallam	0.790	0.047	0.760	0.562	0.661
4430046	Kumarakam	Pallam	0.630	0.037	0.720	0.575	0.648
4440087	Nattakom	Pallam	0.860	0.066	0.733	0.549	0.641
4450087	Panachikkad	Pallam	0.790	0.065	0.768	0.571	0.670
4460052	Puthupally	Pallam	0.680	0.093	0.765	0.567	0.666
4470050	Thiruvarp	Pallam	0.760	0.091	0.763	0.596	0.680
4480102	Vijayapuram	Pallam	0.690	0.094	0.771	0.528	0.650

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Annexure 3.6.3.1. Contd...

Id_Code	Panchayath / Municipality	Block	Accessibility	FAF	QOL (s)	QOL (o)	QOL (c)
4490038	Akalakunnam	Pambady	0.700	0.025	0.632	0.543	0.588
4500044	Elikkulam	Pambady	0.710	0.134	0.584	0.599	0.592
4510048	Kooroppada	Pambady	0.750	0.071	0.518	0.537	0.528
4520030	Meenadam	Pambady	0.690	0.077	0.718	0.532	0.626
4530036	Pallikkathodu	Pambady	0.730	0.039	0.441	0.500	0.471
4540052	Pampady	Pambady	0.680	0.060	0.631	0.545	0.588
4550030	Kadaplamattam	Uzhavur	0.790	0.044	0.762	0.562	0.662
4560040	Kanakkary	Uzhavur	0.830	0.118	0.751	0.598	0.675
4570040	Kidangoor	Uzhavur	0.800	0.133	0.833	0.606	0.720
4580036	Kuruvilangad	Uzhavur	0.740	0.061	0.691	0.583	0.637
4590036	Marangattupilly	Uzhavur	0.680	0.057	0.681	0.588	0.635
4600046	Ramapuram	Uzhavur	0.700	0.076	0.640	0.566	0.603
4610034	Uzhavur	Uzhavur	0.740	0.124	0.635	0.601	0.618
4620030	Veliyannur	Uzhavur	0.780	0.063	0.606	0.588	0.597
4630054	Chirakkadav	Vazhur	0.720	0.098	0.692	0.600	0.646
4640044	Kangazha	Vazhur	0.600	0.068	0.726	0.574	0.650
4650042	Nedumkunnam	Vazhur	0.630	0.108	0.715	0.599	0.657
4660034	Vazhoor	Vazhur	0.720	0.098	0.717	0.598	0.658
4670052	Vellavoor	Vazhur	0.730	0.048	0.724	0.585	0.655
4680040	Chembu	Vaikom	0.850	0.037	0.538	0.575	0.557
4690042	Maravanthuruth	Vaikom	0.840	0.029	0.540	0.549	0.544
4700038	Thalayalam	Vaikom	0.890	0.044	0.515	0.559	0.538
4710040	Tv Puram	Vaikom	0.890	0.047	0.566	0.564	0.565
4720044	Udayanapuram	Vaikom	0.860	0.053	0.522	0.547	0.535
4730036	Vechoor	Vaikom	0.830	0.050	0.573	0.576	0.575
4740096	Changanasseri (M)		0.810	0.128	0.732	0.604	0.668
4750120	Kottayam (M)		0.830	0.129	0.750	0.625	0.687
4760044	Pala (M)		0.710	0.074	0.777	0.592	0.685
4770044	Vaikom (M)		0.860	0.071	0.612	0.577	0.595
Pathanamthitta District							
5010042	Chennerkara	Ilanthur	0.610	0.045	0.540	0.569	0.555
5020036	Cherukol	Ilanthur	0.630	0.035	0.506	0.540	0.523
5030038	Ilanthur	Ilanthur	0.680	0.049	0.518	0.530	0.524
5040040	Omallur	Ilanthur	0.590	0.054	0.479	0.505	0.492
5050036	Kozhanchery	Ilanthur	0.660	0.059	0.512	0.530	0.521
5060032	Mallapuzhassery	Ilanthur	0.630	0.053	0.510	0.526	0.518
5070042	Naranganam	Ilanthur	0.580	0.053	0.545	0.547	0.546
5080050	Aruvapulam	Konny	0.730	0.044	0.609	0.572	0.591
5090056	Konni	Konny	0.640	0.037	0.537	0.542	0.540
5100044	Malayalapuzha	Konny	0.730	0.055	0.597	0.536	0.567
5110028	Mylapra	Konny	0.640	0.178	0.676	0.567	0.622
5120062	Pramadam	Konny	0.740	0.055	0.640	0.546	0.593

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Annexure 3.6.3.1. Contd...

Id_Code	Panchayath / Municipality	Block	Accessibility	FAF	QOL (s)	QOL (o)	QOL (c)
5130038	Thannithod	Konny	0.530	0.028	0.454	0.517	0.486
5140046	Vallikode	Konny	0.700	0.040	0.676	0.556	0.616
5150050	Ayroor	Koipram	0.700	0.128	0.891	0.599	0.745
5160046	Ezhumattoor	Koipram	0.630	0.082	0.729	0.570	0.650
5170048	Iraviperoor	Koipram	0.650	0.088	0.790	0.588	0.689
5180050	Koyipram	Koipram	0.690	0.109	0.889	0.596	0.743
5190038	Puramattam	Koipram	0.610	0.099	0.724	0.584	0.654
5200038	Thottapuzhassery	Koipram	0.810	0.069	0.786	0.525	0.656
5210052	Aranmula	Kulanada	0.630	0.108	0.627	0.584	0.606
5220052	Kulanada	Kulanada	0.600	0.054	0.532	0.521	0.527
5230042	Mezhuvely	Kulanada	0.710	0.111	0.611	0.584	0.598
5240038	Anikkad	Mallappally	0.680	0.058	0.885	0.589	0.737
5250042	Kalloopara	Mallappally	0.790	0.141	0.561	0.618	0.590
5260038	Kaviyoor	Mallappally	0.790	0.144	0.726	0.559	0.642
5270040	Kottanad	Mallappally	0.640	0.033	0.632	0.520	0.576
5280038	Kottangal	Mallappally	0.690	0.060	0.827	0.548	0.688
5290044	Kunnamthanam	Mallappally	0.700	0.096	0.849	0.567	0.708
5300042	Mallappally	Mallappally	0.760	0.204	0.720	0.630	0.675
5310046	Kadapra	Pulikkeezhu	0.750	0.097	0.967	0.597	0.783
5320044	Kuttur	Pulikkeezhu	0.660	0.096	0.853	0.608	0.731
5330034	Nedumpram	Pulikkeezhu	0.630	0.060	0.756	0.561	0.659
5340034	Niranam	Pulikkeezhu	0.620	0.106	0.837	0.602	0.720
5350046	Peringara	Pulikkeezhu	0.670	0.086	0.808	0.565	0.687
5370044	Chittar	Ranni	0.550	0.062	0.537	0.513	0.525
5380038	Naranamuzhi	Ranni	0.590	0.010	0.487	0.497	0.493
5390040	Ranni	Ranni	0.630	0.082	0.611	0.555	0.583
5400038	Ranni_Angadi	Ranni	0.670	0.072	0.683	0.584	0.634
5410048	Ranni-Pazhavangady	Ranni	0.700	0.125	0.687	0.571	0.629
5420050	Ranni-Perinad	Ranni	0.610	0.024	0.628	0.531	0.580
5430046	Seethathod	Ranni	0.490	0.011	0.516	0.504	0.510
5440048	Vadasserikara	Ranni	0.560	0.024	0.446	0.466	0.456
5450044	Vechuchira	Ranni	0.610	0.058	0.650	0.547	0.599
5460075	Pathanamthitta (M)		0.750	0.141	0.747	0.611	0.679
5470102	Thiruvalla (M)		0.760	0.157	0.824	0.614	0.719
Thrissur District							
6010044	Kadukutty	Chalakkudy	0.780	0.071	0.750	0.594	0.672
6020052	Koratty	Chalakkudy	0.820	0.119	0.770	0.598	0.684
6030048	Meloor	Chalakkudy	0.750	0.138	0.766	0.624	0.695

Source : Indices estimated by KSSP