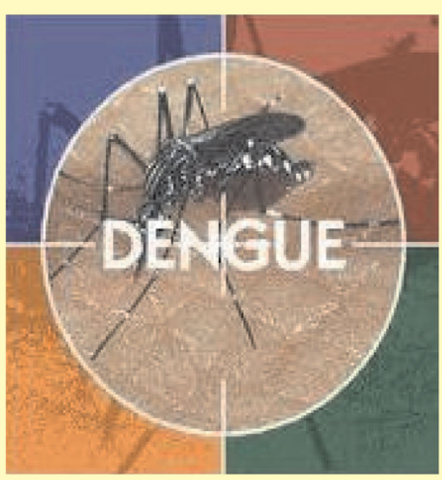
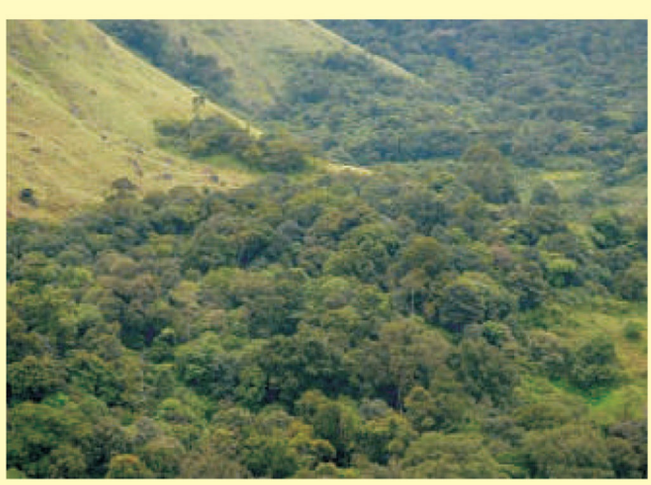
KERALA STATE ACTION PLAN ON CLIMATE CHANGE





Government of Kerala

Department of Environment and Climate Change

August -2014

Response to climate change: Strategy and Action in Kerala

Background

Climate change poses an emerging challenge to sustainability of social and economic development, livelihoods, and environmental management across the globe. The rise in Green House Gases (GHGs) in the atmosphere causes rise in temperature which in turn leads to unpredictable weather including flash floods and drought, and rise in sea level. So far as India is considered, the country is highly vulnerable to climate change because of high physical exposure to climate related disasters (65% is drought prone, 12% is flood prone, 8% susceptible to cyclones) and also the India' economy and population depends on climate sensitive sectors like agriculture, forests, tourism and fisheries.

The concern on climate change has caught intense focus after the publication of Fourth Assessment Report (AR4) of the Inter-Governmental Panel on Climate Change and when post Kyoto strategy became the agenda for discussions in the Conferences of Parties for UNFCC. India had started its work on action plan in 2007 and the National Action Plan for Climate Change (NAPCC) was released in October 2008. The NAPCC sets eight National Missions to respond climate change; these include National Mission on Solar Energy, Enhanced Energy Efficiency, Sustainable Agriculture, Sustainable Habitat, Water, Sustaining Himalayan Eco-System, Green India Mission and Strategic Knowledge for climate change covering range of actions including adaptation and mitigations. The principles adopted for the NAPCC include achieving sustainable development path while advancing economic and environmental objectives. The following points form the basis of the national strategy.

1. Protecting the poor and vulnerable sections of society through an inclusive and sustainable development strategy, sensitive to climate change.

2. Achieving national growth objectives through a qualitative change in direction that enhances ecological sustainability, leading to further mitigation of GHG emissions.

3. Devising efficient and cost effective strategies for end use Demand Side Management.

4. Deploying appropriate technologies both for adaptation and mitigation of GHG emissions extensively as well as at an accelerated pace.

5. Engineering new and innovative market, regulatory and voluntary mechanisms to promote sustainable development.

6. Effecting implementation of programmes through unique linkages including with civil society and local government institutions and through public private partnerships.

7. Welcoming international cooperation for research, development, sharing and transfer of technologies enabled by additional funding and a global IPR regime that enables technology transfer to developing countries under UNFCCC.

Thus in essence the NAPCC provides for measures to promote our development objectives with co-benefits for addressing climate change effectively (NAPCC, 2008).

The Kerala Context

With the formulation of a national policy on climate change, it has become imperative to achieve coherence between the strategies and actions at national and state levels. Adaptation challenges are experienced most acutely at the state level. The demographic, socio-economic and physiographic situations in the states determine the specific vulnerabilities of their economies towards climate change and in such circumstances, it is imperative to work on the precautionary and anticipatory measures for facing the expected changes and adapting to the changes in the long term. At the same time it is also important to work on our environment in a manner that the shocks of changes are not able to alter the circumstances rapidly and there is sufficient time and scope to adopt appropriate adaptive mechanisms to suit the changes. Thus the preparation of State Action Plans for Climate Change (SAPCC) should be consistent with the broad objectives of the NAPCC and result in a set of sectorial activities and programmes that will take into account state level variations, geographical specificities and socio-economic considerations.

In the view of the above requirement, Government of Kerala has been working on a strategy for action in the state in response to Climate Change. It is proposed to identify specific vulnerabilities and plan appropriate responses keeping those in focus. As the foremost impact of the changing climatic pattern relates to the land and water resources, a system for monitoring will be the first imperative. Further, the information at global as well as local level would be needed to be analyzed for any strategy. This will essentially include assessment of efficiency of the present development strategies in this context and probable mid-course corrections wherever found necessary. In the formulation of SAPCC, impact of climate change, assessment of vulnerability, identification, prioritization and financing of adaptation/mitigation options are being dealt with. Thus the SAPCC will build on the existing policies of the state government by taking into consideration the ongoing programmes and schemes

being implemented at the state level as well as the NAPCC. The SAPCC will have to be integrated into the state level planning process so that the resource allocation of the implementation of identified adaptation measures can be made with the objective to achieve the development goals of the state government. Adaptation is a key part of Kerala State Action Plan on Climate Change and it is about taking action now to protect state from the challenges caused by a changing climate.

Vision Mission and Strategy address Climate Change in Kerala

The Kerala State Action Plan on Climate Change developed by the Department of Environment and Climate Change, Government of Kerala aims to address negative consequences of climate change and thus reduce risk associated with it. It also envisaged climate change strategies need to be integrated development planning process in the state

Vision

Placing the climate change concerns at the forefront of sustainable development and for maintaining the quality of life of the people of the State

Mission

- Mainstream climate change strategies into State Level Planning and Development Process.
- Address state specific priority issues with respect of NAPCC.
- Safeguard natural resource of the state from climate change impacts.
- Address the existing as well as future climate change impacts and reduce the associated risk of the state.

Strategy

- Sustainable Management Activities.
- Promote Research and Development Activities.
- Policy Reforms.
- Capacity Building and Strengthening.

SECTION 1

SECTION 2

SECTION 1

The section provides an insight into the State Profile and the State Initiatives to address its Climate Change concerns. Also it gives an overview on climatic trend over Kerala and climatic projections presented. A separate District wise Vulnerability Assessment and overview of Green House Gas emission also depicts in this section.

1. State Profile

1.1 Background

Kerala lies on the South Western coastal region of India between latitudes $8^0$17' and 12^0 47' North and longitudes 74^0 52' and 77^0 24' East. It is spread over an area of 38,863 km^2, stretching 580 km in length and 30-130 km in breadth, while in terms of area, about 1.2% of geographical area of India

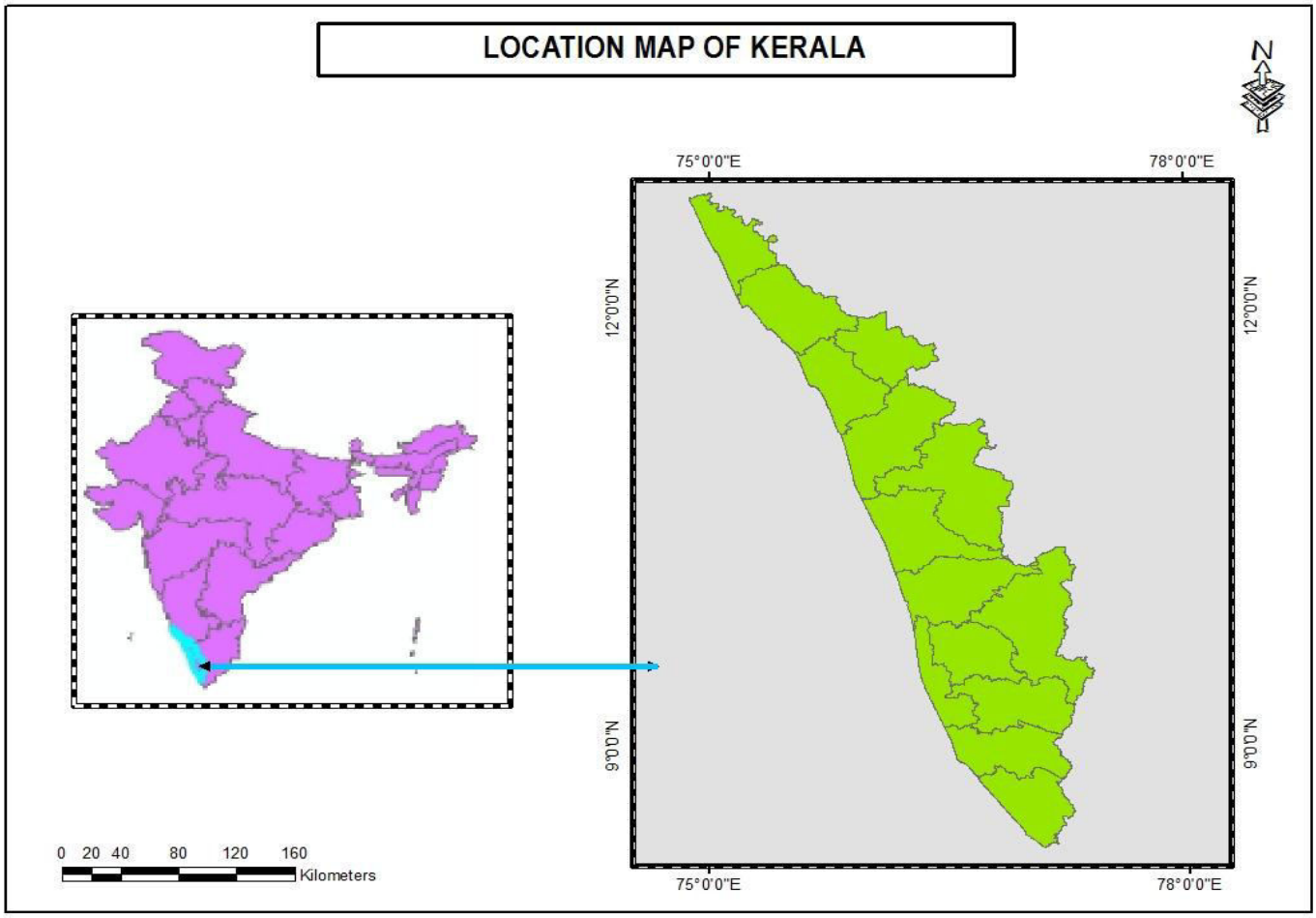


Fig.1.1 Location Map

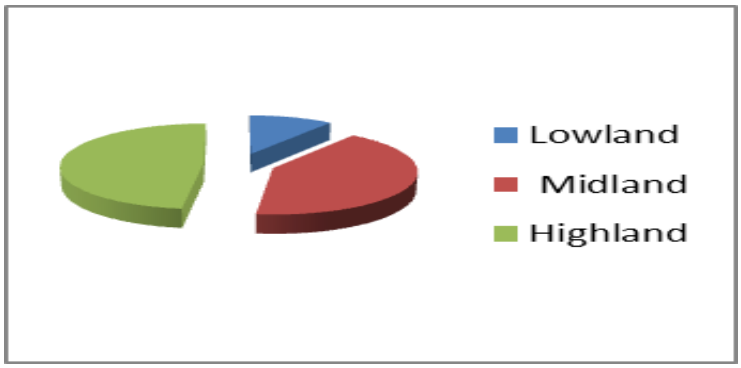
The state's population (in 2011) of 33.3 million accounts for 3.01 per cent of India's population. The population density of the state is 859 persons per km^2, one of the highest in the country. Moreover, the population is spread across the State and as such there are no big urban agglomerations. The biggest city of Kerala, Kochi has a population of only about 0.27 million.

The National Geographic traveler has quoted Kerala as India's most verdant state with one of the world's 50s "must see" destinations. Kerala's achievement and development experience have attracted world-wide attention. This is mainly because it has attained a better quality of life combined with the highest literacy rate.

1.2 Physiography

Physiographic provinces of Kerala have many peculiarities of their own and mainly divided into three physiographic units[1].

Highland (600 m above): The highlands follow a general trend along the direction of the Ghats, starting from extreme North to South of the state. Mountains and peaks above 1800 are very few in number, the highest being Anamudi peak (2695 m) in the Idukki district



Midland (300 – 600 m): The undulating western fringe of the highlands and the laterised rocky spurs projecting westwards and parts of the crustal breaks (passes) form the midlands.

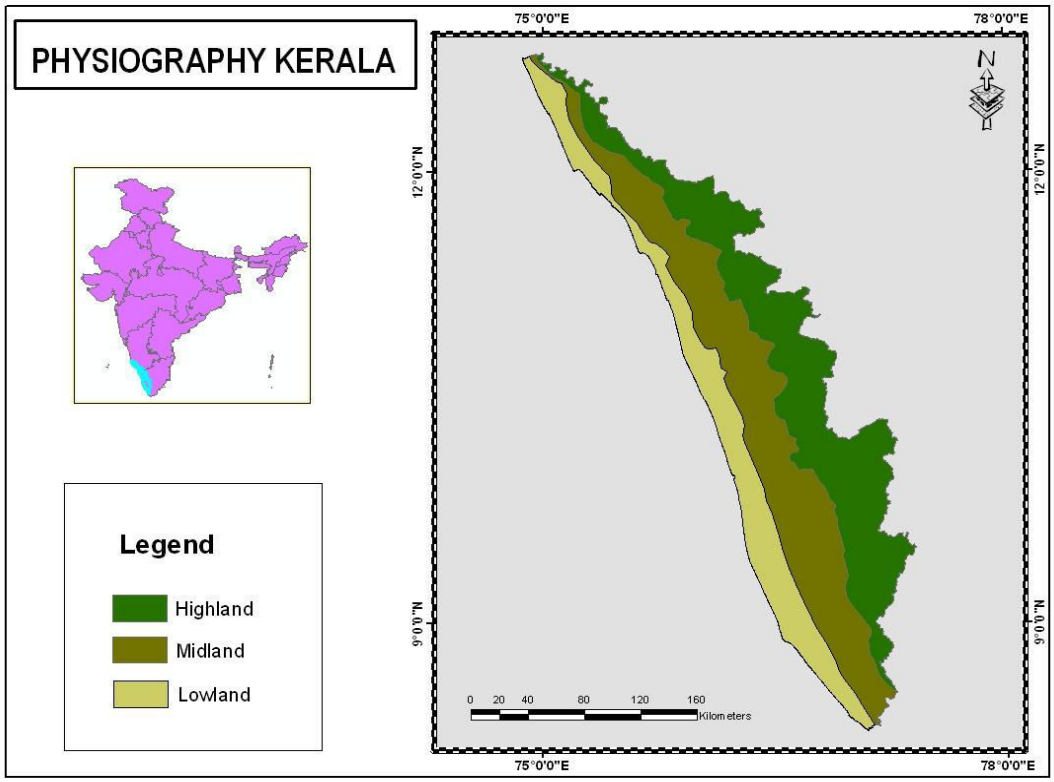


Fig 1.2 Physiographic Map of Kerala

[1] Land Resources of Kerala. Kerala State Land Use Board

Lowland (below 300 m): The lowlands falling under the altitudinal range of less than 300 m. consists of dissected peneplains. The vast low-lying area fringing the coast is not only an important physiographic unit of the state, but also important in terms of economic activity and demographic distribution. Beach dunes, beach ridges, barrier flats, coastal alluvial plains, floodplains, river terraces, marshes and lagoons constitute this unit.

1.3 Climate

The climate of Kerala is tropical monsoon with seasonally excessive rainfall and hot summer[2]. The Western Ghats plays a major role in the climatic conditions that prevail all along the state. The year may be divided into four seasons. The period of March to the end of May is the hot season which is the summer month and is uncomfortable due to high temperature and humidity. This is followed by South West Monsoon season that continued till the beginning of October. From October to December is the North East Monsoon season and two months, January and February, are the winter season. The climate is pleasant from September to February. The state is extremely humid due to the existence of Arabian Sea in the west of it. The annual precipitation varies between 100 cm (around Chinnar) to 500 cm (around Neriyamangalam), with a state average of about 300 cm. March to May is the hottest with maximum temperature reaching more than 32°C and the minimum is attained during December to January. Winds over the state are seasonal; diurnal variation is felt owing to the maritime influence. Annual relative humidity varies between 79 – 80% in the morning and 73 – 77% in the evenings

1.4 Landuse

Kerala has a diverse land use and cropping pattern. Population growth, migration, urbanization, industrialization and globalization had led to significant landuse change in the state. The land reform introduced in the state brought in radical and comprehensive institutional changes leading to drastic transformation in the land holding pattern. This has resulted in shift in the land use pattern. The data on land use pattern of Kerala for the year 2009-10 reveals that out of a total geographical area of 38.86 lakh, net sown area is about 56 per cent[3]. Forest occupies around 28 per cent. Agriculture and forest sectors together account for over 84 per cent of the land area. The net sown area has increased by 4.39 percent while the total cropped area has declined by 0.97 per cent. There was an increase in the area under current fallow (9186 ha) and a decrease in the area under fallow other than current fallow (581 ha) during 2009-10 over 2008-09. The area under cultivable waste increased by 1821 ha. and barren and uncultivated land declined by 7019 ha.

[2] State Environment Report, 2007

[3] Economic Review, 2010

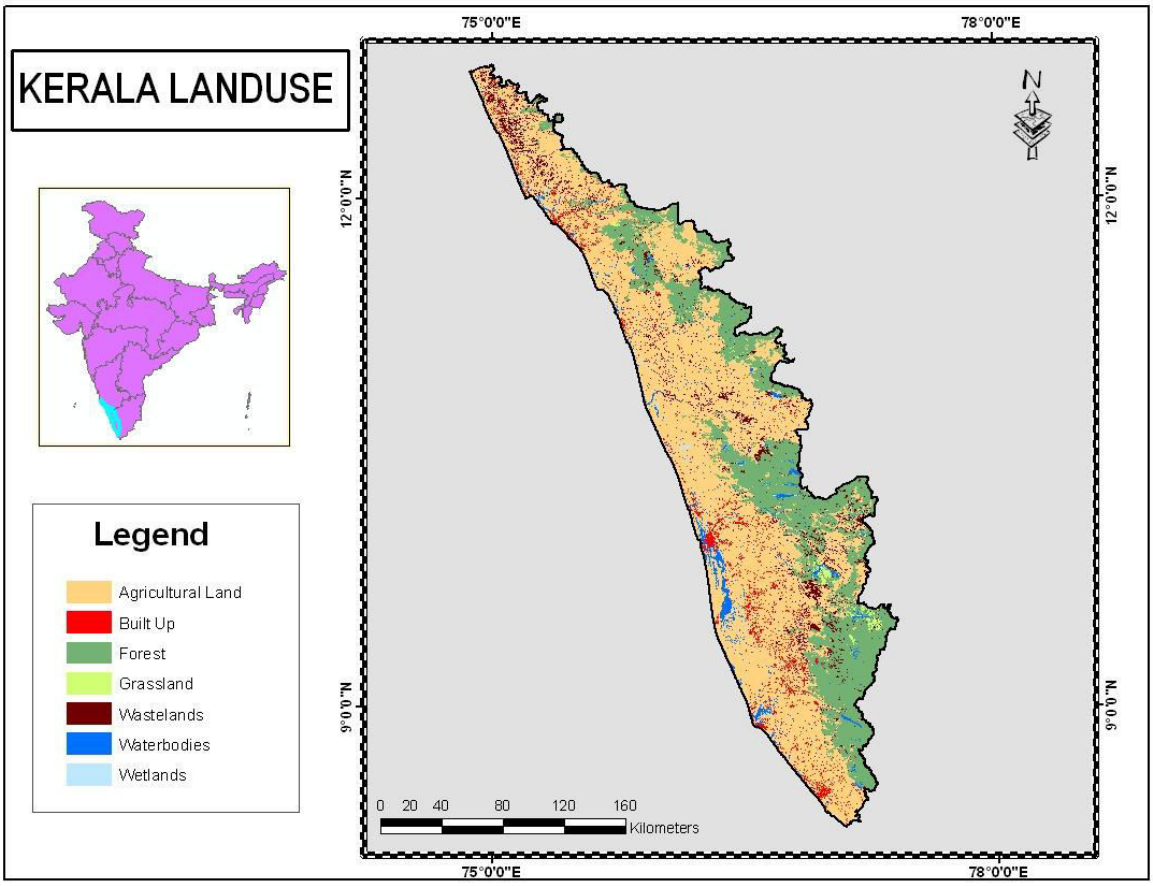


Fig 1.3 Land use Map of Kerala

1.5 Forest

Forest cover of Kerala is largely spread over the Western Ghats which border the state. The recorded forest area is 11309.4754 sq.km. The percentage of forest cover in Kerala is 29.10 which is higher than the national coverage of 19.50 %.[4] This includes 9176.30 sq. kms reserve forests, 295.37 sq.km proposed reserve and 1837.79 sq.km vested forest. Forest types in Kerala are given in the table 1.1.

Forest Types	Area (sq km)	% of the total area
Tropical Wet Evergreen forest	3877.44	34.28
Tropical Moist Deciduous forest	3615.98	31.97
Tropical dry deciduous forest	391.36	3.46
Mountain Sub Tropical	386.42	3.42
Other	3037	27

Table 1.1 Forest Types in Kerala. Source: Forest Statistics 2011

[4] Forest Statistics, 2011

1.6 Biodiversity

Kerala having land areas of only about 1.12 percent of the country houses about 25 % of the biodiversity of the county. This when viewed against the fact that India, a mega- diversity country with 2.4 % of the land area of the world, accounts for only 7-8 % of the recorded species of the world, highlights the richness of the biodiversity of the state. Details of the biodiversity of the country and state is given in the table 1.2 .

Group of living organism	No of species			Percentage of India to world	Percentage of Kerala to India
	World	India	Kerala		
Mammals	45000	430	102	9.55	23.72
Birds	9700	1224	475	11.5	38.5
Reptiles	6500	448	187	6.89	41.74
Amphibians	4000	224	137	5.6	61.16
Fishes	21000	2546	202	12.12	7.9
Flowering plants	250000	15000	3872	6	25.81
Total	295700	19872	4975	6.72	25.03

Table 1.2. Bio diversity of the State. Source: Department of forest and wild life, Govt of Kerala

1.7 Soil

Kerala, being situated in the humid tropical zone with heavy precipitation and high temperature has given rise to widely varying soil groups from similar parent materials. They are forest soil, laterite soil, red soil, alluvial soil, peat soil, sandy soil, and black soil. Though the main geological formation of the state belongs to the Archean period consisting of crystalline and metamorphic rocks, climate and topography seem to be the dominant soil forming factors[5]. The soil types and its characterizes are given in the table 1.3

Sl No	Soil groups	Physiographic division	MSL (metre)	Period	Parent material	Relief	Vegetation
1	Laterite	Midland /dry	70	tertiary	detrial	hilly	Orchard trees
2	Forest Soil	Highland /dry	1000	Archean	Residual gneissic	rolling	Monsoon forest
3	Alluvial soil	Coastal water logged	Sea level	Quaternary	Alluvial clay	flat	rice
4	Sandy soil	Coastal dry	6	Quaternary	Alluvial sand	flat	rice
5	Red soil	Coastal dry	15	Coastak dry	Aeoliean red earth	undulating	cocoanut
6	Black soil	Highland dry	100	Dharwar	Residual basaltic	Undulating	Rice
7	Peaty soil	Midland water logged	Sea level	Cenozoic	Alluvial Peat	Flat	rice

Table 1.3 Soil and its characteristics

[5] Soman K. 2002. Geology of Kerala. Geological Society of India. Banglore

1.8 Water Resources

The rapidly falling terrain, heavy precipitation and the narrow width of the state have given rise to numerous rivers. There are 44 rivers, most of them having their source in the Western Ghats and draining into the Arabian Sea. The important rivers from north to south are; Valapattanam river (110 km), Chaliar (69 km), Kadalundipuzha (130 km), Bharathapuzha (209 km), Chalakudy river (130 km), Periyar (244 km), Pamba (176 km), Achancoil (128 km) and Kalladayar (121 km)[6]. Other than these, there are 35 more small rivers and rivulets flowing down from the Ghats

One of the striking features of the state is the continuous chain of lagoons or backwaters existing along the coastal region. The lagoons or backwaters are connected to the sea through small opening called Azhis or Pozhis according as the opening is permanent or temporary. The important backwaters in Kerala of the state are Kumbala, Kalnad, Bekal, Chittari, Valapattanam, Korapuzha, Kavvayi, Veliyangod, Crangnonore, Perur, Vembanad, Kayalakulam, Ashtamudy, Anjengo, Katinamkulam and Veli

Fresh water lake system is also a unique and vulnerable ecosystem in the state. Large inland freshwater bodies are common in the central and southern parts of Kerala; the important ones among these are the Kolelands of Trichur district, the Punchas/ Chals of Alleppey district, the Sasthakota Kayal of Quilon and Vellayani Kayal of Trivandrum.

1.9 Socio Economics Profile

The state of Kerala for more than a decade now, have received attention from world over for its remarkable achievement in human development[7]. The human development and social indicators have placed Kerala not only among the top performers within the country but the indicators are also comparable to those of the developed countries. The state literacy rate is 93.01 % in 2011 which is highest in the country and the male and the female literacy of 96.2 and 91.98 percent respectively. Remarkably, the school attendance rate in Kerala is more for women as compared to men which is also an exception. In terms of the health indicators, Kerala has the highest life expectancy of 76 years of birth, compared to the rest of the states. The state has also experienced a faster decline in the mortality rates than its other counterparts. The total fertility rates for women 15-49 years is among the best within the country signifying better health indicators for women in the country.

Kerala has a vibrant economy. The service sector (including tourism, public administration, banking and finance, transportation, and communications) and the agricultural and fishing industries dominate the economy of Kerala8. During 2010-11, contribution from primary, secondary and tertiary sector to the GSDP at constant prices

[6] Resouce Atlas of India. Centre for Earth Science Studies.1984. Thiruvananthapuram
[7] Human Development Report 2005. Government of Kerala
[8] Economic Review 2011

(2004-06) constitute 14.94 %, 21.08% and 63.98%, respectively. The state economy depends on emigrants working in foreign countries (mainly in the Persian Gulf countries such as United Arab Emirates or Saudi Arabia) and remittances annually contribute more than a one fifth of GSDP. National Sample Survey Organization (NSSO) data shows that Kerala has the highest level of Monthly Per Capita Consumer Expenditure (MPCE) of Rs.1055.6.

At current prices, GSDP was estimated at Rs. 276996.70 crore (quick estimate) in 2010-11 against the provisional estimate of Rs. 232381.05 crore in 2009-10 with growth rate of 19.2 (Table1.4). At current prices, the per capita GSDP in 2010-11 was ` 80366 registering a growth of 18.33% over the estimate of Rs. 67916 in 2009-10. At current prices the State income was estimated at ` 246212.72 crore (quick estimate) in 2010-11 compared to the provisional estimate of ` 206200.31 crore in 2009-10

Item	Income(Crore)			Growth rate (Percentage)	
	2008-09	2009-10	2010-11	2009-10	2010-11
Gross State Domestic Product (at current prices	202782.79	232381.05	276996.8	14.6	19.2
Net State Domestic Product (at current prices	18034.36	206200.31	246212.72	14.47	19.4
Per Capita State Income (at current prices	59716	67616	80366	13.73	18.33

Table 1.4. State Income Source: Economic Review 2011

1.10 Demography

As per Census 2011, Kerala has a population of 3.33 crore, an increase from figure of 3.18 crore in 2001 census. Although Kerala accounts for only 1 per cent of the total area of India, it contains about 3 per cent of the country's population. The population of Kerala forms 2.76 percent of India in 2011. Total population of Kerala as per 2011 census is 33,387,677 on which male and female are 16,021,290 and 17,366,387 respectively.

Population	**3,33,87,677**
Males	16,021,290
Female	17,366,387
Density	859 per sq. km
Literacy	93.91%
Density	859 per sq km
Sex Ratio	1084
Population growth (%)	4.86

Table 1.5 Populations in Kerala

The total population growth in this decade was 4.86 percent while in previous decade it was 9.42 percent. Literacy rate in Kerala has seen upward trend and is 93.91 percent as per 2011 population census. Population density of Kerala is 859 per sq. km which is higher than national average 382 per sq. km. Sex Ratio of Kerala is 1084 i.e. for each 1000 male, which is below national average of 940 as per census 2011 and the only state in India with a positive figure.

1.11 Governance

For administrative purposes the State is divided into 14 revenue districts i.e Thiruvananthapuram, Kollam, Alappuzha, Pathanamthitta, Kottayam, Idukki, Ernakulam, Thrissur, Palakkad, Malappuram, Kozhikode, Wayanadu, Kannur and Kasaragod. The 14 districts are further divided into 21 Revenue divisions, 63 Taluks and 1453 Revenue Villages. There are 14 District Panchayats, 152 Block Panchayats, 978 Grama Panchayats, 60 Municipalities and 5 Corporations.

1.12 Infrastructure

The 12th Finance Commission ranks Kerala among the high middle on the infrastructure index together with Gujarat, Haryana and Tamil Nadu (Ministry of Finance, 2004). The state has a total road length of 1,73,592 km with a road density of 446 km per 100 sq km. The state is well-connected and other parts of India through eight National Highways. There are 18 ports in Kerala, of which Kochi is the major port. In addition, there are three intermediate and fourteen minor ports. Also state has three airports, handling both domestic and international flights. Kerala is well-connected to the other parts of the country via the railways. As the 2007-08, it had a railway network of 1,148 km with 200 railways station. Kerala has a tele-density of 52 per cent as compared to an all- India average of 36.9 per cent. Power sector in Kerala is almost fully based on its natural resources. Out of the total installed capacity of 2746.19 MW, 1933 MW comes from 24 Hydel stations, 783 MW from thermal projects including NTPC and rest from some alternate energy projects.

2. Climate Change and State Initiatives

2.1 Background

It is need to understanding impending implications of climate change on the local environment and taking preventive actions or adaptive measures accordingly. Local strategies to deal with climate change have to be ensuring resilience in the existing natural resource base of the state against influence of the shock of climate change and adaptive actions based on the available and upcoming information's related to the impacts and implications of climate change. In Kerala, climate change has become an agenda for development planning in recent years. The Environment and Climate Change Department, Government of Kerala has been identified as the nodal agency for coordinating activities related to climate change in the state. An outlay of 1.30 crore is proposed for initiating various activities in the area of climate change during 2012-13. The components of the scheme include the preparation of position papers on climate change through resource institutions and consultants, preparation of consultancy reports on carbon credits, initiating study reports, preparation of climate change action plan for the state and for organizing a workshop on climate change.

2.2 State Initiatives

- In line with the concept of sustainable habitats, works is in progress for adopting the provisions of the Energy Conservation Building Code (ECBC) 2007, suitable for the state. Energy Management Centre (EMC) is pursing the National Mission on Energy efficiency in the state. Department of Environment and Climate Change is organizing capacity building activities with EMC for adopting the ECCB
- Local Self Government in Kerala is quite aware about the imperative of scientific waste management in the urban civic management. Many of the village habitations are also highly urbanized. Waste minimization and treatment of municipal waste is a priority and Kerala Suchita Mission is providing technical back up to the local self-government for attaining scientific waste management capability.
- Kerala Institute of Local Administration (KILA) gives the sensitizing programme on climate change challenges to the Panchayat Raj Institution Members (PRIs) with the support of UNDP
- Kerala has been working on strong renewable energy and energy efficiency strategy hydroelectricity potential is being planned to the attained in a sustainable manner by small hydroelectricity generating system avoiding loss of the forests. About 500 MV is planned for the coming times in this way, for which CDM benefits will able be claimed. About 66 million units have been generated by 41 wind energy projects in the state. Work is on to reduce T & D losses at a rate of 1.5-2 % annually. It is aimed to save about 300 MW by propagating replacement of incandescent lamps by CFLs
- Kerala has initiated plan programmes on Eco restoration of wetlands and river action plan for identifying vulnerabilities and designing interventions for conservation of its water resources.

- There are several important institutions in the state under the aegis of Kerala State Council for Science and Technology, working ion the various aspects of climate change. Centre for Earth Science Studies, Centre for Water Resource Development and Management, Kerala Forest Research Institute, National Transportation Planning and Research Centre are some of the institute especially equipped for the relevant work
- Recently Government has sanctioned to establish the Institute of Climate Change Studies, at Kottayam to make research activities on climate change related aspects

To understand the climate change implications and vulnerability of Kerala and also tackle situation following initiatives under research and development have been taken up by the Department of Environment and Climate Change, Government of Kerala.

- Carbon emission reduction potential of PSUs of Kerala
- Assessment of carbon footprints in institution
- Future Climate Change projection in Kerala using Ultra High Resolution Global Climate Model

2.3 Preparation of Kerala State Action Plan on Climate Change

Kerala State Action Plan on Climate Change (SAPCC) is being formulated by Department of Environment and Climate Change with the technical support of UNDP India. Department of Environment and Climate Change is adopted a comprehensive and systematic approaches to develop State Action Plan which included set up of a State Level Steering Committee, identity sectoral works groups, organized National Level Workshop, reviewed literature, conducted Public Consultation Workshops at three physiographic zones of the state and individual stakeholders consultation meetings. The strategic possibilities for dealing with the climate change situations in the state are proposed through an assessment of vulnerabilities, possible impacts on natural resource base and key human development aspects and options related to response action in high, medium and low. Based on climate change vulnerabilities following broad sectors are specifically relevant in the state i.e. Agriculture, Animal Husbandry, Fisheries and Coastal Resources, Forest And Biodiversity, Waters Resources, Health, Energy, Urban Front and Transport and Tourism and thus strategies have been developed

First, a High level State Steering Committee was constituted with Secretaries of different departments as member under the chairman ship of Chief Secretary. Towards preparation of the State Action Plan on Climate Change, Government of Kerala organized a National Workshop on "Natural Resource Management and Human Development Paradigm in Climate Change Perspective- Adaptive Strategy Option for Kerala" on December 2009. It helped developing baseline scenarios for the preparation of the State Action Plan on Climate Change and

recommendations evolved to identify the priority areas of the state. It also focused the adaptive strategies for overcoming the impacts of climate change in the main developmental sectors. The participants were from the policy formulation and implementation levels from various sector of state governments, research and academic institutions and civil society representatives of known credentials in the relevant areas

Following the National Workshop on climate change under the Chairmanship of High Level Steering Committee, seven sectoral working groups were formulated. The following working groups were set up to deliberate on the climate change related impacts and proposes strategy for response of the State.

Working Group	**Chair**
Climate Change monitoring and networking related to science and technology	EVP and ex-officio Principal Secretary, KSCSTE, Kerala
Water Resource	Secretary, Water Resource
Coastal and Fisheries resources	Secretary Fisheries
Agriculture	Agriculture Production Commissioner
Forest	Principal Secretary Forest
Information, education and Communication	ACS, LSGD
Local Governance	ACS, LSGD

Further, through extensive consultation with various stakeholders in the state, various strategies were evolved for addressing climate change issues in the state. This regular interactive and iterative process is reflected in Kerala SAPCC. Thus this action plan is the result of the input received from various representatives of NGO's, subject experts, heads of various institutions and organizations through written submissions in the workshops and consultations meeting at various levels.

Three regional level consultation meetings organized in the three physiographic zones in the state i.e High land, Midland and Low land as the climate and climate dependent activities in these zones having distinctively unique characteristics. The Regional Public Consultation Workshop for low land organized at Thiruvananthapuram, mid land workshop organized at Thrissur and High land workshop at Sulthan Bathery, Wayanad. These workshops helped for wider consultation and getting feedback on the prepared draft of the action plan from the various NGOs, general public, Research & Development institutions and line departments in these regions

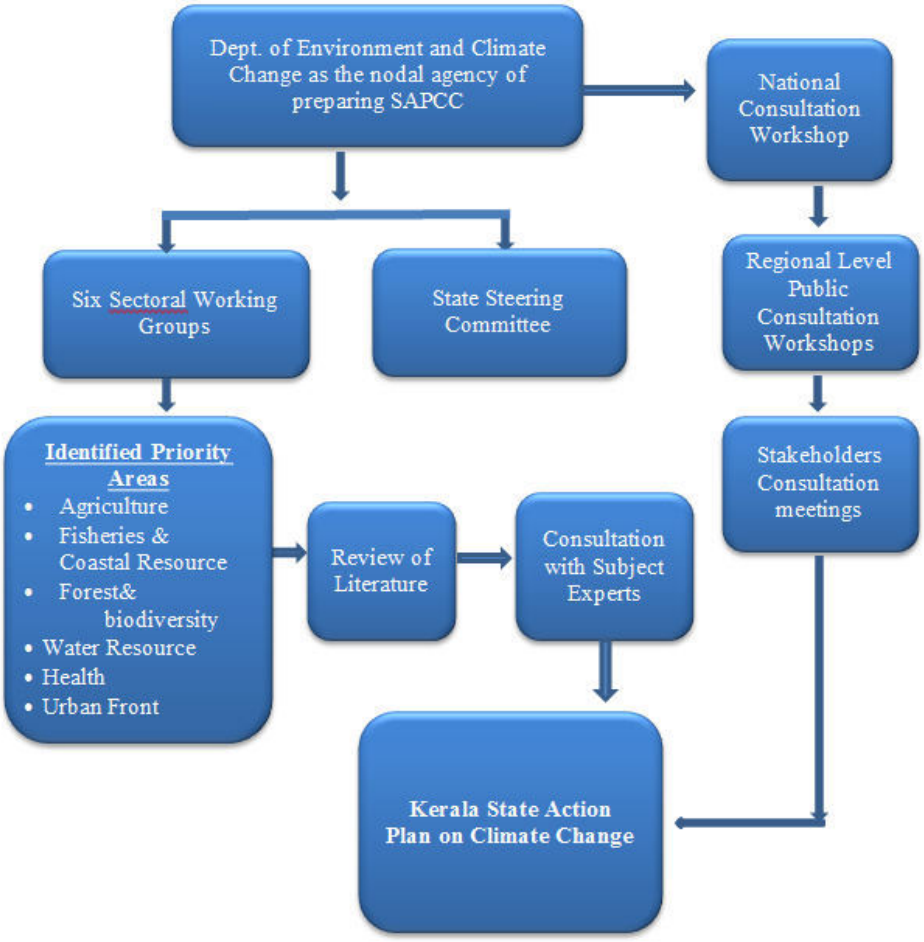


Figure 2.1 : Formulation process of SAPCC

3. Climate Change and Development Issues in the State

3.1 Background

Kerala is acclaimed for its unique development trajectory leading to high human (social) development disproportionate to its economic growth. It has had a unique development experience when compared to the rest of the country. High levels of social indicators comparable with the level of indicators in the developed countries, which came about without the usual 'rapid' economic growth in per capita GSDP and simultaneous increases in the output has in fact attracted a lot of attention to this developmental process and gradually started being referred to as the 'Kerala model of development.

The state has blessed with rich in natural resources i.e. forest, biodiversity, water resources, and mineral resources. Forest occupies around 29 % of total land area in the state. It has land areas of only about 1.12 percent of the country houses about 25 % of the biodiversity of the county. State is gifted with nature's bounty of water resources, with 44 rivers of small and medium category interconnecting backwaters and canals, several lakes and ponds of diverse capacities, streams, springs, wells and extensive wetlands and paddy field. The state is endowed with a number of occurrence/deposits of minerals such as heavy mineral sands, Gold, Iron Ore, Bauxite, Graphite, China clay, Ball clay, Fire clay, Tile and Brick clay, Silica sand, Lignite, Limestone etc (Nair et al., 2005; KSLUB, 1995 and 2002).

3.2 Challenges

Recent years, deterioration of the natural resource base that evidently had far reaching consequences is well evident. The forests resources in state has declined at an unprecedented rate, especially in the highlands of Kerala with its rolling topography and heavy rainfall, soil erosion continued unabated leading to reduced soil quality and low productivity (Vinod et al., 2003; KFRI, 2005). Excessive clearing of forests and the loss of structural integrity, thus, may lead to a severe erosion of biological diversity. In particular, substantial portions of the fresh water swamp forests and mangroves were already converted to crop fields/aquaculture areas, leading to local extinction of many endemics (Varghese and Kumar, 1997). Natural forest has reduced from 44% in 1905 to 28% in 2010. Agriculture fields, particularly paddy fields reduced at alarming rate for mainly for non-agricultural practices. Rubber plantations cover about 18% of the total agricultural land and 11% of the total geographical area of the State. Many of the rivers are drying up. Decrease in rainfall and change in basin ecology lead to perennial river of Kerala to non-perennial one. River water quality is further affected by urban and industrial effluent discharge and lack of sanitation in the rural areas. One of the contributory factors in the Kerala model is free availability of water all through the state. With restricted usability of water the natural advantage of wide spread availability of the resource is eroded. Sand mining from the river bed and clay mining from the river terrace / floodplain add further complexity to the hydrological regime of the river. Construction of dams in the

upper reaches of the river restricts regular flow and also sediment movement. Reclamation of wetland is another factor adding to the ecological transformation of the State (Centre for Earth Science Studies, 1997).

On human development aspects, high population density and high state of urbanization result in high per capita energy needs and thus carbon intensity. It is also faced acute food insecurity and import of food grains from the other states. Land hunger in the state for housing and livelihood leads to encroachment of forests and low lying wetlands. Due to heavy unemployment, the slogan of industrial development at any cost gets support, for the employers using polluting technologies from the workers as also the unemployed. Unregulated backwater tourism (house boats) and 'eco' tourism in the ecologically fragile lands also become an issue. Pro-environment lobbies in the state are either weak, localized or fragmented. A major weakness of these movements is the lack of scientific and technical knowhow. The financial weakness of the State government does not allow for financing cleaner technologies to replace the existing polluting technologies. The existing low industrial base allows for a strategy of future industrialization of the state using less energy intensive and low GHG emission technologies.

The rapidly expanding infrastructure development in the state as well as large proportion of goods and traffic movements through road transport has been a cause of increasing quantum of carbon based emissions in the state. Transport management is a potential area for management of carbon emission in the state. While this pace has all the potential of impacting the natural resource base and state of the environment in the state, the demand for energy consequent to high urbanization in the wake of high population density runs a risk of high carbon footprints if green technologies are not integrated in the development process.

3.3 Policy framework

Vulnerabilities owing to climate change have huge dimension in the state. State has been already faced various types of developmental and environmental issues. Meanwhile climate change accelerates these issues into more complicated one. Water scarcity become more acute, frequent spread of vector and water borne diseases, severe forest and biodiversity degradation, decrease the agricultural production in the state etc. are some common issues which may become severe and relevant in the future. Same time various programmes and policies taken may also become unable to address these problems successfully. In this background the local strategies to deal with climate change have to be directed towards post containing the change ensuring resilience in the existing natural resource base of the state against the influence of shock of climate change and adaptive actions based on the available and upcoming information's related to the impacts and implication of climate change.

4. Observed Climate Change trends and Projected Climate Change

4.1 Background

The climate of Kerala is tropical monsoon with seasonally excessive rainfall and hot summer[1]. The state having four seasons 1) the period of March to the end of May is the hot season. This is followed by 2) the South West Monsoon season that continued till the beginning of October. From October to December is the 3) the North East Monsoon season and two months January and February and 4) the Winter season. The climate in the state is pleasant from September to February and summer months March to May is uncomfortable due to high temperature and humidity. The state is extremely humid due to the existence of Arabian Sea in the west of it.

Temperature: The mean minimum temperature in the state is 22-24^0 C and the mean maximum temperature is 32-34 ^{0} C. There is spatial variation in annual mean temperature ranging from 25.5 to 27.5 ^{0} C in the coastal belt, 27.5 to 29.5 ^{0} C in the central region and 17.5 to 21.5 ^{0} C in the hilly regions. During summer months the temperature is high leading to drying of surface soil and drought condition.

Rainfall: Kerala is situated in the high rainfall humid tropical region The principal rain-giving seasons in Kerala are the South-West Monsoon (June- September) and North-East Monsoon (October- November). The pre-monsoon months (March-May) account for the major thunderstorm activity in the state and winter months (December – February) are characterized.

The total annual rainfall in the state varies from 360 cm over the extreme northern parts to about 180 cm in the southern parts. The southwest monsoon (June- October) is the principal rainy season when the state receives about 70 % of its annual rainfall.

[1] State Environment Report of Kerala. 2005. Kerala State Council of Science and Technology and Environment, Thiruvananthapuram

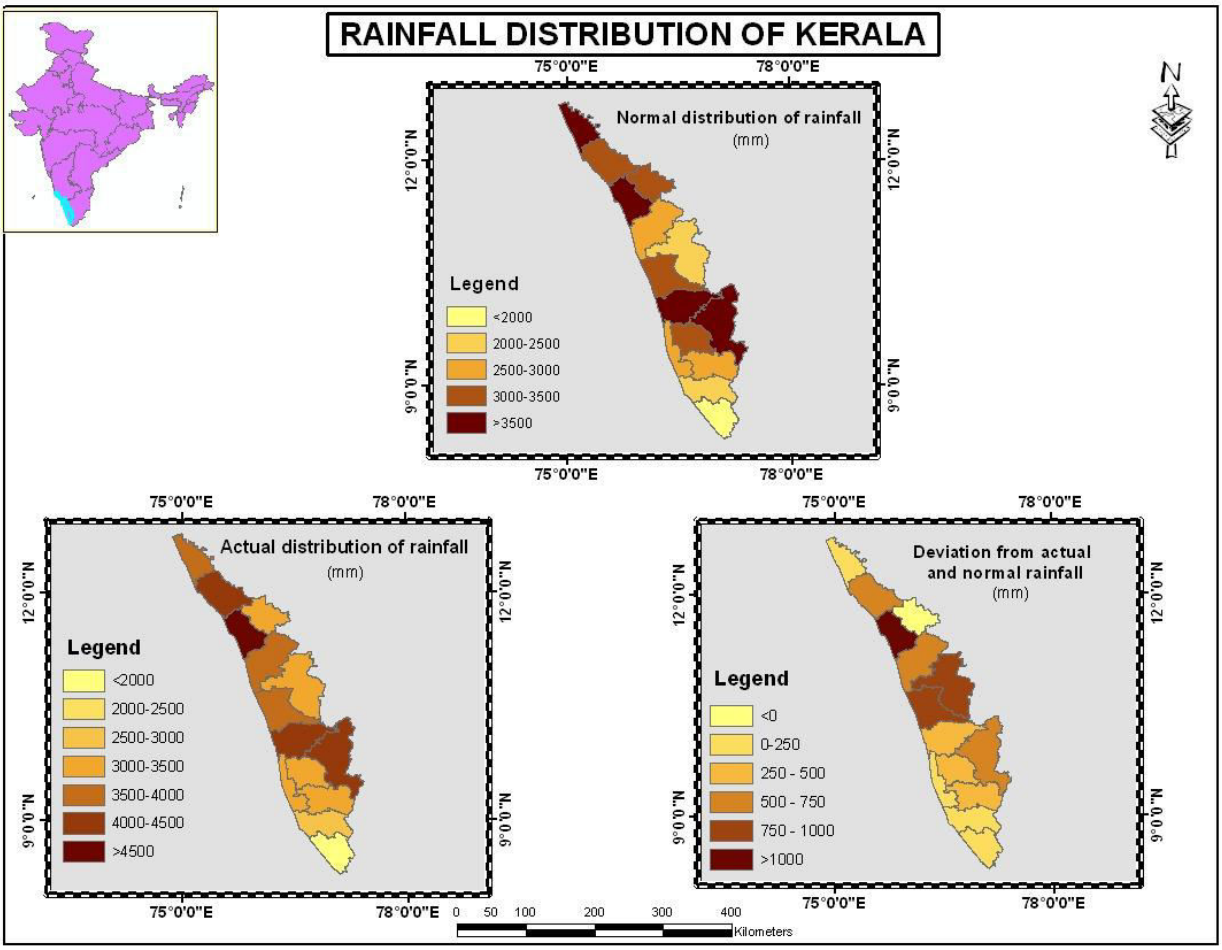


Fig 4.1 Rainfall Distribution Map of Kerala

Wind: Wind over the state are seasonal only in the region of Palghat Gap where winds are predominantly from the east in the period from November to March and from west in the rest of the year. In other parts of the state flow of winds is mainly governed by differential heating of land and water mass together with mountain winds.

Humidity: As the state stretches from north to south with Arabian Sea on its west, relative humidity, in general is high over the state. The relative humidity during the monsoon season is about 85 %[2].

[2] State Environment Report of Kerala. 2005. Kerala State Council of Science and Technology and Environment, Thiruvananthapuram

4.2 Observed Climate Change trends

4.2.1 Changes in rainfall trend in the Past

As per the analysis done by Indian Meteorological Department (IMD) of historic rainfall data of Kerala indicates cyclic trends in annual rainfall with a declining trend and South West Monsoon rainfall during the last 60 years. It is observed the onset of monsoon appears to be little early over Kerala and rainfall distribution is highly erratic in recent years. It also shows that the monsoon rainfall is likely to be below normal (2142 mm), if the onset of monsoon is early i.e. on or before 25 May.

A detailed study was done by P V Joesh and Krisna Menon about the monsoonal trend of Kerala over last 100 years and it shown unique phenomena of monsoon behavior. The rainfall of Kerala has shown a decreasing trend in the last 100 years. This decrease is large in South Kerala, particularly in the hill areas around Cardamom hills where at Peermade (Idukki district) the annual rainfall has decreased through about 26% of the long term mean in the last 100 years. In the recent few decades the rainfall of North Kerala has also begun to decreasing trend (Rao, et al., 2009) reported that there exists a cyclic trend in annual rainfall with a declining trend and South West Monsoon rainfall and an increasing trend in post monsoon rainfall since last 50-60 years.

Another observation (Ram Mohan et. al 2009), during the period 1951-2005, the number of wet years of Northeast Monsoon increased during the post 1975 period compared to the pre-1976 period. Above normal years of North East Monsoon also increased during the post 1976 period. The December rainfall over Kerala has decreased at the rate of -0.197mm per year. Wet years of South West Monsoon have decreased in the post-1976 period compared to pre-1976 period. The number of dry years and below normal years of South West Monsoon has increased in the post 1976 period.

The analysis of rainfall data (Soman et.al 1988) from 75 rain gauge station in Kerala for the period 1901-1980 showed a decreasing trend in the annual and seasonal rainfall over the midland and highland regions. The hilly tracts of Ernakulam, Idukki, and Kottayam district showed a decrease of 15 to 20 % in annual and Southwest Monsoon rainfall. In the central region of the state, about 20 % decrease in rainfall during in North East Monsoon was observed.

Kerala Agriculture University observed rainfall and number of rainy days showed declining trend in recent years during the South West Monsoon (June- September) at four selected location viz Pilicode, Vellanikkara, Amabalavayal and Pampaddumpara. Thus it is noticed that rainfall across the high ranges of Kerala

is declining. The Kerala State Planning Board's, Compendium of Environment Statistics finds that as of 2003, the state's annual rainfall has received nearly 17 per cent short of the normal rainfall from 1990 to 2003.

4.2.2 Changes in the Temperature

According to Indian Meteorological Department, during the last 43 years, the mean maximum temperature has risen about 0.8 ^{0} Celsius, the minimum by 0.2 ^{0} Celsius and the average by 0.6^0 Celsius over Kerala (27.3 - 27.9 ^{0} Celsius) a clear upward trend in surface air temperature. Such warming was noticed in the entire Kerala coast. Also differences in maximum and minimum temperature was widening along the high ranges of Kerala. The changes in thermal and moisture regime over the year have resulted in the shifting of climate in Kerala from B4 to B2 class, moving from wetness to dryness within the humid type of climate (Prasada Rao et al. 2009). For the last three years, sunstrokes events are reporting which is uncommon in the past, from various parts of the state

Monthly Mean Maximum Temperature and Months Total Rainfall data for the last 10 years of Thiruvananthapuram city was collected from climatologically division of Meteorological Resource Centre, Thiruvananthapuram and were analyzed to know the aberration. The monthly mean maximum temperature of Thiruvananthapuram city is by and large constant but shows an increasing trend. Fig. 4.1 illustrates the phenomena.

Year	Annual Mean Max Temperature
2000	32.0
2001	31.7
2002	32.0
2003	32.5
2004	32.1
2005	32.1
2006	32.2
2007	31.3
2008	32.0
2009	32.4
2010	32.0

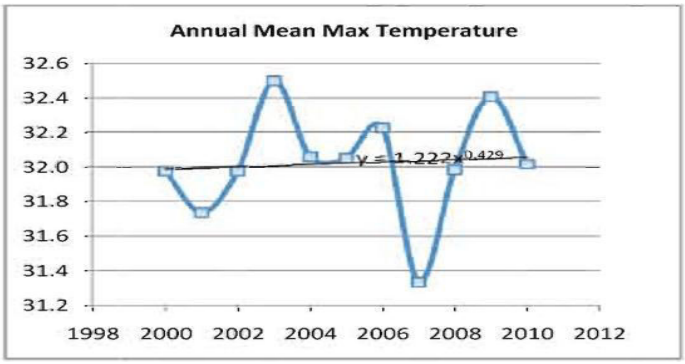


Fig. 4.1 Monthly Mean Maximum Temperature and Months Total Rainfall data for the last 10 years of Thiruvananthapuram city

Temperature data recorded at the Regional Agricultural Research Station, Ambalavayal (Wayanad district) and Cardamom Research Station at Pampadumpara (Idukki district) under the Kerala Agricultural University studies revealed that the maximum temperature over the high ranges of Kerala has increased by 1.46° C from 1984 to 2009. It reveals that the effect of global warming and deforestation is felt more across the high ranges of Kerala situated in the Western Ghats, one of the hot spot areas of bio-diversity.

The micro study done by CWRDM at Kottamparaba, Kozhikhode district al shows the decade; mean of daily maximum temperature rose to the tune of 0.6 ^{0} Celsius during winter and 0.55 ^{0} Celsius during summer season between 1983 and 2010. Over the 27 years period, the difference between daily maximum and minimum temperature has increased by 15 ^{0} Celsius during winter season and 0.72 ^{0} Celsius during summer.

4.3 Climate Change Projections

In the first report on "Impact of climate change in four regions of the country" submitted to the Government of India by the Indian Network for Climate Change Assessment (INCCA) has been pointed out that reduced rainfall, increased atmospheric temperature and flooding due to sea level are the climate change scenarios for the Western Ghats and Kerala in the next 20 years. Under the projected climate change scenario, it is certain that the temperature is likely to increase by 2°C by 2050. The minimum surface air temperature in the Western Ghats region may rise by 2°C to 4.5°C. The average temperature in the region bordering Kerala is likely to rise by 1°C to 3°C. The number of rainy days is likely to decrease along the entire Western Coast, including the Western Ghats. Also it is projected that if the sea level rises by one metre, 169 sq. km of the coastal region surrounding Kochi will be inundated.

To develop the high resolution climate change scenarios for impact assessment studies, a high resolution regional climate model, PRECIS, developed by the Hadley Centre, UK is run at IITM, Pune, at 50 km x 50 km horizontal resolution over the South Asian domain. Here, three simulations from a seventeen-member perturbed physics ensemble (PPE) produced using HadCM3 under the Quantifying Uncertainty in Model Predictions (QUMP) project of Hadley Centre Met Office, U.K., have been used as LBCs for the 138 year simulations of the regional climate model – PRECIS. The climate change scenarios for summer monsoon rainfall and the annual average temperature are shown for the state for 1970s, 2020s, 2050s and 2080s[3].

[3] Indian Institute of Tropical Meteorology. With respect to the baseline period of 1961-1990 for the three QUMP simulations.

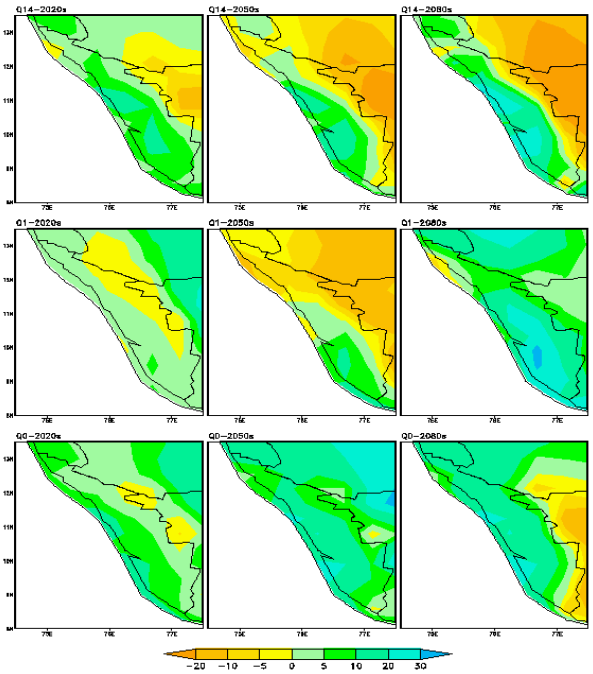


Fig 4.2 Projected future changes in mean monsoon precipitation (%) in 2020s, 2050s and 2080s with respect to the baseline period of 1961-1990 for the three QUMP simulations. Projected future changes in mean monsoon precipitation (%) in 2020s, 2050s and 2080s with respect to the baseline period of 1961-1990 for the three QUMP simulations.

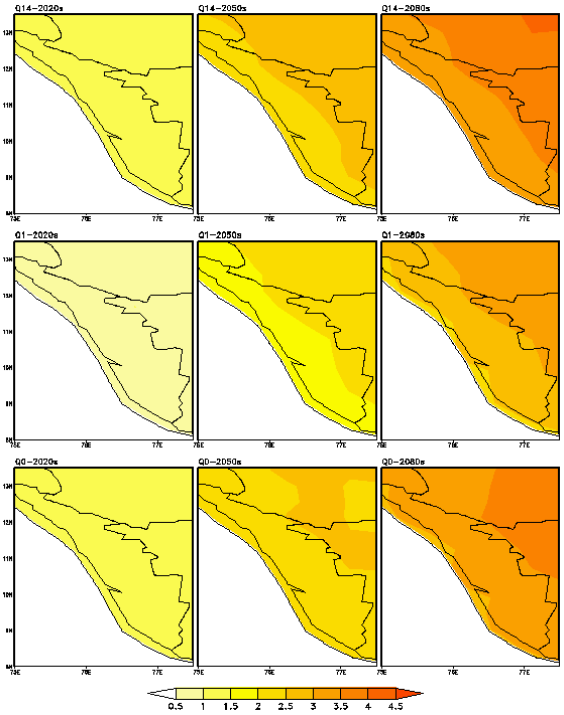


Fig 4.3 Projected future changes in mean annual surface air temperature (0C) in 2020s, 2050s and 2080s with respect to baseline (1961-1990) for the three QUMP simulations

For the better understanding district wise projected annual rainfall and temperature in 2050 for the state have been developed. Following maps depicts the projected district wise change in the rainfall in 2050. It is seen that negative change in deviations of rainfall observed in the Northern Districts i.e. Wayanad, Kannur and Kasaraghode (Fig 4.4). It is also seen that other Northern districts like Kozhikhode, Malappuram and Kannur may have slight changes (decrease rainfall from normal). Unlike to this, Southern Districts will have tendency of increase the rainfall of 10 to 30 rainfalls from the normal. From the average it is observed that South -Central Kerala districts clearly shows having the maximum deviation of 20 to 30 Centimetre deviation from the normal which comprising the districts of Ernakulum, Alappuzha, Kottayam, Pathanamthitta and Idukki.

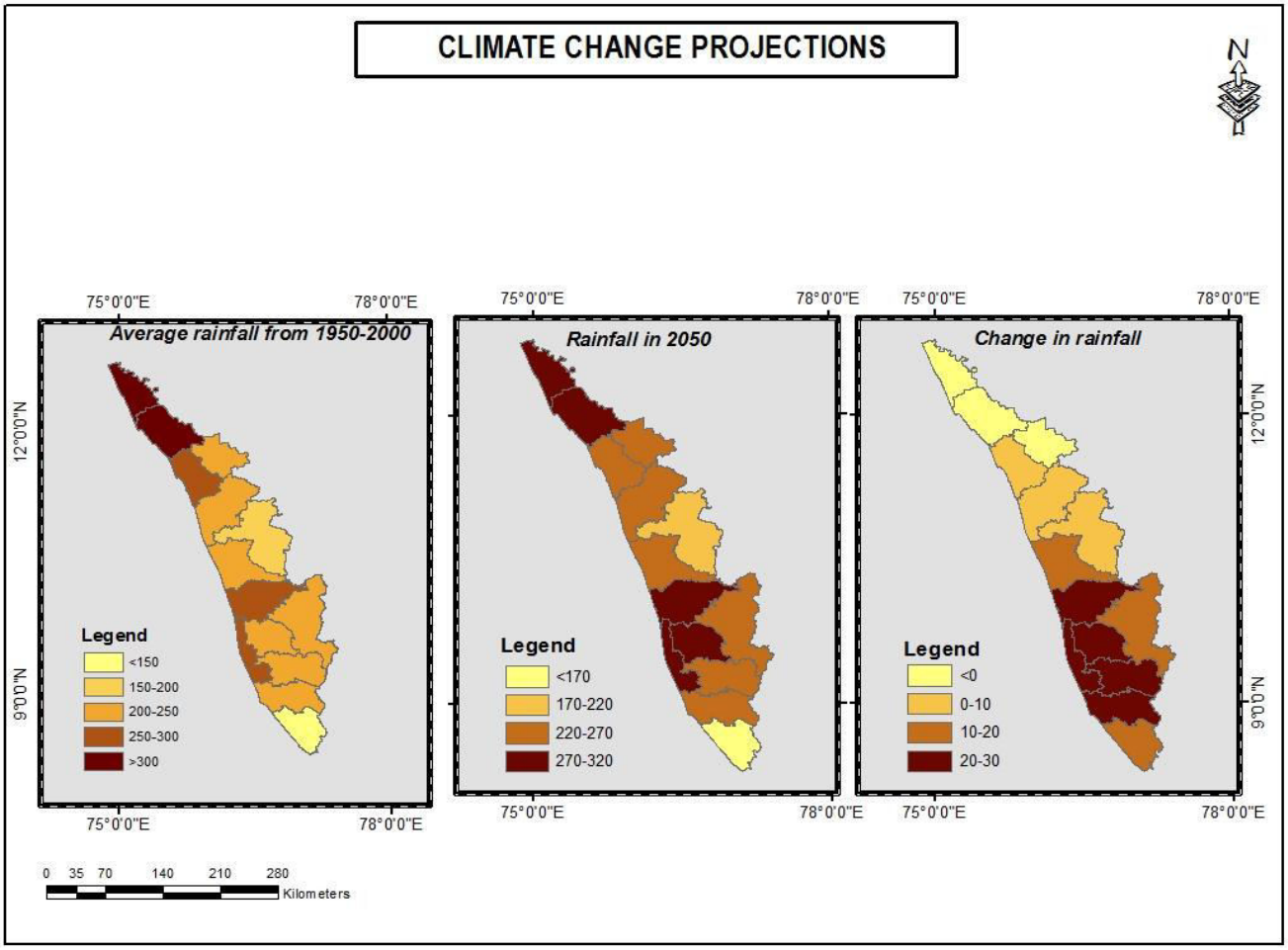


Fig 4.4 Average Rainfall Projection 2050

Maximum Temperature increase can be seen in the Southern and Central Districts of Kerala (Fig 4.5). Most of the districts in the southern Kerala are typically observed the increase in the temperature 1.66 ^{0} C to 1.77 ^{0}

C comprising Thiruvananthapuram, Kollam, Pathanamthitta, Kottayam and Kollam and central Kerala districts comprising Thrissur. Palaghat, Ernakulam and Alappzuha would be observed a change from 1.62 to 1.66 ^{0} C.

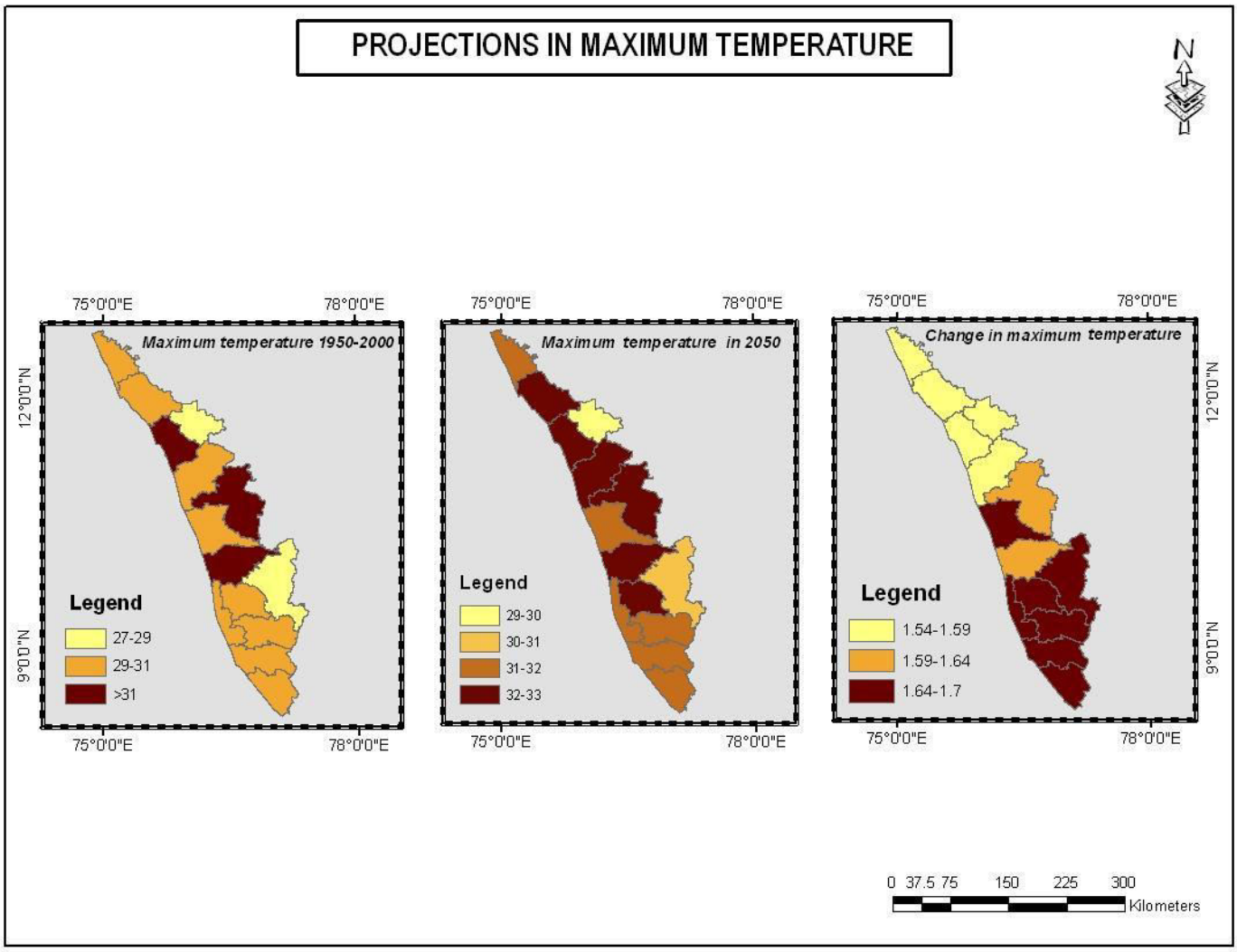


Fig 4.5 Average maximum temperature projection in 2050

Minimum Temperature rise of 1.54 to 1.59 ^{0} Celsius is seen in southern districts (Fig 4.4) in Kerala i.e Thiruvananthapuram, Kollam, Pathanamthitta, Kottayam, Alappuzha and Idukki and Central Kerala region i.e Thrissur. Other two districts in central Kerala having a deviation of 1.59 to 1.64 ^{0} C. Northern Kerala districts have less deviations in Minimum Temperature rise.

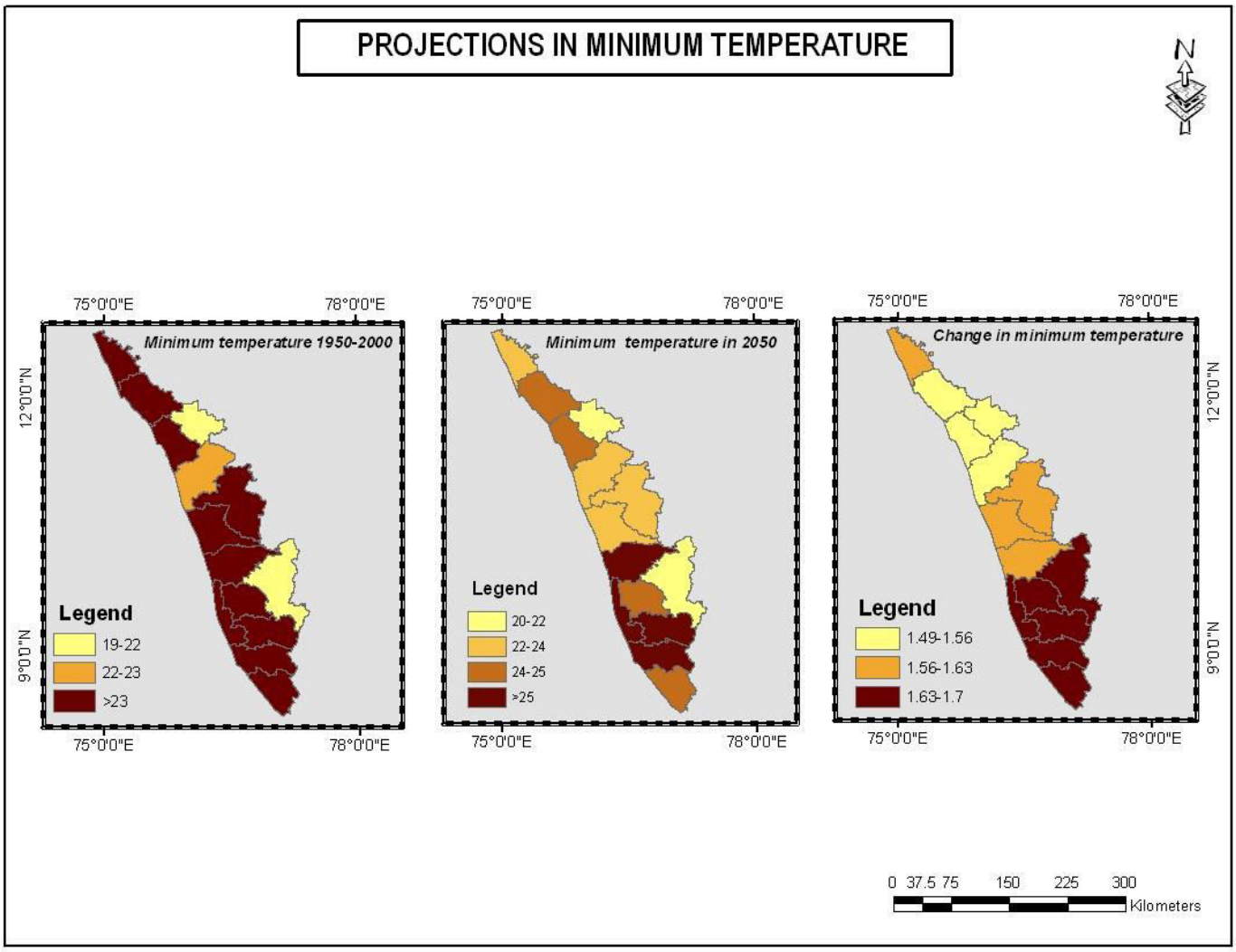


Fig 4.6 Change in average minimum temperature in 2050

4.4 Sea Level Rise and Projections

It is now established that the sea level is on the rise due to global warming and the projected Sea Level Rise (SLR) along Kerala coast on a conservative estimation is about 100 to 200 mm over the next 100 years. Vulnerability to Sea Level Rise would be of alarming to the majority coastal communities which live on sandy coasts, most of which are barrier beaches or spits. Backwater banks, islands and filtration ponds/paddy fields are other sections of the coastal zone which are highly susceptible to Sea Level Rise. If the sea level rises by one metre, 169 sq. km of the coastal region surrounding Kochi will be inundated.

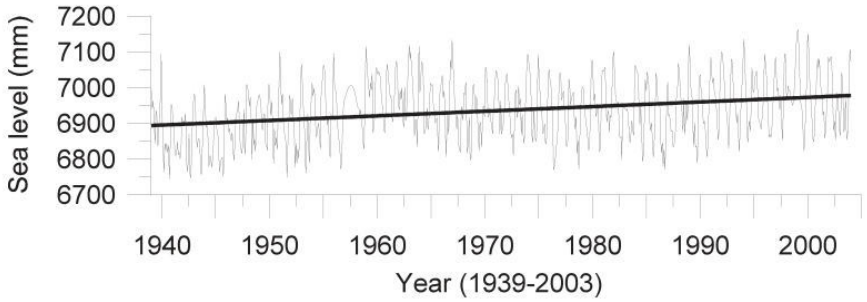


Fig. 4.7 Historic sea level rise in Kochi coast

The historic sea level rise for Cochin is estimated to have been 2 cm in the last one century (Emery and Aubrey, 1989; Das and Radhakrishan, 1993). The scenario of future sea level were obtained by adding the projected values for a given year to the local trend of 0,02 cm per year times the number of years from present (Fig. 2.5)

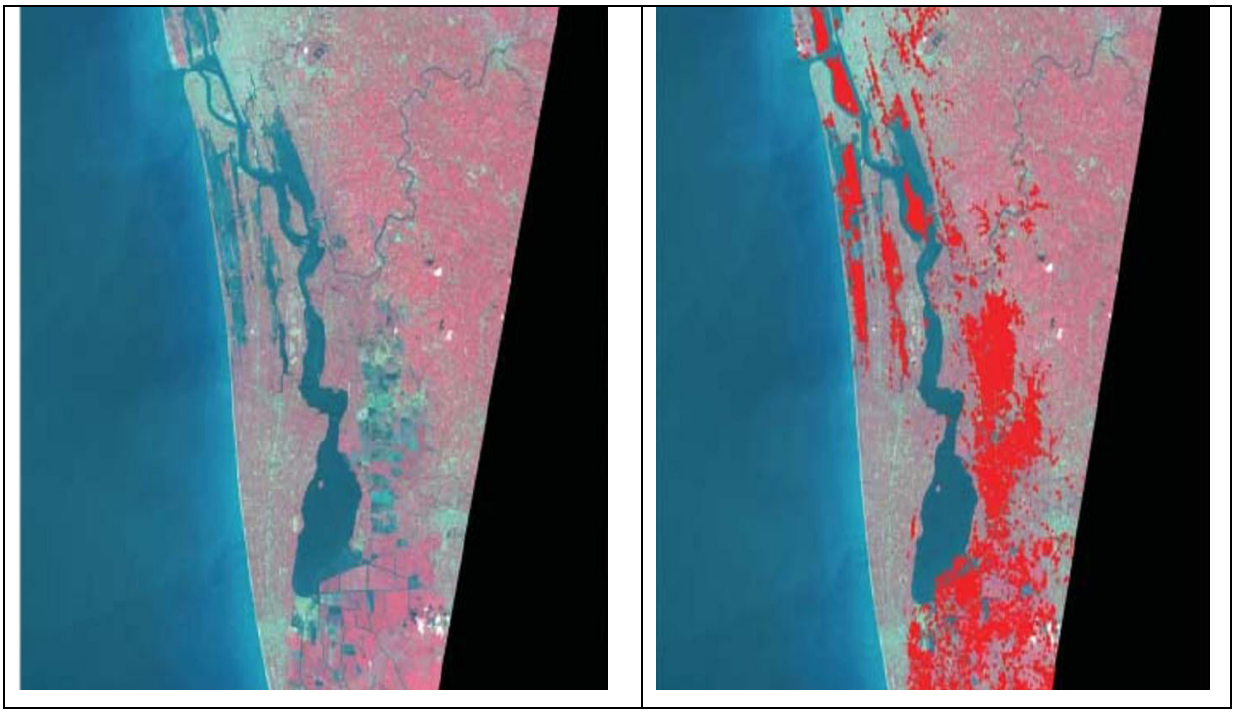


Fig. 4.8 Present and projected inundation area in satellite images. Source. Climate Change and India. 4*4 assessments.

Fig. 4.8 gives the satellite images, with the first one showing the current position of Kochi and second one showing inundation areas (red marks) for a 1 meter sea level rise in Kochi. It clearly shows that coastal region of Kerala is one of most vulnerable region in the country due to projected sea level rise. It is now established that the sea level is on the rise due to global warming and the projected Sea Level Rise (SLR) along Kerala coast on a conservative estimation is about 100 to 200 mm over the next 100 years[4]. Vulnerability to SLR would be of alarming to the majority coastal communities which live on sandy coasts, most of which are barrier beaches or spits. Backwater banks, islands and filtration ponds/paddy fields are other sections of the coastal zone which are highly susceptible to Sea Level Rise.

[4] . Climate Change and India. 4*4 assessments.

5. Climate Change Vulnerability Assessment of Kerala

5.1 Background

Vulnerability assessment is the process of identifying, quantifying, and prioritizing (or ranking) the vulnerabilities in a system. Within the range of climate change studies the most vulnerable are considered to be those who are most exposed to hazard, who possess limited resources to cope, heavily dependent on subsistence activities involving extraction natural resources and who have least resilience to climate shocks (Bohle, Bowling and Watts 1994)

Understanding the regional and local dimensions of vulnerability is therefore essential to develop appropriate and targeted adaptation efforts. Assessment of vulnerability to climate variability and change broadly helps in

• Understanding current vulnerability.

• Identify the factors that render some districts more vulnerable than others.

• Inform and facilitate the decision-making process.

• Selection of adaptation strategies and practices

To date, hardly any studies providing through, comprehensive socio economic or environmental assessment of where the state is vulnerable from future Climate Change when and from what specific climate change impacts. Based on some general understanding of climate change and profile of the state following paragraphs depict the vulnerability to climate change

5.2 Climate Change Vulnerability Profile of Kerala

Vulnerability to climate change can be considered to be high in state due to unique social, economic, environmental and physical conditions that amplify susceptibility to negative impacts and contribute to low capacity to cope with and adapt to climate related hazards. Generally vulnerability profile of the state towards climate change as follows

- Kerala constitutes only 1.18 % of the total areas of India but accounts for about 3.1 % of Indian's population. The density of population is 859 persons/ sq. km which are the three times as densely settled as rest of India.
- High dependency of the state's socio-economic nature to climate sensitive sectors like Agriculture, fisheries and forests.
- Multi Hazards profile of the states which is more exposed to climate related hazards like flood and droughts.
- Kerala has a very long coastline of 570 km, out of which 322 km is prone to sever sea erosion.
- Occurrence of many fragile ecosystem of the state like Mangroves, Shola forest and Tropical evergreen forest, river Pozhi and Azhi etc and many biodiversity regions.

- Reduction in the availability of fresh water and impacts on agriculture production and food security due to predicted decline of rainfall.
- Boundary shifts for different forest types, with consequent implication for species diversity and forest dependent communities.
- Threats of sea level rise in the low lying areas along the coastal areas of the state.
- Changes of virulence and disease pattern especially vector borne and water borne diseases.
- Increase energy demands and subsequent impacts on climate sensitive infrastructure.
- Land degradation may also be exacerbated in the state, posing additional threats to human well-being and development if human pressures on lands intensify.

5.3 Coastal Kerala is risky zone to climate change impacts

The coastline of the state of Kerala is 580 km long where it consists of nine districts. The total areas of coastal districts are 22418 sq. km with population density of 2022/sq. km (2001 census) as against 859/sq. km in the state. It has the concentration of major population centers at low elevations including all five Corporations of the state i.e. Thiruvananthapuram, Kollam, Ernakulam, Trissur and Kozhikode. Coastal areas have vibrant geographical area in the state which influences all sectors of the state economy. The human presence, influence and activity of the coastal areas have reached in every parts of the state. Moreover natural ecosystems of the coast are gifted with beaches, dunes, barrier, beaches, salt marches, lagoons, backwater, mangroves forest and estuaries.

Coastal region of state will be particularly vulnerable to the climate change of present and anticipated risk. It is estimated that sea level rise by 3.5 to 34.6 inches between 1990 and 2100 would result in salinity intrusion to coastal groundwater, endangering wetlands and inundating valuable land and coastal communities and the most vulnerable stretches along the western Indian coast are parts of the Konkan coast and south Kerala (India's Second National Communication to UNFCC). It is also assessed that the sea level rise is 1.0 m and 2.0 m respectively 169 sq. km and 599 sq. km will be inundated in the coastal regions of surrounding Kochi. Another study shows if the sea level rise increase by 0.5 metre then 212 sq. km of wetland may loss the in the state (Sharma and Dwivedi). This clearly indicates the vulnerability of the coastal region where even with a few millimeter rises in sea level. The potential impacts of global climate change in coastal Kerala are salinity intrusion into aquifers and rise in salinity of wetlands (Thrivikramaji, 2008). The sea level rise for Cochin during the past century is estimated at 2 cm (Emery and Aubrey, 1989; Das and Radhakrishna, 1993). But the rate of increase is accelerating. It may rise at the rate of 5 mm per year in decades to come. This will accelerate erosion and increase the risk of flooding (Nicholls et al., 1999). The shore line change assessment of Kerala coast (SASCOM) for a

The probable impacts of climate change in Kerala are listed as follows by the CWRDM

- Higher temperature, and higher rates of evaporation and transpiration
- Location- specific higher/ lower precipitation and shifting pattern of monsoon
- Increased surface runoff during monsoon causing floods and decreased summer flow
- Soil erosion leading to degradation of soils, siltation of water bodies and canals, and reduction in capacity and reservoirs
    - Higher rates of soil moisture depletion and faster drier up of soil
- Higher rates of of groundwater depletion, and declining water table
- Drying up / shrinking of ponds, tanks , lakes, wells etc
- Increased incidence of droughts, floods and landslide
- Sea level rise
- Change in sea waves and tidal inundation
- Salinity intrusion/ ingress into surface and groundwater in coastal areas
- Coastal erosion

period of 38 years from 1972-2010 showing coast is very exposed to already vulnerable to coast 63.02 % exposed to erosion. It is inferred that there will be increased coastal erosion, inundations, persistent storm events, shifts in wetlands, incursion of saline water into fresh water aquifers.

5.4 High Dependency on Climate Sensitive Sectors

The state's high dependency of climate sensitive sectors like agriculture, fisheries, forest, water resource and health, make the state vulnerable to climate change. These sectors have immense contribution of evolving current socio- economic condition and unique development scenario of the state. Same time climate change impacts on these sectors might cause drastic change in the development process of the state.

5.4.1 Agriculture- Agriculture is the mainstay of state economy and provides food and livelihood security to a substantial section of the population. Cultivated land is declining year after year across the state and production is stagnated mostly due to weather aberrations. A study conducted at International Rice Research Institute has revealed that for every 1°C rise in temperature, paddy yield declined by 10 per cent. In the projected climate change scenario, temperature rise is being experienced across the state. Thus an increase of temperature by 2°C by 2025 would affect paddy production in Kerala. With each degree rise in temperature, rice yield would be reduced

by 6 %. The crop maturity period may also get reduced, which might affect the paddy productivity drastically. This would adversely affect the state where rice is the stable food of majority of the population. Widening in temperature range along with deforestation may be detrimental to thermo-sensitive crops like cardamom, coffee, tea, cocoa and black pepper cultivation across the high ranges of Kerala. Any sort of change in climate will have a detrimental effect on the cropping seasons and cropping pattern that has been traditionally practiced in the state. Ultimately rains and temperature change will make many of the crops currently raised in the state unsuitable. Heavy pre-monsoon showers (and a lethal attack by wasps) may hit pepper production in Kerala, the main producer of the commodity in India. Increase in maximum temperature of 1-3° C during summer 2004 adversely affected thermo-sensitive crops like black pepper and cocoa in Kerala (Rao. et al., 2008). Records show that almost all the plantation crops suffered to a great extent in 1983 and 2004 due to disastrous summer droughts. Climate change and unseasonal rain in November and January over the years 2009 and 2010 had been dampened the prospects of mango farmer's in Palakkad district iof the state. Moreover, the climate projections across the high ranges indicate that the Southwest Monsoon rainfall is likely to decline, and surface air temperature and its range are likely to increase. Under such circumstances, there is a threat to thermo sensitive crops like black pepper, cardamom, tea and coffee. At the same time, arable land along the coast lines are bound to be reduced as an intrusion of saline water. Coastal erosion, submergence of shorelines could mainly affect agriculture through inundation of low lying lands.

5.4.2 Fisheries and coastal resources: Climate Change has huge implications on fisheries and coastal resources of the state. With the increasing temperature of the sea due to climate change, small fish and plants vanish first. The change in the availability of oxygen threatens almost all the species. In the state 10 species of fresh water fish have been identified as most threatened to climate change. The fish population in the surface of the sea decline fast. The changes in the pattern of the waves and pattern of the wind affect the migration of the fish. Production from marine capture fisheries has been stagnant during the past 10 years because of overfishing, unregulated fishing, habitat destruction and pollution; climate change may exacerbate this situation. Warming of water may impact fish diversity, distribution, abundance and phenology. Besides exploring northern waters, the Indian mackerel has been descending deeper as well during the last two decades (CMFRI, 2008). Some tropical fish stocks may face regional extinction. Some others may move towards higher latitudes. Coastal habitats and resources are likely to be impacted through sea level rise, warming sea temperatures, extremes of nutrient enrichment (eutrophication) and invasive species. Most fish species have a narrow range of optimum temperatures related to their basic metabolism and availability of food organisms. Even a difference of 1 degree C in seawater may affect their distribution and life processes.

5.4.3 Forest and Biodiversity – Despite immense and uncountable environmental values of forest and biodiversity in the state, it is also as a resource to the tribal and rural people for their livelihood. Moreover, various forest products are processed or marketed on a fairly large scale by industries, mainly for the consumption of urban population has significant contribution to state economy. Climate Change has the potential to cause immense deterioration to forest and biodiversity loss, affecting both individual species and their ecosystems that support Sustainable Development of the state. Devastating effects on the native habitats of many animals and plants due to climate change is likely to drive a considerable number of today's known animal and plant species to extinction. Of the 300 rare endangered species or threatened species in the Western Ghats, 159 are in Kerala. Of these 70 are herbs, 23 climbers, eight epiphytes, 15 shrubs and 43 trees. Besides, hot temperature and dry condition also increase the likelihood of forest fires in the state that eventually resulted deterioration of sizable amount forest cover in the state.

5.4.4 Water Resource: Kerala has immense potential of water resource. Climate Change is likely to impact significantly upon the water resources of the state. Though Kerala is endowed with plenty of rainfall, the state often experience scarcity of water in the midst of abundance. Climate-related warming of water resources especially lakes (Santhancotta lakes) and rivers(Bharathapuzha) that have been observed from the various parts of the state. Also due to climate variability, many lakes have exhibited prolonged stratification with decrease in surface water nutrient concentration. It also affects groundwater recharge rates and depth of groundwater. These factors lead to impending disaster in the form of severe water scarcity and saline water intrusion along the coastal areas. Destruction of freshwater lakes or conversion of wetlands aggravated the scarcity of fresh water, especially in rainfall deficit years during summer in places like Kuttanad. It has also been observed that over exploitation of ground water in certain stretches of Kerala coast has contributed to the entry of salinity into the coastal aquifers from the sea.

5.4.5 Health Risk and Climate Change - Kerala has better health indicators such as Death Rate, Infant Mortality Rate (IMR) and Expect on of Life at Birth than most States in India. However recent trends indicates that health status of the state faces the threats of re-emerging communicable diseases. Changes in the climate may causes vector-borne diseases in several ways, namely, their survival and reproduction rates, the intensity and temporal pattern of vector activity and the rates of development, survival and reproduction of pathogens within vectors. In the state, there has been witnessing unprecedented upsurge of the vector-borne diseases since 1996. Japanease encephalitis first appeared in the state in Kuttanad area in Alappuzha district in the year 1990. Dengue fever was surfaced as a new problem in the state in 1997 and has now become almost endemic in the state. Chikungunea fever, yet another arbovial disease which appeared in epidemic from during 2006-07 added a new dimension to the entire scenario of the vector borne diseases in Kerala. In 2008, World health Organization (WHO) reported

that an outbreak of Chikungunya in Kerala in the last two years (2006 and 2007) was mainly due to climate change. Climate change will have significant and far-reaching public health consequences, and these health impacts are occurring sooner than expected. Malaria is a climate-sensitive disease and its transmission dynamics are greatly affected by climatic conditions. Due to change in climate, Malaria symptoms have been reported from various places in the state and also in near future state become a malaria prone site.

5.5 Multi Extreme events profile accelerate risk of climate change

Kerala is one multi hazard prone state in the country. The state is prone to various climatic extreme events like floods, storm surges, cyclone-related torrential downpours, occasional droughts, sunstrokes and rises in sea level. State experiences increasing frequency and intensity of weather-related extremes. Changes in temperature and rainfall will lead to frequent occurrence of floods and droughts and heat waves. Recent news on the occurrence of off-seasonal natural disasters, such as pre-monsoon drought and post-monsoon flooding was as a result of changing climate in the state. Increasing off-monsoon seasonal floods and thunderstorms in some parts of Kerala, (De et al., 2005), make it important to look at the change in extreme rainfalls in the other seasons as well. Landslide is another major hazard affecting the state and is aggravated by heavy rainfall and slope failure. Lightning, though not formally included under weather extremes (disaster), has claimed 300 lives during the last 15 years . With temperature increase, convective rains with formations of thunderstorms are expected to occur frequently, increasing the lightning incidents and resultant loss of human lives. As per the BMTPC vulnerability map, the state is also susceptible to cyclonic winds. 96.9% of the total area in the state lies in the 140.4 km/h wind zone (moderate damage risk zone) and rest lies in 118.8 km/h wind zone. Climatic change may accelerate most intense cyclones in the Arabian Sea. The probable maximum storm surge height in the state is 3.5 m and minimum is 2.3. If the storm surge during high tide, the maximum surge height in the state may reach 4.2 m and minimum storm height may reach up to 3 meters. This has added significance especially because altitude of lowlands which constitutes about 54.17 % area in the state, is only 10-300 m, and the altitude of coastal plain and lagoons which constitutes about 16.40 % of the total areas is 10 m of the MSL.

5.6 Farmers, fishermen and tribal as exposed livelihood to climate change

Most vulnerable sections in the state are the people who are exposed to climate change through their livelihood and same time that are less adaptive capacity to address consequences of climate change. Famers, fishermen and tribal population are most vulnerable groups in the state to climate change whose livelihood exposed and less resilient to address the climate change. Farmers become most risky section in the state because small change in climate will drastically affect their live hood. Also fishermen in the state already under the risk of changing climate change through reduction fish production and their catch due to changing climate phenomena. The tribal in the state have least capacity to withstand from risk of climate change in the state.

5.7 Vulnerable hotspot districts: With respect to Climate change the hotspot analysis of districts in Kerala are determined based on the following considerations: hazard exposures, (flood and drought) impact on biodiversity, and impact on life, livelihood and wellbeing of inhabitants of the areas. The degree of vulnerability of climate sensitive sectors, tribal population and low performer of Human Development Index were also considered in identifying hotspots. The major climate change hotspot districts in Kerala are Alappuzha, Palaghat and hilly districts of Wayanad and Idukki. To identify this, Simple Composite Vulnerability Index was being developed in GIS Platform by combining social economical vulnerability index and environmental vulnerability index. Based on the Composite Vulnerability Index the state is classified into four groups i.e. Very High Vulnerable District, High Vulnerable District, Moderate Vulnerable and Least Vulnerable Districts (as in figure 4.1)

As per this study**,** Alappuzha and Palaghat districts are the most vulnerable to climate change exposure, as these districts having higher values of Composite Vulnerability Index. Overall, Palagaht has higher composite vulnerability index as social economic vulnerability index is an important determinant in this district. The higher percentage of population relying on agricultural related activities and is comparatively low performance in the Human Development Index and high in term of social deprivation groups. Alappuzha also showed very higher values of CVI showing exposure in terms various environmental variables like coastal wetlands, lagoons and sand beach. The district which is under very high vulnerability category lack adaptive capacity and show higher sensitivity and exposure to climate change in terms of social and environmental variables.

Four districts that are under high vulnerable groups include districts located in hilly region i.e. Idukki and Wayanad and Southern district of Thiruvananthapuram and Northern district Kannur. Hilly districts of Idukki and Wayanad have large areas of dense forest cover and shola forest comprise high values of environmental vulnerability. Kannur is also coming under these categories as it has the maximum areas of mangrove forest and other variables of environment and social factors. Thiruvananthapuram is also comes under this category since the district has medium values of in term of all the indicators.

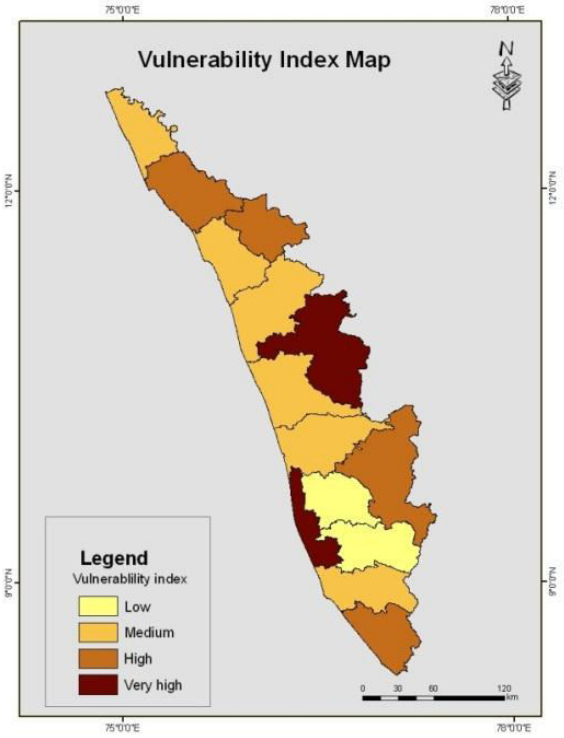


Fig 5.1. Vulnerable Districts in Kerala

5.8 Lack of Comprehensive Adaptation Strategy

In general, Kerala has many policies, strategies and plans for addressing various climate change related challenges for agriculture, water resources, forests and ecosystems, and coastal marine environment. However, the policy framework to align human development and climate change response efforts through adaptation is largely lacking in the state. The states institutional capacity to respond effectively to climate change is weak. Apart from the Directorate of Environment and Climate Change under Department Environment and other few research and development institutions at the state level (e.g. CESS, CWRDM), there is no formal institutional structure at state and local government levels to address climate change. Well acclaimed state local self-governments structure in the state has not yet started any concrete steps for dealing with climate change. There are very few people with proven competencies in the climate change issues in the state and facilities remain inadequate. Existing coping strategies are ineffective or unsustainable, and may exacerbate vulnerability to Climate change over time.

5.9 Conclusion

As mentioned above, Kerala is severely threatened by climate change and suffer from a relatively high vulnerability to present and expected impacts**.** Vulnerabilities owing to climate change have huge dimension in the state. It has already faced various types of developmental and environmental issues. Meanwhile, climate change accelerates these issues into more complicated one. Water scarcity become more, spread of vector and

water borne diseases, degradation of forest and biodiversity, decrease the agricultural production etc. are some common issues which may become severe and relevant in the future. Same time various programmes and policies taken may also become unable to address these problems successfully. In this background the local strategies to deal with climate change have to be directed towards post containing the change ensuring resilience in the existing natural resource base of the state against the influence of shock of climate change and adaptive actions based on the available and upcoming information's related to the impacts and implication of climate change.

6. Green House Gases Emission in Kerala

6.1 Background

Central Government has set up an Indian Network on Climate Change Assessment (INCCA) in 2009 for taking up compilation of climate change related information in a format which would be comparable to the global information on various related aspects. INCCA has been working on compilation since then and two reports have been published so far. First in this series has been the assessment of Green House Gas emissions and comparison between the values for 1994 and 2007. As regional/state level emission data are not available in comparable figures, state level figures may be based on the national data and projections based on per capita values.

- The net Greenhouse Gas (GHG) emissions from India, that is emissions along with LULUCF, in 2007 were 1727.71 million tons of CO_2 equivalent (eq) of which
  - CO_2 emissions were 1221.76 million tons;
  - CH_4 emissions were 20.56 million tons; and
  - N_2O emissions were 0.24 million tons
- GHG emissions from Energy, Industry, Agriculture, and Waste sectors constituted 58%, 22%, 17% and 3% of the net CO_2 eq emissions respectively.
- Energy sector emitted 1100.06 million tons of CO_2 eq, of which 719.31 million tons of CO_2 eq were emitted from electricity generation and 142.04 million tons of CO_2 eq from the transport sector.
- Industry sector emitted 412.55 million tons of CO_2 eq.
- LULUCF sector was a net sink. It sequestered 177.03 million tons of CO_2.
- India's per capita CO_2 eq emissions including LULUCF were 1.5 tons/capita in 2007.

Considering the population of the state as 3,33,87,677 (2011 census provisional figures), the total Green House Gas emissions will be 50.08 million tons. However, the actual emissions for the state could be far below this range for the fact that relative contribution of power for Energy, Industry and Agriculture sector is from hydroelectric power.

Due to the population pressure, forest areas are under threat which leads to the higher concentration of carbon dioxide in the atmosphere. Similarly coconut husk retting which is a major activity in the coastal areas of the state generates methane along with hydrogen sulphide. Fluxes from waste land are influenced by human activities like aquaculture, discharge of sewage and domestic waste. On the average, nearly 7.5 million households in Kerala need 37.5 million kg of firewood. Total assumption of all petroleum products during 2003-04 in Kerala was 3.87589 tones.

6.2 Carbon dioxide

Kerala emits only less quantity of carbon dioxide i.e only 0.94 % of the total carbon emission in the country[1]. In the year 2000 the state produces 30314.19 metric tons of carbon which is far less than most of other states in the counrty. The carbon emission of the state is very less compares that of Delhi and Rajasthan where these states have more population than Kerala. The state carbon emission in 1980 is 946.09 metric tones and it reached 30314.19 metric tones 2000 shows that there is increasing trend of emission but it is not that much alarming when compare the population rise and development activities have been taking place during this period.

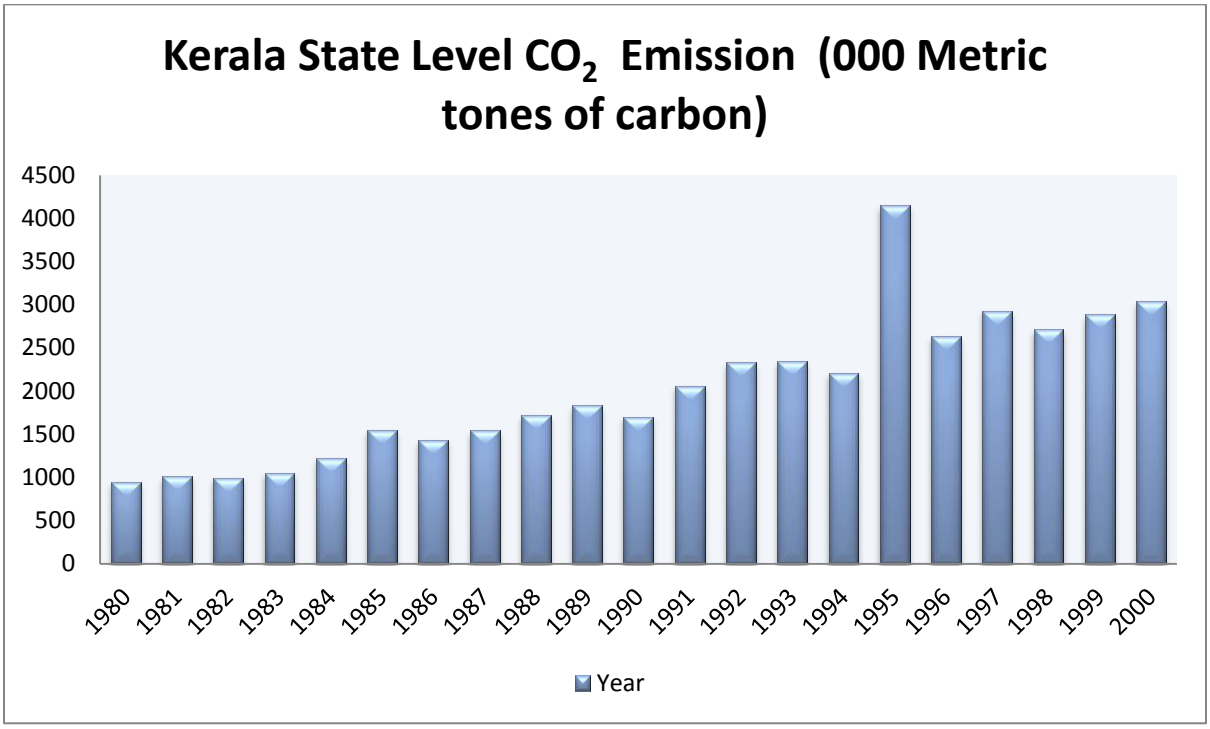


Fig 6.1. State Level CO2 Emission. Source: Contemporary issues and ideals in Social science, 2008

While looking source wise emission of carbon dioxide of the state High Speed Diesel Oil contributes its maximum in 1980 and 2000 and it contributes 31 % and 35 % respectively in these years. During same period maximum increase of CO_2 emission occurred from use LPG which has increased of 7% of growth. Share of CO_2 emission has been decreased from Coal, Kerosene, Furnase oil

[1] Ghosal Tapas and Bhattacharya Ranajoy.2002. Contemporary Issues and ideas in Social Science. State Level Carbon Dioxide Emission of India

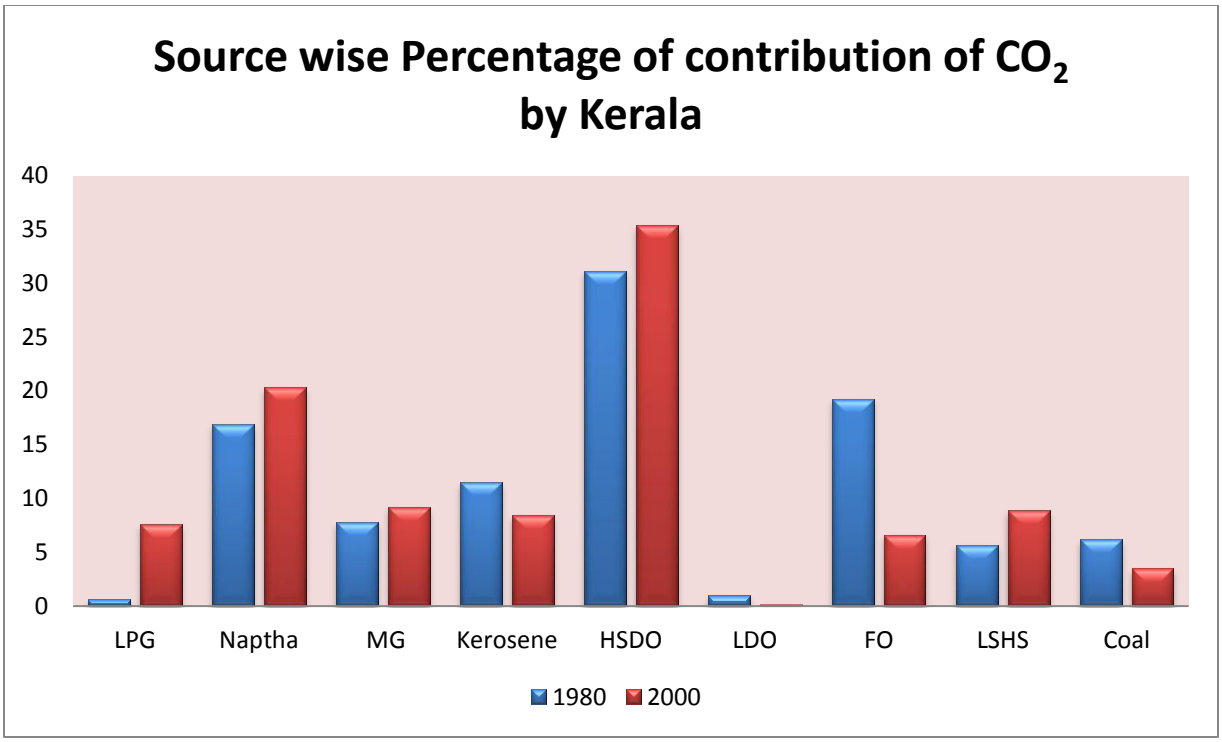


Fig 6.2 Source wise Percentage of contribution by Kerala

6.3 Methane

Methane is recognized as the second important Greenhouse Gases contribute 15 to 20 % of global warming. Methane is produced during the anaerobic decomposition of any biological matter. Wetlands, both natural and under cultivation, are major source of methane. Fluxes from the wetlands, under cultivation, depends on the agricultural practices like use of fertilizers, water logging, cultivators etc. The fluxes from the natural wetlands like lakes and estuaries are also influenced by human activities, to some extent. Aquaculture, coconut husk retting, discharge of sewerage and domestic wastes etc, are some of the major human influences on estuaries affecting methane fluxes. Other factors influencing methane fluxes from the estuaries are temperature, sediments characteristics, salinity etc.

In the state, methane is mainly produced under the anaerobic conditions existing during the cultivation of paddy. The land under cultivation of rice is factor in the production of methane. Apart from rice fields, which under certain conditions of cultivation, give rice to methane production, all wetlands emit methane from the organic carbon present. The estuary in the state contains high organic matter. For example, the range of values observed in the Vembanad lake varies from 1.72 to 11.7 % of methane in air. Organic carbon in the Ashtamudi estuary has been found to range between 8.81 to 17. 8 mg to 17. 28 mg/g during pre-monsoon periods. The corresponding ranges of values for monsoon and post monsoon periods varied from 6.68 to 11.75 mg/g and 7.59

to 12.91 mg/g respectively. Methane is also produced due to enteric fermentation in the guts of ruminant animals. Dairy cattle like cows, buffaloes, as well as farm animals contribute to the atmospheric methane

6.4 Nitrous oxide

Nitrous oxide is another greenhouse gas whole global warming potential compared to carbon dioxide. In spite of the relatively small atmospheric concentrations, this gas has significance due to high warming potential and its releases from common anthropogenic activities. Nitrous oxide is produced mainly from agriculture soil and is related to use of fertilizers.

In Kerala, the emission rate of CO_2 and other green-house gases (GHG) are comparatively low. Kerala has a critical eminence for Carbon Sequestration Potential. In the percentage of geographic area covered by forest, Kerala's rank was the fourth (Kerala: 28.9%, India: 23.4%) (GoI, 2005). The forests in state is better stocked than forests in other parts of India which shows Kerala has better carbon sink potential.

SECTION 2

This section provides an overview of identified issues and possible solutions to address following sectors. In light of the all the stakeholders consultation meetings and Public Consultation Workshops undertaken during the process of preparation of State Action Plan on Climate Change, many concerns were shared and possible solutions were suggested by the participants. The solutions that were suggested have been categorized as strategies and activities.

- ***Agriculture***
- ***Animal Husbandry***
- ***Fisheries and Coastal Ecosystem***
- ***Forestry and Biodiversity***
- ***Water Resources***
- ***Human Health***
- ***Energy***
- ***Urban Front and Transport***
- ***Tourism***
- ***ICT, Knowledge Management and Governance***

7. Agriculture

7.1 Background

The agriculture is an important subsector of the primary sector in Kerala. The sector still accounts for more than 80 % of the State Domestic Product generated within the primary sector and 33 % of the state gross domestic product[1]. Still majority of the population in the state are dependent directly or indirectly on agriculture for their livelihood. In the state out of 38, 86,287 ha of total geographical area, 26,47,461 ha of land, constituting 53.49 % is cultivated one with various crops during the year 2010-11. With these diverse topography of the state, the agricultural scenario also changes with the change in landforms. Low land is the low lying coastal belt in the west, where rice and coconut are the main crops. The high land consists of the Western Ghats mountain range forming the eastern part of the state cultivates major crops include Rubber, Spices, Coffee, and Tea. The midland, a varied terrain of small valleys and hills has a wide variety of crops like Rice, Tapioca, Cocoa, Clove, Nutmeg, Ginger, Pepper, Arecanut, Cashew, Coconut, Rubber etc.

Agricultural Statistics at a glance	
Total Geographical Area	38, 86,287 ha
Total cropped area (2011)	26,47,461 ha
Average Annual Rainfall	3225 mm
Total Population (2011)	318.39 lakhs
Density of population per sq. km (2011)	859
Agriculture Laborers	1620851
Small/ Marginal Farmers	724125
Net sown area	2071507 ha
Area sown more than once	67205 ha
Cropping intensity	127.80 %
Agriculture Laborers	1653601 (16.1%)
Cultivators	740403

The major crops[2] in the state include Coconut (7,87,769 ha); Rubber (5,17,475 ha); Paddy (2,34,265 ha); Pepper (1,53,711 ha); Banana (1,04,865 ha); Arecanut (97,492); Tapioca (87,241 ha); Coffee (84,696 ha); Cardamom (41,588 ha), Tea (36,557 ha) and Ginger (7,421 ha)[3]. Paddy, accounts for 90 % of the area under food grains and coconut, tapioca, rubber, Cashew, Pepper, Banana, Coffee, Tea, Arecanut, Cardamom and Seasamum account for 82-84 % of the area under non-food\grains crops.

[1] State Profile of Kerala 2010-11. Government of India, Economic Investigation Division
[2] Economic Review 2009
[3] Economic Review 2010

Agricultural crops in the state are broadly classified as food crops and non-food crops. Food crops are cereals & millets, sugar crops, spices & condiments, fresh fruits, vegetables, etc. The major non-food crops are rubber, betel leaves, lemon grass, etc. Another classification of crops is seasonal crops, annual crops and perennial crops which are based on their life time.

Seasonal crops: Paddy, pulses, tapioca, vegetables, sweet potato, tubers, groundnut, ginger, turmeric, cotton, tobacco, onion, tur, etc.

Annual crops: Sugarcane, banana, plantain, pineapple, betel leaves, etc.

Perennial crops: Coconut, arecanut, cashew, mango, jack, tamarind, pepper, rubber, tea, coffee, cardamom, cloves, nutmeg, cinnamon, cocoa, papaya, etc.

The production of food grains during the year under report is 524316 tones as against 600054 tones in 2009-10 recording a sudden decrease of 75738 tones or 12.62%. Rice is major constituent accounting for almost 100% of food grain production in the state.

As per the assessment of the Directorate of Economics and Statistics, the net irrigated area in the state as on March 2010, is 3.86 lakh ha. and the gross area irrigated is 4.54 lakh ha. Only 16.34 % of the net cropped area is irrigated. During 2009-10, among the crops, paddy tops among the major crop supported by irrigation. It accounted for about 37 per cent followed by Coconut (33%), Banana (8%), Arecanut (8%) and Vegetables (4%)

The nature of zone, extent of area, type of soil and principal crops for 13 agro-climatic zones[4] are given in the Table 7.1. It may be observed that rice is one of the principle crops in all the zones except in the high ranges. Coconut is also widespread. Tea, coffee, and cardamom are limited to the high ranges. River bank alluvium cuts across different zones and therefore is not computed separately for area measurem

Nature of zone	Area in %	Soil Type	Principle crops
High land	27.4	Laterite without B horizon	Rubber, coconut, cashew, arecanut
High ranges	15.9	Red loam	Tea, coffee, cardamom
North Midland (Malappuram type)	13.1	Laterite without B horizon	coconut, rice, cashew, aracanut, rubber
North Midland	11.6	Laterite without B horizon	Coconut, rice, cashew, rubber, arecanut
Southern Midland	10	Laterite with B horizon	Rubber, coconut, rice, tapioca, arecanut
Central Midland	8.2	Laterite without B horizon	Rubber, rice, coconut, tapioca, arecanut, banana
Coastal sandy (Palakkad)	4.8	sandy loam	Coconut, rice
Palakkad	3.9	Red loam	Rice, cotton, groundnut, millet

[4] Report of the committee on Agro-climatic zones and cropping pattern, Department of Agriculture, GOK (1974).

Chitoor Block	1.6	black soil	Rice, sugarcane, cotton, groundnut, millet
Onattukara	1.6	Sandy loam	Rice, coconut, tapioca, arecanut
Red loam	1	Red loam	Coconut, tapioca, rubber, rice
Kuttanad	0.9	Peat	Rice, coconut
Riverbank alluvium		Alluvium	Rice, coconut, sugarcane, aracanut

Table 7.1 Agro-Climatic Zones in Kerala (Source: Agro-climatic zones and cropping pattern, Department of Agriculture, GOK (1974).

Agriculture continues to be the mainstay and core sector of State's economy for years[5]. The provisional estimate of agricultural income of the state recorded a slight increase of 2.75 % during 2008-09. The trend in agricultural income in Kerala during the period from 2004-05 to 2009-10 shown in Table 7.2. The provisional estimate of 2009-10 indicated an increase of 0.25 % in growth over 2008-09. The share of agricultural and allied sectors in GSDP indicated a continuous decline in the state. The share was only 17.58 % during 2009-10.[6]

Year	Agriculture Income	Rate of change over previous year	Agriculture and Allied sectors	Share of Agricultural and Allied sectors in GSDP
2004-05	16980.51		20843.21	17.48
2005-06	18041.97	6.25	21882.16	17.48
2006-07	16567.85	-8.17	20507.67	17.48
2007-08	16196.6	-2.24	20255.14	17.48
2008-09	16641.7	2.75	20779.74	17.48
2009-10	16683.91	0.25	20927.91	17.48

Table 7.2 Agriculture Income of the State. (Source: Economic Review, 2010)

7.2 Policies and programmes

Some of the existing agricultural policies and programmes targeting to increase agricultural production in Kerala are very relevant in context of climate change. Watershed management programme, soil and water conservation initiatives, rain water harvesting, input availability and efficiency, promoting organic farming and insurance schemes are particularly relevant. Some of the key programmes in the agriculture sector in the states relevant in the context of climate change are given below:

- **The Kerala Conversion of Paddy Land and Wetland Bill, 2007:** This bill is intended to conserve the paddy land and wetland and to restrict the conversion or reclamation thereof in Kerala.

[5] Economic Review 2010
[6] Agriculture Statistics 2009-10, Department of Economics and Statistics, Government of Kerala

- **Insurance Schemes:** A significant contribution made as the part of rice farmer's welfare is the commencement of Kisansree, a programme for providing insurance cover to five lakh farmers in the state
- **Rashtriya Krishi Vikas Yojana (RKVY):** As per the scheme, the Government of Kerala has to prepare the State and District-level plans in the field of agriculture based on agro-climatic conditions, availability of technology and natural resources.
- **Training Institute:** Kerala has started an agricultural training institute and identified as a very important input to strengthen the micro level agricultural activities to make it more farmer-friendly and profit oriented.
- **Formation of Debt relief Commission:** Formation of Debt Relief Commission was much lauded as the state had no model in the country to emulate.
- **Organic farming:** Kerala has a remarkable share in the organic agriculture. The Department of Agriculture, the State Horticulture Mission (SHM) and the VFPCK are the major agencies supporting the organic farming directly in the state apart from NGOs.
- **Collective farming through Kumdumbashree** : Harithashree the lease land farming promoted by the State Poverty Eradication Mission, Kerala, through Kudumbashree, has helped women farmers to stay on in agriculture for their livelihood. The major crops cultivated by the Kudumbashree group is paddy (27 % of area) followed by plantation and vegetables during 2009-10 under the lease land farming

7.3 Concerns

Declining profitability of crops, shortage of farm laborers, abnormal increase in land prices and high rate of conversion of agriculture land for other uses and other various problems are faced by the agriculture sector in the state. Some of the general issues faced by the agriculture sector in the state are follows

- **Low yield:** Low yield of agricultural crops is continued to be a major problem. The state agricultural yields are far below international levels, except in the case of rubber.
- **Inefficient input and information services to farmers:** A major reason for low productivity from food crops is the increasing expenditure on inputs such as fertilizer, pesticides and herbicides.
- **Low profitability**: Rapid increase in the daily wages of farm laborers and fertilizer prices, along with relatively lower growth rates in the farm prices of agricultural products in the absence of any major improvement in farm technology have adversely affected the profitability of crops.
- **Abnormal increase in land prices:** The land is not always treated as a means of production in the state but is often regarded as an asset that can be used for speculative exchange
- **Small Farm size :** Nearly 84 percent of the holdings are small, of less than 0.5 hectare, while at the other extreme, the percentage of holding above 10 hectares is only 0.06.

- **Shortage of farm laborers :** In spite of the substantial increase in wage rates, the gap between demand the supply in the agricultural labour market has been widening in recent years.
- **Conversion of agricultural land for other uses:** Agricultural land throughout the state is being converted for the construction of residential building; commercial establishment, roads, health and educational institutions etc., and that in turn reduced the total area under cultivation.
- **Policies and Programmes:** On several occasions, policies taken at the national level proved to be unfriendly to the interests of the farmers in Kerala. Liberalized import of palm oil, rubber, spice etc. may be very important at the national level due to various policy decisions taken as a part of global and regional trade agreements. But it really kills the growth and prosperity of state farming sector.

7.4 Vulnerability

The diversity and size of state's agriculture sector creates unique opportunities and challenges with regard to Climate Change. It is considered that climate change alters both average temperature and precipitation patters, which in turn influence crop yield, pest and weed ranges and introduction and changes in growing season. Extreme events, such as floods, drought and heat waves may be among the most challenging of Climate Change for agriculture. It also effect on shift in the sowing time and length of growing seasons geographically, which would alter planting and harvesting dates of crops currently used in a particular area. Seasonal precipitation and its quantity could change due to climate change. With warmer temperature, evapotranspiration rates would rise, which would call for much greater efficiency of water use.[7] Perhaps most important of all, there would likely be increased variability in weather, which might mean more frequent extreme events such as heat waves, droughts and floods. Climate change will have far-reaching consequences for agriculture that will disproportionately affect the farmers in the state. Greater risk of crop failure and already reported crop loss due weather anomalies imposed economic loss in the state and they are likely to get far more severe as global warming continues. Crop losses were considerably high during these weather extremes.

Climate Change impacts in Crops

Variability in crop yields, decreased water availability for crop production, increased risk of extinction of already threatened crop species, reduced quantity and quality of crop produced; reduces crop and fodder productivity, increased susceptibility to pests and diseases; shift in cropping patterns.

The heavy monsoon rainfall in 2007 followed by unusual summer showers in March 2008 together adversely affected the paddy production of the State. The lull in monsoon over Kerala during 2002 followed by floods in October 2002 due to cyclonic storm over Karnataka coast devastated seasonal crops and plantations to a considerable extent across the state. Kannur received 370 mm of rainfall on 14th October 2002, which was the

[7] Rao GSHV, Kesava Rao AVR, Krishakumar K.N amd C.S Gopakumar.2009. Climate Change

highest and not received since 1924. The widespread post monsoon rainfall during 2010 devastated the paddy fields especially in upper Kuttanad and Kole lands of Thrissur. The State received record rainfall during post monsoon 2010. Low lands of southern districts were flooded due to the prolonged rainfall during November, 2010. Widening in temperature range along with deforestation may be detrimental to thermo-sensitive crops like Cardamom, Coffee, Tea, Cocoa and Black Pepper across the high ranges of the state. In the state five main factors may affect agriculture productivity, changes in temperature, precipitation, carbon dioxide, fertilization, climate variability and surface water runoff.

7.4.1 Effect of climatic changes in the state agriculture sector

Some observed effects due to climate changes on agriculture sector are

Direct

- Increased temperature enhances the metabolic activity of the plant, reduces crop duration and reduces crop yield
- Due to increase temperature, soil moisture decreases leading drought which in turn reduces the soil fertility due to increase in the organic matter decomposition.
- Increase in temperature and precipitation increases the relative humidity of the state which in turn paves way for new pests and diseases. Minor pests turn into major pest's epidermis in various agricultural region of the state.
- The excess rainfall received in low field causes scale breach of bund and over flowing of water above the bund
- Deficiency/ failure of North East Monsoon coupled with failure of summer showers led to drying up of surface water amount during summer, which are the major water resources. The meteorological droughts during monsoon and summer droughts are not uncommon across the State during the recent years
- Deficiency of rainfall adversely affects most of the perennial crops hence the summer drought adversely affects most of them in Kerala[8]. It will adversely affect crops like black pepper and cardamom as their growth, development and reproductive phase may depend on rainfall distribution.

Climate Change Impacts on Farm System

Direct crop damages due to water logging/nutrient loss, salinity ingress and water stress, crop acreage affected, delayed sowing, reduced soil fertility including soil moisture holding capacities, poverty leading to adverse impacts on farmer health;, water scarcity, land and energy concerns. damage to farm infrastructure; loss of agricultural land, natural salinity of soil is increasing due to recurrent intrusion of sea water, increase soil erosion and land subsidence in the farm areas

[8] Rao GSSHV.2010. Climate Change and Agriculture over India, PHI Learning Private Limited

- Drought is the major constraint for the crop productivity, more so in plantation crops since they are widely grown in different soil types such as sandy, sandy loam, laterite and forest soils in the state[9]. As these crops are mainly grown under the rain fed condition, productivity is affected due to the dry summer. During the period soil water deficit coupled with changes in atmospheric parameters aggravate the situation leading to soil as well as atmospheric drought.
- Dry spells vary with the location and year. The influence of varying climate in south and north Kerala on coconut production emphasizes this factor.

Climate Change impacts on food system

Production impacts, impact on market policy, food security, agro-processing units/cottage industries, self-sufficiency; impacts on emergency reserves of staple food supplies; aggravated social inequalities, temporary, permanent displacement leading to water and food insecurity,

Indirect

- Increased temperature and changes in precipitation leads to soil erosion and degradation. If left untreated, these lands are prone to laterization, desertification and may become permanently barren.
- Changes in temperature and relative humidity encourage the development of new pests, diseases, and weeds which would compete with the cultivable crop for available resources thereby adversely affecting crop production and productivity.
- Due to increased temperature, organic matter decomposition increases leading to the decreases in the C:N ratio. If the C:N ratio reduces below 10:1, it adversely affects not only the Nitrogen availability of the soil, but also the availability of other macro and micro nutrients which are essential for the normal growth of the crop.
- Increased temperature during flowering stage can lead to panic sterility in paddy which would drastically reduce the yield
- Kerala's conventional agro-climatic zones have been drawn based on water availability, soil conditions and other climatic factors. With changes in climatic condition, becoming more pronounced and perceptible, with changes in rainfall pattern, drought, increased rate of runoff causing floods and the erratic behavior of rivers, the conventional agro-climatic zone will have to be redrawn and redefined. There will be consequential impact on the crops and cropping pattern.

[9]Projection ad impacts on plantation crops in Kerala Proceeding of the National Seminar on Climate Change Adapatation Strategies in Agriculture and Allied sectores, Kerala Agriculture University, Vellanikkara, 03-04 December 2009. Pp 23-36

Impact of Climate Change on individual Crops

Paddy: Abrupt increases in temperature and monsoon uncertainties are likely to influence the production adversely. Salt water intrusion and salination of fertile rice land are becoming a problem in Kuttanad (Alappuzha and Kottayam districts) Pokkali land (Ernakulam and Alappuzha) Kaipad lands (Kannur District) and Kole land (Thrissur and Malappuram). This is also being projected as implication of climate change at the regional level. The summer rain usually comes to the state as a relief to the inhabitants in the month of March and April as it may ease the water shortage but for last few years summer rain became havoc to paddy cultivation in the state. Also, as per the 4x4 assessment, productivity of rice is likely to decrease by 4% but with slight gain in northern Kerala.

Cardamom: The inter-annual fluctuation in cardamom production was common due to weather aberration. For example, cardamom production was badly hit during 1983 due to unprecedented drought that occurred from November 1982 to May 1983 across the cardamom tract of the Western Ghats. Similar was the case during 2003-04 over Kerala. It was noticed that cardamom production over Kerala in recent years was badly hit also due to dry spells that occurred during the monsoon of 2002 and 2003. There existed a strong relationship between dry spells and cardamom production.

Cashew: Cashew is also highly weather sensitive. Despite advanced technologies in crop production and crop improvement, cashew productivity is declining over Kerala. The potent factor for low yield in recent years is nothing but weather aberration in addition to the environmental features

7.4.2 Strategies to address climate change challenges

Strategy	Activities	Implementing agency	Deliverables	Budget	
				Annual Plan	Next Five Years
Crop Improvement and management	Research on developing new varieties crops with climate extremes	Indian Cardamom Research Institute	Develop cardamom clones/varieties which are tolerant to drought/diseases	10 lakhs	50 lakhs
		Central Tuber Crops Research Institute	New genotypes of cassava mosaic resistance and drought tolerance	2 Crore	10 crore
	Use improved seeds	Agriculture Dept.	Identify suitable high yielding varieties tolerant to various abiotic and biotic stress; biotic stresses include pest and diseases	25 lakhs	2 Crore
	Diversified crops and cropping systems and changing crop type	Agriculture Dept.	Improved cropping patters with inclusion of dominant crops in highlands, midlands and lowlands	25 Lakhs	1 Crore
	Input management and enhancing input use efficiency	Agriculture Dept.	Improve agricultural technologies focusing on timing and quantity of inputs (seeds, fertilizers, pesticides etc.) and farm operations to reduce the impacts of climate	25 Lakhs	1 Crore
	Decision and	Agriculture Dept.	Forecasting of possible insect or disease based timely	20 lakhs	1 Crore

Mainstream Integrated Pest Management system	Information Support System for pest & disease surveillance		weather information. Application of Geo-informatics for real pest and disease monitoring The development of skills and attitude towards bio-intensive pest management Improving the decision making power of the farmers for pest management of their crop		
	Research on characteristics and spread of new pests due to variation climate parameters	Kerala Agriculture University	Research on climate sensitivity of infectious disease and disease classifications relevant to climate/health relationships	1 crore	5 crore
	Promote organic pest control activities	Agriculture dept.	Use of existing conventional pesticides where desirable and practicable. Incentivizing research, commercial production and marketing of bio-pesticide	1 crore	5 crore
	Strengthen laboratories on studying pest activities	Kerala Agriculture University	Research on pest activities	10 Lakhs	1 Crore
Sustainable Land Use and Management	Improve water use efficiency in the agriculture fields	Agriculture dept.	Promote various contour bunding techniques hilly and slope fields, moisture conservation pits	1 crore	5 crore
	Various soil testing assessment	Soil Survey department	Regular testing of soil and issuance of annual soil health cards that identify nutrient deficiencies of the soil for all agro climatic zones in the state	50 lakhs	2.5 crore

Promote Organic farming	Promote various organic farming practices	Agriculture dept.	Encourage various organic farming activities like crop residues, animal manures, legumes, green manures, organic wastes and bio-fertilizers, biological pest control, tillage	2 crore	10 crore
Water Use efficiency in the various agricultural practices	Developing mechanism for integrated management of rainwater, surface and ground water	Agricultural department/Water resources department	Maintain a network of small water harvesting structures in mid land and low land areas to fully exploit the high precipitation in monsoon Improved water management practices both on-farm and off-farm to increase water use efficiencies and reduce water pollution Increasing soil organic matter to heighten the water retention capacity of soils Implement in situ soil and moisture conservation techniques; .	30 lakhs	2 crore
Flood control and Drought management	Promote various irrigation feeding for areas prone to drought		Identifying major vulnerable parametres	2 crore	10 crore
	Flood and drought vulnerability Assessment of major ago-climatic region in the state	Agriculture Dept./SDMA	Preparing individual vulnerability Mapping of each agro-climatic region Risk estimation due to the expected events	1 Crore	5 Crore
Preserving buffer stock of seed	Provision to be included for construction of seeds godowns so as to ensure availability of seeds during emergency	Agriculture Dept.	Protecting local food supplies, assets and livelihoods against the effects of increasing Weather variability. Avoiding disruptions or declines in local food supplies	1 Crore	5 Crore

	situation		due to changes in temperature and precipitation regimes,		
Agro processing and cold storages	Facilitate more agro processing and cold storage centers	Agriculture Dept.	Set up more agro processing and cold storage centres across ago climactic regions in the state.	1 Crore	5 Crore
	Energy Efficient technologies and Energy Conservation in Cold Storage	Energy Management Centre	Capacity Building programme for agro processing and cold storage in Energy Efficiency & Energy Conservation, inviting application for audit and baseline data collection, energy audit and technology mapping with respect to Energy Efficiency Implementation of selected projects as domo, moniting and verification.	1 crore	10 Crore
Promote Energy Efficiency and Conservation in Agriculture practice	Energy efficient Pumping System	Energy Management Centre	Capacity building programme in pumping systems and Survey and detailsed analysis of existing pumping system Identification and replacement of selected energy inefficient system with BEE star labeled systems based on the study as a demo	1 Crore	5crore
Extend more Crop insurance Schemes	Provide separate fund in nearest commercial bank for meeting the expenses due to weather related calamities.	. Agriculture Dept.	Extent weather based insurance scheme in all intensive farming areas	2 Crore	10 crore
Provide better weather forecasting	Forecasting of short, medium and long range for weather tuned farming	Agriculture dept	Set up more weather instrument each agro climatic zones Prepare a basic cropping calendar and associated risks	1 Crore	5 crore

			for each season for three districts. Localized weather and climate information to the farmers		
Strengthening livelihoods through work and income security of farmers	Encourage group cooperation in certain farm operation with the support of agri-clinics and agri-business centers	Agriculture Dept.	Provide expert services and advice to farmers on cropping practices, technology dissemination, crop protection service, market trends and prices of crops Provide clinical services for plant and animal health which would enhance the productivity of crops	1 Crore	5 Crore
	Assistance to farmers to improve agricultural practices and diversify livelihoods	Agriculture Dept./ Kerala Agriculture University	Develop decentralised village-based agricultural processing centres as a support of local farmers Implementation of agricultural extension and training schemes and farmer-to-farmer learning programs. Strengthening of land tenure for agricultural households, strengthening and up-scaling of national microfinance scheme, increased access to veterinary services or implementation of counter-season cropping practices. Occupational diversification and skills training	1 Crore	5 Crore
Declare special agricultural zone	Identify vulnerable agricultural regions prone to various climate change impact.	Agricultural Dept./CESS/KSREC	Climate Change Vulnerability Assessment of each agro-climatic zones in the state	2 Crore	10 Crore

			Climate sensitive zones like Kuttanad region having intensive farming activities are to be declared as special agricultural zone		
Capacity building of the farmers	Awareness and assistance shall be provided to farmers for environmental modification in respect to change in climate	Agriculture dept.	Empowering farmers to better anticipate and plan for climate change Advise on cropping, water management and nutrient management practices	1 Crore	10 Crore
Strengthening research on Agriculture and Climate Change	Action research on adaptation strategy for mitigating and adverse impacts of climate change for enhancing crop production	Kerala Agriculture University/ Agriculture dept.	Information system within the department needs to be strengthened with focus on collection of baseline data and system to measure changes periodically with climate change impacts Provide adequate research facilities to existing agriculture universities and state agriculture research laboratories	1 Crore	4 Crore
Total				**24.30 Crore**	**126.5 Crore**

8. Animals Husbandry

8.1 Background

Animal Husbandry sector in the state is a major contributor to Gross State Domestic Product (GSDP). In 2010-11 this sector generated an output comprised 4% of GDP and 26 % of the agriculture GDP. In the state, majority of livestock owning farmers are either small and marginal or even landless. In view of its suitability for combining with crop sub sector and sustainability as a household enterprise with the active involvement of women, it is emerging as a very popular supplementary avocation in the small farms.

In Kerala, nearly 94 per cent of the livestock population is concentrated in rural areas, 80 per cent of the livestock farmers are marginal farmers and agricultural labourers. About 5 lakh are dependent solely on livestock for their livelihood where as another 5 lakh depends on livestock as a subsidiary means for supporting their livelihood. Women constitute 60 per cent of the workforce in this sector. Most of the cattle holdings are one cow farms. Nearly 65 per cent of the meat required for the state is met from animals of neighboring States

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Cattle wealth is the main stay of the rural economy in the state. The growth rate in milk production from 2006-07 to 2010 is in a tune of 6.12%. Also the egg production gained a growth of 8.13 % for the above period. The milk production during 2009-10 was 25.37 lakh tonnes and 2010-11 was 26.43 lakh tonnes. Similarly the egg production during 2009-10 million and 2010-11 is 1685.6 million. In terms of production average milk yield production in 2009-10 is 2537 litters and production of egg is 16 lakhs and meat production is 321560 tones.

Milk Production	2537
Egg (in lakhs No)	16330
Meat Production	321560

Table 8.2 Production in 2009-10

8.2 Programmes and Policies

Several programmes -centrally sponsored, state sponsored and those of LSG plan- has been put forward by Animal Husbandry Department, Dairy Departments, Kerala Livestock Development Board, Milma, Kerala Poultry Development Corporation etc. Programmes in Animal Husbandry sector has also been initiated by other departments as RD, SC, ST as livelihood interventions. The Government has implemented various schemes to increase milk production. These include programmes like Pasugramam, M.S.D.P, Vidharbha package (by

inducting high yielding crossbred cows to the State), subsidies for promoting fodder cultivation, pedigree improvement through artificial insemination, calf feed subsidy, welfare fund scheme and other welfare activities for the dairy farmers.

8.3 Concern

The major factor affecting enhanced milk production in the State is the high cost of production compared to that of the neighboring States. It is difficult to establish equilibrium between the procurement and selling prices without hurting both rural producers and urban consumers. The high cost of production calls for a higher price for the product. Further it will result in the flooding of cheaper milk from neighboring States that creates problem for our producers

Higher temperatures and changing rainfall patterns can enhance the spread of existing vector borne diseases *(Bhattacharya et al, 2006)* and macro parasites, accompanied by the emergence of new livestock diseases. Temperature and humidity variations could also have a significant association with bacterial, viral and increased helminth infections, protozoan diseases such as Trypanosomiasis and Babesiasis. Some of the viral diseases (PPR) may also reappear affecting small ruminant population as well. Frequency of incidences of mastitis and foot diseases among crossbred cows and other animals with high productivity may increase due to increase in the number of stressful days.

8.4 Vulnerability

Observation is done by present available resource due to changing climate, it is found that the farmers will get a set back by decreased production of milk and egg in the coming years especially duing the summer period. The production reduction will be atleast 10 % less of the expected quantity of production of milk and egg. In this way the livestock sector will be suffering a loss of atleast 30 crores and poultry sector may be a loss of 1.8 crores. The total reduction in production alone will be approximately Rs 31.8 crores in the Animals Husbandary sector

Climate Change Impact in Animal Husbandry

Productivity of animals is being affected due to heat stress; new diseases and change in pattern of existing diseases observed; large numbers of animals is unproductive and are a competition for resources; lack of sanitation, improper utilization & storage of dung, lack of balance diet for livestock, fodder and pasture land are the main concern for livestock rearing.

8.5 Strategies to address climate change challenges

Strategies	Activities	Implementing Agency	Deliverables	Budgets	
				Annual Plan	Next five years
Renovation of cattle sheds based on environmental parameters	Improve cattle sheds for alleviating heat stress in livestock	Animal Husbandry Dept.	Improve construction of cattle sheds by providing environmental parameters Improved for ventilation and automatic drinking system to alleviate heat stress	20 lakhs	1 Crore
	Encourage biogas plant to utilize the methane gas produced for energy resource (Methane Farming Project)	Animal Husbandry Dept.	Encouraging farmers to use cattle dung for bio gas generation Subsidies to farmers and technical training to set up biogas plant Plant, and practice appropriate silviculture on, fodder and other trees to provide shade for livestock	40 lakhs	2 Crore
Feed and fodder development (Improved pasture management)	Promoting mixed crop system, growing fodder on waste land, agro forestry etc.	Animal Husbandry Dept.	Plant more drought-/temperature-/flood- tolerant fodder tree species Selection of faster growing breeds. Encourage natural regeneration of, and practice appropriate silviculture on fodder Provide more slips/plants/seeds for propagation	20 lakhs	1Crore
Strengthen disease investigation system	Research on the new and emerging	Veterinary University	Study on emerging diseases due to emergence of new pest and vectors	25 lakhs	1.5 Crore

	diseases among livestock due to change in climate				
Refrigerating facility at strategic locations	Establish refrigerating facilities to preserve cattle and poultry products from damages in changed climatic condition	Animal Husbandry Dept.	Set up of more modern refrigerating facility Design and Construction of small Poultry Processing Plants	1 Crore	3 Crore
Sustainable Livelihood Approach to the Farmers	Capacity Building programmes for the farmers	Animals Husbadary Dept.	Set up of animal health camps to make farmers aware of different control measures Extend coverage of agriculture insurance to animal husbandry Training to farmers on various adaptation measures	5 Crore	20 Crore
Research on native species breeding and rearing	Focused research on cross breeding to adapt climate change	Veterinary University	Identifying and strengthening local breeds that have adapted to local climatic stress and feed sources Improving local genetics through cross-breeding with heat and diseases tolerant breeds Research on Impacts of climate change on livestock	1 Crore	5 Crore
Total				**7.85 Crore**	**33.50 Crore**

9. Fisheries and Coastal Ecosystem

9.1 Background

Fisheries sector plays an important role in the State Domestic Product of Kerala by contributing a substantial amount and it support about 3.3 % of total population in Kerala. It is an important source of livelihood for a large section of people, especially economically backward class of the state[1]. The state is abundantly rich with marine, brackish water and fresh water resources. These water bodies are inhabited by a wide variety of aquatic fauna and flora and the state occupies one of the foremost positions in the aquatic biodiversity. The fishery landing in the state comprises about 240 species including 60 species supporting major fisheries (Pillai and Goerge 2007). The fishable water comprises 24,39,000 ha within the 100 fathoms limit, backwaters form 46,130 ha, reservoirs and lakes more than 29635 ha, paddy fields suitable for prawn fisheries 12,512 ha and rivers having a length of more than 4,827 km (85,000 ha) and innumerable tanks, ponds and other similar water bodies (3,300ha). During 2008-09 total fish production in state was 666803 tonnes wherein marin sector contribute bulk share of 583150 tonnes and inalnd sector contributes only 83653 tonnes[2].

Fisheries at a Glance	
Fisheable Water (Marine)	24,39,000 ha
Fisherable Water (Inland)	95864 ha
Mairne sector production	666803 tonnes
Inland sector production	83653 tonnes
Fishing village	335
Fishermen Population	12 lakhs

Category	Potential (Lakh metric tonnes)
Oil sardines	1.11
other sardines	0.13
Promfrets	0.02
mackerels	0.49
Ribbon fishes	0.19
Penaied Prawns	0.64
Cephalopods	0.19
Others	2.94
Total	5.72

Table: 3.1. Estimated Annual Catchable Potential in 9-50 depth: Source Economic Review 2004

The continental shelf off Kerala with an average width of 60 km has a fishable area of over 38000 sq. km. Some of the fishing grounds off the Kerala coast enjoy international reputation. These include of Wedge Bank, about 60 km south off Vizhinjam, well known of its perch fisheries, the deep sea of Kollam in the slopes of the continental shelf reputed for prawns and lobsters and the pelagic fishery resources within 50 m depth range. The marine resources account for nearly 39.40 % of the marine export of India and 35.85 % of the foreign exchange earnings from sea food products. On several location along the coast between Kollam and Kannur, the annual phenomenon locally known as “chakara” is formed[3].

[1] Nair N Blachandran.1989. Summary Report of the Expert Committee of Marine Fishery Resources Management in Kerala
[2] Economic Review 2010
[3] Ammini P.L (1999) Status of marine fisheries in Kerala with reference to ban of monsoon trawling, Marine Fisheries Information service T&E, Sec,160. Pp24-36

The "chakara" forms during the south - west monsoon in June-July and consists of mud-banks which lie in the shallow sea adjacent to the coast. Thus Kerala's coastal waters account for one of the best fishing areas in the country. The fish catches from Kerala coast include more than 300 different species; the commercially important number is about 40 only[4]. The high value species among the fish catches are still few; prominent among them are seer fish, prawn, ribbon fish and mackerel. The quality of these high value species in the total catch ultimately decides the income of the fisherman.

Year	Exports	Share of Kerala to all India %
1998-99	760641	23
1999-00	92148	27
2000-01	88852	20
2001-02	72756	17
2002-03	81393	17
2003-04	76627	19
2004-05	87378	19
2005-06	97311	19
2006-07	108616	18

Table 9.2, Export of marine product from Kerala (in metric tonnes) Source: Economic Review

Geographically, inland fisheries have great scope in the state. An inimitable feature of the state is the occurrence of 49 interconnected backwaters (Kayals) which have an area of 46,129 ha. The total brackish water resources of the state is estimated as 1,43,696 ha. It is endowed with a total area of about 2,26,274 ha of fresh water. The inland fisheries consists of the estuarine fisheries and fresh water fisheries, the former confined to the extensive estuarine areas, backwaters, brackish water lagoons, river mouths and the adjoining paddy fields while the latter occurs in the rivers, reservoirs, ponds and lakes**.** Potentially the vast and varied inland fishery resources of the state are one of the richest in the country. The inland sector of the state contribute around 0.78 lakh metric tons of fish annually, which accounts for a value of Rs 30,000 lakh.

The population of fisher fold of Kerala is about 12 lakhs, which includes 8.46 lakhs in the marine sector and 3.2 lakh in the inland sector. Out of this number of active fisherman is estimated as 2.54 lakhs, of this 1.91 lakhs is in the marine sector and 0.42 lakh is in the inland sector. The fisherman settlements are spread over in 222 fishing village in marine sector and 113 villages in the inland sector. Geographically the fishing activities are mainly spread over 200 Grama Panchayat, 1 Municipality and Five Corporations. The total fisherman population in Alappuzha districts is 1.91 lakhs which is the highest fisherman populated district, followed by Thiruvananthapuram (1.88 lakhs) and Ernakulum (1.52 lakhs).

[4] CMFRI (2006) : Marine Fisheries Census. 2005.

9.2 Programmes and Policies

- The Kerala Fisherman Debt Relied Commission Act, the Fisherman Welfare Act and the Monsoon Pelagic Fishing Protection Act were enacted to address the critical issues in the Fisheries sector of Kerala.
- Debt and relief Commission is expedient to provide for urgent relief to the fisherman who is in distress due to indebtedness to constituting a commission for recommending approximate relief measures to such fisherman and for solving their problems.
- Kerala is one of the earliest states to enact the Marine Fishing Regulation Act for enforcing regulatory measures for restricting the number of fishing crafts and to ban the use of destructive nets. Kerala has a full- fledged Marine Enforcement and Vigilance Wing, consisting of officer and constables drawn from the Police Department, to assist the implementation of the Act and for undertaking search and rescue operations
- Matsyafed the short name of the Kerala State Co-operative Federation for Fisheries Development (KSCDC) is an apex federation of 654 Primary Fishermen Co-operative Societies spread over 10 districts of Kerala was formed for the upliftment of the community which takes care of welfare programmes in employment generation, motivation, extension services, commercial activities, aqua culture development and women empowerment.
- Matsya Keralam: A new programme initiated by the Government with the support of the Local Self Governments for the development of Inland fisheries and aqua culture. The objective was to enhance the fish production from inland and brackish water areas, create new employment opportunities in rural areas and to increase the export of fish and fish products by developing a well-designed marketing system for aquaculture products.

9.3 Concern

- **Deep sea fishing not tapped:** The fish resources in offshore and deep sea are not exploited due to lack of large sized vessels and fishing technology suitable for exploitation of deep - sea resources
- **Inadequate cold storage facilities :** Inadequate of cold storage facilities and cold chain in the learning centres the fishermen are not in a position to take the advantage of bumber catches
- **Lack of facilities in Landing Centers/ fishing harbors**: Due to the lack of facilities in landing centres/ fishing harbors etc. the marine product export scenario of the state have faced serious problem[5].
- **Role of middleman in fish marketing:** The fish marketing scenarios of the state is largest in the hands of middlemen and big merchants.

[5] R Korakandy.2005. Coastal Zone Management in Kerala. A Study of Political Economy and Sustainable Development. Kalpaz Publication. New Delhi

- **Usage of banned fishing practices and banned gears:** Bottom trawling, night trawling, purse seining, etc and the usage of mesh size below 20 mm in any type of gears are banned in the state with powerful act and rules. However, the effective enforcement of these lawa is yet to be realized.
- **Aquatic pollution** Lack if facilities for monitoring the marine and estuarine pollution is becoming a severe threat, which may pose hazards to the aquatic living resources. The non- biodegradable pollutants alter the aquatic ecosystem to a considerable extent.
- **Aquaculture potential yet to be tapped fully :** The potential for marine, brackish water, freshwater, cold water aquaculture and ornamental fisheries are not adequately tapped.
- **Unhygienic condition prevalent in fish markets:** Domestic fish markets do not cop with the demands of the modern society. The drainage and the waste disposal facilities of such markets were pathetic. There are insufficient facilities for parking vehicles, public comfort stations, storage facilities for fish and other perishable commodities etc in such markets.
- **General backwardness of coastal communities:** Lack of sufficient housing and other social infrastructure facilities like drinking water, sanitation, electricity etc, still haunt the coastal villages.
- **Loss of water spread area:** The massive reclamation of backwaters for the purposes of agriculture, urbanization, housing, aquaculture, port constriction, etc brought about a reduction in the extent of backwaters in Kerala
- **Threat to Biodiversity:** The biodiversity of these river system is alarmingly declining due to a variety of reasons viz obstruction in river courses, regulation and diversification of water flow, sand mining and habitat destruction, deforestation to soil erosion and unethical fishing practices.
- **Destruction of mangroves:** Destruction of mangrove led to the depletion of these fishery resources in the state.
- **Clandestine introduction of exotic fishes:** The clandestine introduction of exotic fishes and their intrusion in the natural waters are a matter of grave concern. The biodiversity of fish wealth is under threat due to the competition of such fishes with indigenous fauna for food and habitat
- **Lack of insurance schemes in shrimp/fish culture:** Insurance companies totally neglect aquaculture industry from their area of coverage due to technical and other reasons.

9.4 Vulnerability

Climate change can impact fisheries through multiple pathways[6]. Changes in water temperature, precipitation and oceanographic variables such as wind velocity, wave action and sea level rise, can bring about significant ecological and biological changes in marine and freshwater ecosystem and directly impact people whose livelihood depend on those ecosystem. Also, climate change strongly influences the distribution and abundance of fishes. The effects of increasing temperature on marine and fresh ecosystem are already evident.

Climate Change Impacts on Marine fisheries

Changes in fish yield in the sea, changes in the boundaries of fish species, water borne diseases among fishes increases, damage coastal infrastructure , stock depletion, increasing incidence of diseases among fishes, damage or loss of coastal infrastructure, loss of livelihood of fishermen and coastal inhabitants, changes in product

In order to assess the effects of changing climate related physical chemical parameters of the sea on fisheries resources of Kerala, the historical data of available physiological parameters in general and Sea Surface Temperature (SST) in particular and the marine fish landing during 1960 -2009 were analyzed by Centre Marine Fisheries Research Institute. An increasing trend was observed during the past 50 years in the study. The Sea Surface Temperature (SST) values ranged from 28.0°C to 28.6°C during this period which indicates an increase of 0.6 °C in SST.

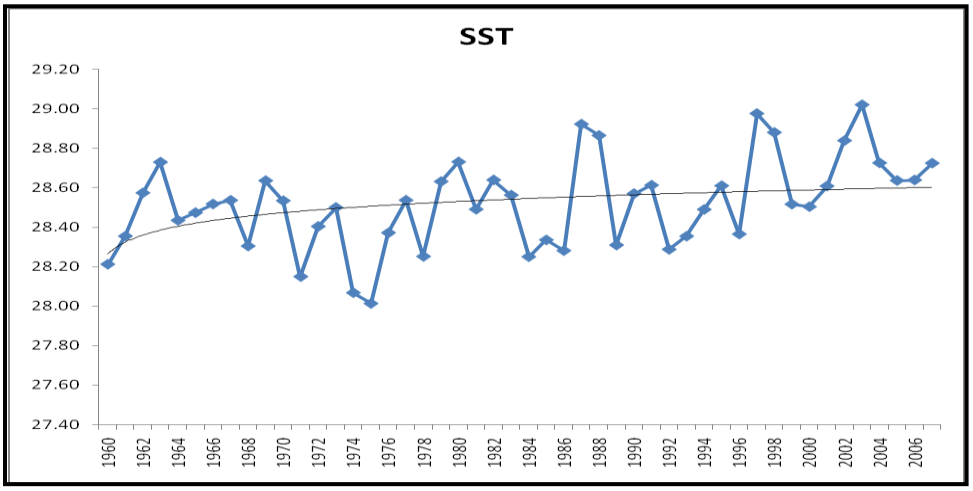


Fig. 4.1 Trend of Sea Surface Temperature during 1960 to 2008

[6] Lehodey,P, Alheit J, Barange M et al (2006) ' Climate Variability, fish and fisheries, Journal of Climate ,Vol 10, Pp5009-5030

The increase Sea Surface Temperature due to the climate change results in change in the life history traits of fishes especially the pelagic group of fishes[7]. The resultant increase in temperature leads to faster growth, early maturity thereby decrease in longevity (life span) of fishes. This increase in growth rate is attributed to their increased metabolic rate. The increasing trend of cephalopod landing observed in the initial years of capture in Kerala fisheries is also might be attributed to this fact.

Perception of Fishermen

The traditional fishing community depends on their daily catches for survival and they also depend on their own calculations of fish availability during every season. These calculations based on thousands of years collective wisdom of the fishing community is today being upset with present crisis. Rains do not pour when they are supposed to. When it does not rain, there is a drought and when it rains there are floods. The patterns of the winds have also changed with more and more storms in the coastal

Also Kerala is traditional home for sardines and mackerels, the two species have moved away from local waters and also shifted to deeper waters. Several important species of fish and high-value shrimp too have become rare in the catches, while some traditional species in Vembanad Lake have reportedly disappeared. Same time puffer fish has become abundant and are seen as a major cause of destruction of fishing nets. While the overall number of fishing days by small scale boats has decreased, the number has increased (over fewer fishing trips) in case of the larger fishing vessels like trawlers. The main shoreline change in many villages has been the virtual disappearance of beaches

The coastal biodiversity of Kerala is also vulnerable to projected climate change scenario[8]. Potential decline in mangrove forest habitat resulting from sea level rise, changes in sediments and pollutant loading from river and lake basin combined with land reclamation for agriculture or overexploitation could also impact on fisheries by reducing or degrading critical coastal habitats. Mangrove forest loss for instance can negatively affect the diversity of benthic invertebrates such as tiger prawns or mud crabs. The degradation of coastal wetlands is linked to be continuing problem due to climate change.

Climate Change impact on Inland fisheries: stress on fish species due to depletion of inland water bodies, decreased fish pawning, increased water borne diseases among fishes, outbreak of diseases during drought in inland water bodies, heavy deposit of silt during heavy flood events, Inland fish seed availability get affected.

[7] CMFRI(2008) Research Highlights 2007-2008. Central Marine Fisheries Research Institute, Cochin, Kerala
[8] James, PSBR. 1992. The Indian Marine Fisheries Resources- Past, present and future. Indian Journal of Fisheries, 39 , Pp1-4

9.5 Strategies to address climate change concerns

Strategies	Activities	Implementing Agency	Deliverables	Budget	
				Annual Plan	Budget for next five years
Promote Sustainable inland fisheries activities	Sustainable fish stock enhancement and livelihood improvement of fishermen encaged in inland fisheries	Fisheries Dept.	The protected fishery domain of small-scale fishing and medium-scale fishing the inland water bodies. Stock in the natural water bodies of the fish-scarce provinces Destroying weeds in the inland water bodies. Promote fish seed production stations to produce enough fingerlings for stocking programmes.	20 Crore	100 Crore
	Promotion of conventional fish farming systems	Fisheries Dept.	Fish production in inland waters will be increased through introduction of fish pens and cages.	5 Crore	20 Crore
Establish Fish sanctuaries (Inland Fisheries)	Identify potential areas for conservation of inland fisheries species	FIRMA	Identify and protect valuable areas (inland water bodies) Ensuring supply of fish seed for augmenting availability.	5 Crore	50 Croe
Designate more fish multiplication and rearing centers	Propagation of indigenous and commercially important inland fishes	Kerala State Biodiversity Board	Conservation of fish diversity of Vellayani and Shathamkotta Lakes and enhanced food security **Deliverables** Local technical capacity enhanced to diversity livelihood/income generation and enhanced food	4 Lakhs	20 Lakhs

			security and nutrition Protection of biological and cultural diversity Enrichment of local fish stock in water bodies Capacity building to fishermen in improved fishery technology		
Mangrove Conservation	Specific programme for Mangrove Plantation	Fisheries Dept.	Mangrove plantation along the canals, ponds and other water bodies in the coastal region for the conservation of bio-diversity	4 Crore	20 Crore
Management of diseases	Monitoring diseases incidence in aquaculture	FIRMA Fisheries Dept.	Study diseases on inland aquaculture due to change climate parameters and other pollution reason	2 Crore	20 Crore
Carbon footprint reduction methods in the fishery sector	Improving energy efficiency in the fisheries sector	Fisheries Dept./FIMA	Promotion of fuel-efficient methods, support low impact aquaculture, increase energy efficiency for fishing and storage methods Minimizing the carbon footprint from fishing vessels by Install an electronic fuel meter to help monitor fuel consumption and establish an optimum steaming speed. Up gradation of fishing crafts for fishing with energy efficient and low emission\ engines. Incorporate renewable energy based drying and process	20 Crore	100 Crore
	Rehabilitation of marine fishermen to other areas	Fisheries Dept./ SDAM	Identify the most vulnerable fishing community settlement exposed sea erosion, coastal flooding etc. Participatory assessment of	10 Crore	50 Crore

Sustainable Livelihood Approach of fishermen Community			fishermen vulnerabilities and adaptive capacity		
	Ensuring safety of fishermen at sea, vessel tracking, design disaster response, early warning system etc,	Fisheries Dept. Disaster Management Department Institute of Land Disaster Management	Improved communication networks an Weather warning systems Training to fishermen on teach data gathering and interpretation of data Improved vessel stability/safety Revamping the VHF and public alert system in coastal village implemented by Disaster Management Department Disaster response training programme for fisher-community	3 Crore	20 Crore
	Economic and social empowerment of fisher women by popularizing microenterprises and Self Help Group	Fisheries Dept.	Awareness of the causes and consequences of climate change in order to sensitize fisher women on the dangers of climate change and to the possible requirements/mechanisms of adaptation to evaluate fisherwomen SHGs in terms of their participation in different livelihood programmes and utilization of microcredit Implement micro-insurance policy for the SHGs for womens	2 Crore	10 Crore
	Alternate employment and livelihood shall be created to the fishermen and their families especially investing in education and training for alternative occupations.	Fisheries Dept.	Develop Diversify livelihood portfolio programmes of fishermen (e.g. non fisheries economic activities Promotion of mixed farming system (For integrated rice, vegetables and animal husbandry practices with fish culture)	5 Crore	15 Core

	Insurance and social safety scheme shall be developed in the fisheries sector		Implement special insurance scheme of small scale fishermen	1 Crore	5 Crore
Climate Change related projects for fisheries sector	Set up climate Change Centre at Kerala University of Fisheries and Ocean Studies	KUFOS	Strengthens Kerala Universities of Fisheries and Ocean Studies to start climate change faculty for taken academic related activities	50 Lakhs	1 Crore
	Project: Sustainable Coastal Activities	Physical Oceanography Division	Assessment of near shore dynamics of Kerala Coast and marine hazard vulnerability assessment	50 lakhs	2 Crore
	Project: Wetland Conservation	Environment and Climate Change Dept.	Assess wetland vulnerability to climate change	50 lakhs	2 Crore
	Project: Coastal Ecosystem Conservation	Environment and Climate Change Dept.	Protect various fragile coastal ecosystem from the projected impacts of climate change Climate Change Vulnerability Assessment of Coastal fragile ecosystem.	25 lakhs	1 Crore
Total				**78.79 Crore**	**417.2 Crore**

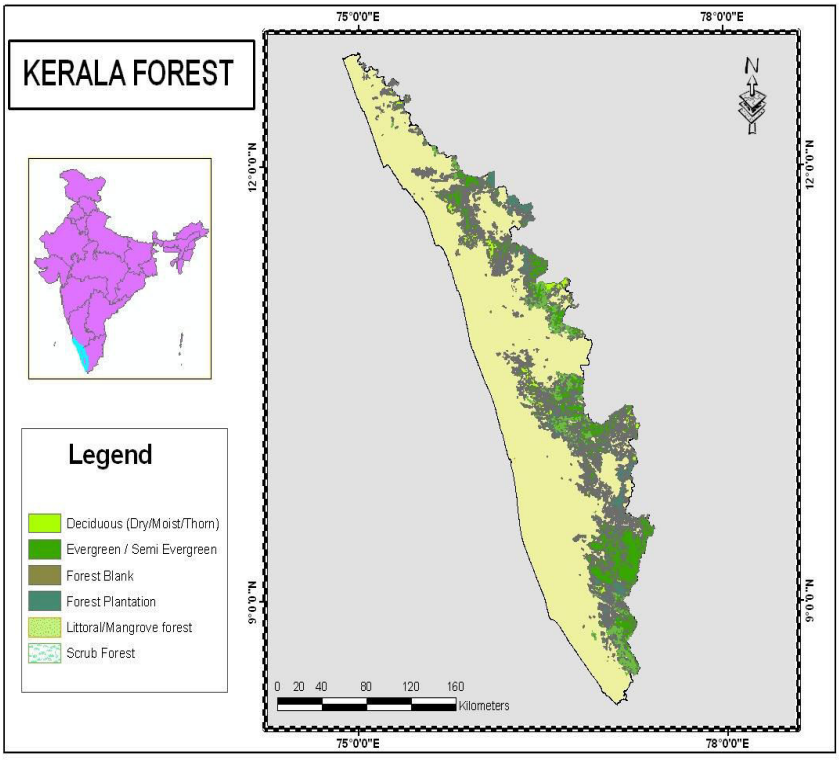
10. Forest and Biodiversity

10.1 Background

Forest of Kerala falls in two bio-geographic province of Western Ghats and West Coast, and has rich in bio-diversity. The recorded forest area in the State is 11,309.48 sq.km which constitutes 29.10 % of State's geographical area. The State has 5 National Parks and 17 Wildlife Sanctuaries constituted in an areas of 3213. 2372 sq. km which constitutes 6.12% of the State's geographical area. Also state has two Biosphere Reserves combined an area of 4738.8 sq.km.

Forest Statistics at a Glance	
Geographical area of State	38,863 sq.km
Total Forest Area in the State	11,309.48 sq.km
Reserve forest	9146.30 sq. km
% of the forest areas	29.10%
Scheduled Tribe Population (2001 Census)	3,64,189
Tribal Population	364189
No. of Tribal Settlements	705
Per Capita Land (as per 2001 Census)	0.122 Ha
Per Capita Forest Land (as per 2001 Census)	0.036 Ha
Revenue from Forest (Rs. in lakhs)	27409.58
Forest under Protected Areas	3213.23 sq. km

Huge spectrum of flora and fauna has its home in this verdant state. Forest of Kerala has a rich and varied biodiversity encompassing a wide spectrum of landforms of midlands and highlands with varied ecological niches vegetation includes tropical wet evergreen forests, tropical moist deciduous forests, tropical dry deciduous forests, shola forests and grasslands. Forest type shows wide variation ranging from tropical wet evergreen to tropical dry deciduous**.** The predominant three broad types are tropical moist deciduous forest from the plains to 750 MSL, tropical wet evergreen forest in the mountain of Ghats and tropical semi evergreen forest between these two types.



As per the classification of forest area in Kerala in the context of land utilization in the year 2011 shows that 79.43 % of the area is under dense forest and 13 % of the area is under plantations, while 7 % of the areas are given to other[1]. The forests contribute substantially to the non tax revenue of the state. The revenue from the forestry sector by way of sale of timber and other forest products come to Rs 272.8 crores in 2009-10. The forest of Kerala is mainly classified into seven major categories (Table 10.1).

Forest type	Area (sq.km)	% of the total area
Tropical wet evergreen and Semi Evergreen	3877.4413	34.28
Tropical Moist Deciduous Forest	3615. 98	31.97
Tropical Dry deciduous forest	391.3636	3.46
Mountain Sub Tropical Temperate Sholas	386.4210	3.42
Plantation	1492.9166	13.20
Grasslands	501.0866	4.43
Others	1044	9.24
Total	11309.4754	

Table 10.1 Forest Type in Kerala. Source: Forest Statistics , 2011

In the state of Kerala, there are 22 protected areas including 17 Wildlife Sanctuaries and 5 National Parks[2]. Special projects were initiated for the conservation of rare, endemic and endangered species like the tiger and elephants. Project Tiger launched in 1973 at the national level was implemented in Periyar in Kerala in 1978 and Project Elephant in 1991-92. During the year 2010-2011 Kerala has 3213.2372 sq. km of forests under protected areas (National Parks and Wild Life Sanctuaries) and forms 28.41 % of the total forest areas

Sl No	Type	Number	Area (km^2)
1	National Parks	5	355.5
2	Wildlife Sanctuaries	17	3211.7372
3	Biosphere Reserves	2	3283.40
4	Community Reserve	1	1.5

Table 10.2 Protected areas of the state. Source: Forest Statistics, 2011

[1] Forest Statistics 2011, Kerala Forest Department
[2] http://www.forest.kerala.gov.in/index.php?option=com_content&view=article&id=326&Itemid=280

10.2 Biodiversity

Kerala, hailed as the bio diversity paradise of India, accommodates the culture of over two hundred plant species in its wet, garden and dry lands making it an ever green tract of unique ecological significance. The biodiversity richness of Kerala is well known (Table 10.3). The forest of the state, falling the Western Ghats from the part of a biodiversity hotspot, a concept developed by noted ecologist Norman Myers in 1988.

Group of living organism	No of species			Percentage of India to world	Percentage of Kerala to India
	World	India	Kerala		
Mammals	45000	430	102	9.55	23.72
Birds	9700	1224	475	11.5	38.5
Reptiles	6500	448	187	6.89	41.74
Amphibians	4000	224	137	5.6	61.16
Fishes	21000	2546	202	12.12	7.9
Flowering plants	250000	15000	387	6	25.81
Total	295700	19872	4975	6.72	25.03

Table 10.3 Biodiversity of the state. Source: Economic Review 2004

Kerala having land areas of only about 1.12 percent of the country houses about 25 % of the biodiversity of the county.

Sl. No	Group	No. of Species
1	Mammals	145
2	Birds	486
3	Reptiles	164
4	Amphibians	85
5	Freshwater Fishes	196
6	Insects	4027
	TOTAL	**5103**

Table 10.4 Totals No. of Species Diversity in the state

Kerala on the windward side of the Southern Western Ghats stretching along the western coast is biogeographically the most important region in India. Western Ghats represents one of 34 hot spots of bio-diversity and is considered to be a repository of endemic, rare, and endangered flora and fauna[3]. The three main centers of endemism in the southern Western Ghats, Agathymala, Anamala, and Silent valley are located in the state. More than 90 % (4679 species) of the flowering plants species reported from the Western Ghats are found in the state, of which 35 % (1637 species) are endemic. Out of the 337 species of vertebrates endemic to the Western Ghats., about 66 % are found in Kerala. The streams and rivers, part of the Western Ghats is considered to be an exceptional hot spot of freshwater fish diversity. Among the native ornamental fishes of the region, Red Lined Torpedo fish, Puntius denisonii, locally known as Chorakanni or Miss Kerala, has gained worldwide attention and has become one of the India's biggest exports in recent times.

[3] www.cepf.net/Documents/final.westernghatssrilanka_westernghats.ep.pdf

10.3 Mangroves

The mangrove areas in the state is distributed along the fringes of backwaters and estuaries that are inter-tidal zones of Arabian sea, Mangrove areas are confined mainly in Kasaragode, Kannur, Kozhikhode, Malappuram, Ernakulam, Kottayam, Alappuzha, Kollam and Thiruvananthapuram districts in scattered bits ((Table 10.5)

District	Basha,1991 (in ha)	Mohanandas 1997(in ha)
Thiruvananthapuram	23	15
Kollam	58	15
Alappuzha	90	25
Kottayam	80	20
Ernakulam	260	250
Thissur	21	25
Malappuram	12	100
Kozhikhode	293	200
Kannur	755	3500
Kasaraghode	79	50
Total	1671	42000

Table 10.5 Areas of Mangrove forest in Kerala, 1991 & 1997. Source: State Environment Report 2007

There are 14 true mangrove species in Kerala, mostly belonging to Aegiceras, Avicenia, Brugiera, Ceriops, Kandelia and Rhizophora, whereas mangroves associated species are quite diverse and many of them are also common in the terrestrial habitats also.

10.4 Programmes and Policies

Programmes of Kerala Forest & Wild Life Department

Kerala Forest and Wild life department has the broad mandate of conserving and expanding unique and complex natural forest of Kerala for posterity, in particular with regard to water, biodiversity, productivity, soil, environmental, historical, and cultural and aesthetic values without affecting their ecological processes. Some of the important activities of the Department are protection and enrichment of natural forest, regeneration of degraded forest, conservation of biodiversity, and wildlife, soil and moisture conservation, fire and weed management, raising and management of forest plantation, distribution of seedling to farmers, and other institutions for raising trees outside the forest, involving local communities and tribal in forest conservation through Participatory Forest Management (PFM) Programme so as to elicit their support for conservation and provide them livelihood opportunities, facilitate protection of unique habitats

outside forest areas, ecotourism, etc. Many of these activities are directly related to climate change programme.

Kerala initiatives on Green India Mission

The Green India Mission is one of the eight Missions under the National Action Plan on Climate Change (NAPCC). It recognizes that climate change phenomena will seriously affect and alter the distribution, type and quality of natural resources of the country and the associated livelihood of the people. GIM aims to address key concerns related to climate change in the forestry sector namely Adaptation, Mitigation, Vulnerability and Ecosystem Services

In this regard to address climate change, the Department of Forest has prepared a draft plan which is proposed to be implemented under Green India Mission. This perspective plan is for a period of five years for funding support of 250 crore. Plan is proposed to be implemented for 6 identified priority landscape of the state which is spread in 7 districts. Plan will be implemented through various Vana Samrakshna Samithies (VSS) and Eco development Committees (EDCs) under the umbrella of 24 Forest Development Agencies (FDA)

The main objectives of Green India Mission activities in the state are Objective

By implementing the project, it is expected that the following can be achieved:-

- To address the environmental issues of the landscape
- To improve the quality of forests
- To conserve the endangered and endemic species of the landscape
- To improve the tree cover
- To Improve soil and moisture condition
- To improve livelihood by providing more employment to the dependent communities
- To reduce dependency over forests
- To encourage people for the use of alternate fuel and energy sources
- To effectively conserve the eco system
- To create more awareness among the local people about forests and its conservation
- To conserve mangroves and sacred groves
- To combine activities of social forestry and agro forestry
- To increase forest cover in urban and peri-urban areas

Process Undertaken for Preparation of Micro Plan / Sub-landscape Plan

FDAs have done the process of preparation of perspective plans, as envisaged in the guidelines for GIM, approved by the Government of India. Perspective plans submitted by FDAs have been consolidated at State level. For the preparation of perspective plans, baseline survey of sub landscapes has conducted in the identified landscapes. Utilising the Bridge Plan fund, SFDA and FDAs have arranged training programmes on GIM for the preparation of village level micro plans. In order to prepare the perspective plan for GIM, a lot of

awareness campaigns had been carried out for VSS members, tribal communities, local village people, staff of Forest Department, NGOs and staff of other line departments. Range Level micro planning teams were formed headed by the Range Officers. Broad discussions have been carried out before preparing the micro plan.

Forest Policy and Regulations

The forests in the State in general are managed under the following legislations

- Kerala Forest Act (1961) and Amendments
- The Kerala Cattle Trespass Act, 1961
- The Kerala Cattle Trespass Rules, 1962.
- Kerala Land Reforms Act, 1963
- The Kerala Forest (Collection of Drift and Stranded Timber) Rules, 1965
- The Forest Settlement Rules, 1965
- The Kerala Private Forests (Vesting and Assignment) Act, 1971
- The Kerala Private Forests (Tribunal) Rules, 1972
- The Kerala Preservation of Private Forest Act, 1972.
- The Wildlife (Protection) Act, 1972
- The Kerala Private Forests (Vesting and Assignment) Rules, 1974
- The Kerala Private Forests (Exemption from Vesting) Rules, 1974
- The Kerala Restriction on Cutting and Destruction of Valuable Trees Act, 1974.
- The Kerala Restriction on Cutting and Destruction of Valuable Trees Rules, 1974.
- The Kerala Forest Produce Transit Rules, 1975
- Kerala Private Forests (Vesting and Assignment) Appeal Rules, 1977.
- The Kerala Forest Produce (Fixation of Selling Price) Act, 1978
- The Kerala Forest Produce (Fixation of Selling Price) Rules, 1978.
- The Forest (Conservation) Act, 1980.
- The Kerala Vested Forests (Management of Reserved Areas) Rules, 1980.
- The Kerala Rules For Payment of Compensation to Victims of Attack by Wild
- Animals, 1980.
- The Forest (Conservation) Rules, 1981.
- The Kerala Preservation of Trees And Regulation of Cultivation in Hill Areas
- Ordinance, 1983.
- The Wildlife (Protection) Licensing (Additional Matters for Consideration) Rules, 1983.
- The Kerala Forest (Grazing) Rules, 1985.
- The Kerala Preservation of Trees Act, 1986.
- The Kerala Forest Development Fund Rules, 1989.
- The Recognition of Zoo Rules, 1992.
- The Wildlife (Protection) Rules, 1995.
    - The Wildlife (Specified Plants Conditions for Possession by Licensee) Rules, 1995.
    - The Kerala Captive Elephants (Management and Maintenance) Rules, 2003.
    - The Forest (Conservation) Rules, 2003.
    - Declaration of Wild Life Stock Rules, 2003.
- The National Board for Wildlife Rules, 2003.
- Forest Right Act, 2006

10.5 Concern

- **Conversion of forest areas for non-forestry purposes:** Due to various requirements like electricity, irrigation, and drinking water, several dams have been constricted in the natural forests of the state, affecting or depleting the environment and rich biodiversity.
- **Encroachment and other illegal occupations:** Due to population pressure and need for more areas to construct dwelling houses and practice cultivation of various domestic and economic species, people of the midland and low lands is being encroached to the forest areas.
- **Plantation establishment, especially of exotic species:** In order to meet the timber and pulpwood requirement of the state, in the forested zone of the highlands, more than 70000 ha natural forests are converted into forest plantation, mainly teak and eucalypts. These plantation species are very harmful to the overall wealth of indigenous biological resources of the state.
- **Grazing:** Grazing by cattle in forest, although not rampant as elsewhere in the country, is identified as a threat to biodiversity in Kerala. Cattle grazing in forests not only remove the biomass and compete with wild herbivores but also spread contagious diseases to wild animals.
- **Forest Fire:** Fire is one of the major threats to the forests of Kerala. The effect of fire depends on the type of vegetation, frequency and intensity of fire and season of burning. Fire causes extensive damage in deciduous forests and grasslands due to heavy fuel load.
- **Eco tourism and pilgrimage:** are considered to be one of the major and increasing threats to biodiversity conservation. Approximately 13 million people visit forest areas annually either as pilgrims or visitors. The major impact of tourism and pilgrimage is littering and over-utilization of resources causing soil erosion, fire, disturbance to wild animals for feeding, ranging etc.
- **Occurrence of weeds:** Weeds are undesired plants in the cropping system as they flourish at the cost of the desired species, reducing the natural regeneration and affecting the forest composition to a great extent. A survey conducted by Sankaran and Sreenivasan (1999) revealed that in a short period of 20 years, mikania has become a serious threat to forest plantations in Kerala. The frequent cultural practices and the thin canopy especially in young plantations, act as a catalyst in promoting infestation in plantations. Periodic weeding carried out in the plantations has not been very effective in controlling the weed.
- **Incidences of pests and diseases:** Pests and diseases are part of the natural ecosystem but sometimes they assume epidemic proportions and pose threat to the useful species of plants and animals. Several such cases are reported from forest. Some of these are the teak defoliator and skeletoniser (Hybalea peura and Eutectona machaeralis) prevalent throughout teak plantations in Kerala. Similarly the wild animals are also affected by certain diseases such as anthrax, rinder pest and the like.

10.6 Vulnerability

Climate is one of the most important determinants of global vegetation patterns and has significant influence on the distribution, structure and ecology of natural eco-systems including forests. Changes in climate alter the configuration of forest eco-systems. Based on a range of vegetation modeling studies, IPCC (2007) suggests significant forest dieback towards the end of this century and beyond, especially in tropical, boreal and mountain areas. About 75 % of India's forests are projected to change in character irrespective of the nature of change by the end of the century[4].

Kerala unique in having a rich variety of forest types - from the mangroves to the shola. Change in the climatic conditions in the region results in a cascade of impacts because of the wide range of ecosystems and habitats in the State. For example, a shift in vegetation type boundaries may be expected both along a Western Ghats regions of Kerala and along an altitudinal gradient (with species adapted to the warmer, lower elevation migrating to higher altitudes). The montane regions of the Western Ghats featuring a mixture of stunned evergreen forest and grassland with ecotones are a sensitive indicator of past climate change (Sukumar et al, 1993, 1995).

10.6.1 Likely climate change impact in forest sector

The likely changes due to climate change are as follows:

- Changes in the location of optimal growing areas for given species, resulting in shifts in species composition and changes in the size of the forest estate
- Increase or decrease in the production of wood or non-timber forest products per unit area
- Changes in the type, location, or intensity of pest and disease outbreaks and fires
- Increase or decrease in the amount of carbon stored by the forest ecosystem
- Disturbances of ecosystem function
  - increased or decreased nutrient retention and litter decay rate
  - bud-break, flowering or leaf-fall out of phase with climate or pollinators
- Changes in biodiversity
  - due to unfavorable climates

[4] Ravindran, Joshi, Sukumar & Saxena, 2006. Current Science

- due to changes in disturbance or disease regimes
- due to breakdowns of symbioses processes

- Shift in the location, type, or number of forest sector jobs
- Change in forest amenity value
- Afforestation or deforestation as a result of land competition with agriculture.

Many of the impacts of climate change on forests and other natural ecosystems such as loss of biodiversity could be irreversible. In India climate change is predicted to alter existing biome types, cause forest dieback, and consequent loss of biodiversity. However, Net Primary Productivity is predicted to increase. These shifts will require adaptation of communities dependent on forest resources, as well as adjustment at the regional and national levels as shifts occur in timber production. There are very few studies addressing the impact of climate change on forests in India. Most of the earlier studies were based on GCM models and earlier versions of BIOME model that had limited capacity in categorizing plant functional types[5].

Climate Change Impact on Forest Sector

Reduction of forest cover, more plants and animals species become vulnerable and extinct, shifting the forest boundaries, tropical evergreen forest, sholas, mangrove forest etc. are exposed to loss, increased competition from exotics species, increase in forest fires as temperature increases, loss of fragile ecosystem, likely to impact wild life by impacting their habitat, increase the social vulnerability of the tribal people, increasing the incidence man animals conflict, opening of vulnerable colonization by invasive species, impact the quality and quantity of forest products, loss of endangered flora and fauna, encroachment to forest areas, water scarcity become severe in the interiors of forest, life of wild life sanctuaries, national park and other conservation sites become under risk of extreme events, loss of wild life due to various extreme events.

[5] NATCOM 2004, Ravindranath

10.6.2 Impact on Tropical Evergreen: Most evidence suggest that tropical forest may not be resilient to climate change over the long term, primarily owing to a predicted reduction in rainfall and increased drought (IPCC 2007, Malhi et al. 2009). It is predicted that much of the rain forest will change states to drier and possibly more open forests, reducing habitats, lowering regional water suppliers and becoming a far less productive forest. Sustained increase in temperature of as little as 1 degree C could be sufficient to cause change in the growth and regeneration of capacity of many tress species[6].

Climate Change and threat to Biodiversity

The Economic Review prepared by the State Planning Board, 2003 warns that a third of the State's biodiversity would vanish or would be close to extinction by 2030 unless steps are taken to check extinction of species. Of the 300 rare endangered species or threatened species in the Western Ghats, 159 are in Kerala. Of these 70 are herbs, 23 climbers, 8 epiphytes, 15 shrubs and 43 trees. Besides, 10 species of fresh water fish have been identified as most threatened. Kerala has a flora of 10,035 species, which represents 22 per cent of Indian flora. Of these, 3872 are flowering plants of which 1272 are endemic. 102 species of mammals, 476 birds, 169 reptiles, 89 amphibians and 262 species of fresh water fish are reported from Kerala. The review recalls that during the 20th century, at least 50 plant species have become extinct in the country. Describing a conservation strategy, the review says that ecologically sensitive areas have to be identified with reference to topography, hydrological regimes and have to be networked with species diversity in order to conserve the extinction of rare species of flora and fauna of the State under the projected climate change scenario.

10.6.3 Impact on Shola forest: Higher elevation (1800 m) of the Western Ghats in Kerala feature stunned montane forest (shola) and grasslands that are likely to be highly sensitive to climate change. Montane grasslands in the Western Ghats are the only habitats of the Nilgiri tahr. Enhanced CO_2 could fertilize the growth of plants such as the exotic wattles. Warmer temperatures could likewise facilitate the spread of woody plants including the invasive wattle and scotch broom. Grasslands could further reduce with adverse consequences for the tahr and montane species.

10.6.4 Impact on Mangrove forest: Climate change components that affect mangrove in the state include changes in sea level, precipitation, temperature, CO_2 concentration, health of functionally linked neighboring ecosystem, as well as human response to climate change. Mangrove habitats are subjected to immediate threat due to sea level rise because of close proximity with the sea.

10.6.7 Impacts of Wild life.

Recent evidence of animal- human conflict in the near to the forest areas in the state is observed that there is climate variability and usual weather observation inside the forest biome. This has resulted many wild

[6] Revindranath, N H and Sukumar. R. 2000. Climate Change and tropical forest in India, Climate Change,39,Pp 563-581

animals is visited nearly human settlement areas lead to incidents of human animals conflict. As it is many endangered wild life species in the state may get hit due to the negative consequences of the climate change. Climate change may adversely alter the production of biomass and fruits on which the wild animals thrive. As a result, the animals may come in direct conflict with man outside the forests.

10.6.8 Increase incidence of forest fires

The frequency and intensity of forest fires in Kerala is a major consideration in assessing the impact of climate change. Increased temperature, lower humidity and reduced precipitation can all increase risk of forest fires. During the year 2010-2011 a total of 489 no. of incidents relating to forest fire have been reported amounting for a total destruction of 2364.414 ha of forest area[7]

10.6.9 Species migration, forest succession and area changes

Each species would have a different response to a changing climate. Species with a narrow geographical range, those with poor dispersal abilities and slow growing, late successional species may be unable to adapt to rapidly changing climate. These may be replaced by fastest growing, more mobile species.

10.7 Strategies to address climate change challenges

Strategy	Activities	Implementing agency	Identified and prioritized deliverables	Budget	
				Annual Plan	Next Five Years
Special protection of unique eco-systems like shola forests, sandalwood areas, wetlands and other eco-systems	Conservation of Fresh Water swamps at Kalsamal and Asramom mangrove ecosystem	State Biodiversity Board	Improvement of habitat by fencing to delineate the land use and prevent anthropogenic intervention Reduce habitat destruction, pollution, encroachment and other development activities detrimental to biodiversity, Protecting and enhancing biodiversity Promotion of species and habitat conservation	3 lakhs	10 lakhs
Forest profile augmentation	Ecologically important biomes will be identified, surveyed and notified for preservation.	State Biodiversity Board	Identification and survey of Ecologically important biomes for notification and preservation as Biodiversity heritage sites (BHS) with community participation	5 lakhs	25 lakhs

[7] Forest Statistics 2011, Kerala Forest Department

Increasing green cover outside the forest areas	Increasing tree cover through agroforestry, urban forestry and tree-planting in rural landscapes	Forest dept.	Afforestation programmes outside forest areas with the involvement of Panchayat, local bodies, non-governmental organizations, educational institutions etc., can improve the tree planting activities Enhancement of forest seed banks and the development of new plant varieties Raising and distribution of seedlings of farmers and other institution for planting trees. A target of 1 crore seeding will be produce a year	2 crore	10 crore
Develop integrated water resource management plan for the forest areas	Lakes/wetlands conservation in forest areas.	Forest Dept.	Spring recharge and enhancing ground water recharge at areas within the forest that vulnerable to water stress due to climate change	2 Crore	10 Crore
	Vulnerability assessment of climate variability impact of water resource in the forest	KFRI	Identify critical areas within forests for soil and water conservation and management	1 Crore	5 Crore
Preventing man animals conflicts	Promote sustainable forest management programmes for the wild life to thrive within the forest area	Forest Dept.	Eco-restoration of the wildlife habitats by afforestation of fodder tree species, indigenous grasses and bamboos in blank areas and degraded forests.	1 crore	5 crore
	Identification of conflicts areas	Forest Dept./ Environment Dept.	Major, Conflict identification areas and prioritation to develop proactive strategies to curb Identification and mapping of critical elephant migration corridors and routes.	1 Crore	5 Crore
	Mobilizing community initiatives to curb the man-animal conflict	Forest Dept.	Eco-development activities in the fringe villages to reduce biotic pressure inside forest areas. establishment of alternate systems to meet sustenance need of forest-dependent human populations,	1 Crore	5 Crore

			popularization of Non-Conventional Energy systems.		
Social advancement of forest dependent communities	Training to forest communities on sustainable harvesting practices	Forest Dept.	Modifying harvesting regime based on careful analysis of factors affecting yield and harvest	1 Crore	3 Crore
	Enhancing existing capacities and role of Institutional arrangement at grassroots level	Forest Dept.	Strengthening the existing comprehensive institutional arrangement i.e Forest development Agencies (FDA), VSSs and EDS for participatory forest management	50 Lakhs	2 Crore
	Gender perceptive livelihood approaches	Forest Dept.	Identify and address the constraints which are likely to prevent women from participating in forest related activities; collaborate with women organizations in implementing the forest policy; women organizations and groups should be integrated in all forest management plans.	10 lakhs	50 lakhs
Forest Fire control measures	Identified most vulnerable areas prone to forest fires	Kerala Forest Research Institute/ Dept. of Environment and Climate Change	Mapping spatial distribution biophysical vulnerability of vegetation susceptible to forest fire	1 Crore	5 Crore
	Early detection and management including community participation in management of fires	Forest Dept.	Establishing firebreaks, buffer strips and fire lines, protecting valuable trees by removing underbrush and sheathing useful vines; relying on experienced villagers to manage the fires; implementing a monitoring system for patrolling fire-prone areas during the dry season, and building watchtowers	1 Crore	5 Crore

	Strengthening modern fire management facilities	Forest Dept.	Implement modern forest fire management facilities to curb fire threat to the critical areas	5 Crore	20 Crore
Information, Education and Communication on Biodiversity Conservation	Resource Centre for education on Biodiversity conservation at Kerala Biodiversity Park, Vallakadavu, Trivandrrum	Kerala Biodiversity Board	Develop educational material on Biodiversity Conservation, audio visual material on Biodiversity and educational programmes for school children	5 lakhs	25 lakhs
Assessment of climate vulnerability and climate change impacts on state biodiversity and forest resources	Undertake studies on indigenous tree species to assess their vulnerabilities to climate change, their carbon sequestration potential and their adaptability to changing climatic parameters	Kerala Forest Research Institute	To investigate the extent to which the species in the proposed area ares vulnerable to climate change. To explore the weather climate threshold and resilience to climate variations To investigate feasible adaptation options to mitigate the effects of climate change	1 crore	10 Crore
	Monitoring Global Climate Change Impacts In Western Ghats	National Centre for Earth Science Studies	Setting up a mountain research station preferably in the High Ranges (above 2000m) and monitoring stations one each in north and south Kerala at 1000m msl. Long-term monitoring and analysis of indicators of systemic and cumulative environmental changes in mountain regions Integrated model-based studies of environmental change in different mountain regions Process studies along altitudinal gradients and in associated headwater basins Study on sustainable land use and natural resources management at local	60 lakhs	3 Crore

			and regional scales.		
Develop forest management plans for different forest types in view of Climate Chanage	Undertake detailed study to understand impacts of climate change on forest productivity in different forest types using different climate and biodiversity models	State Biodiversity Board	Research on Impact of climate change at species level: Bamboo forest	5 lakhs	5 lakhs
	Forest management plan for highly degraded or deforested areas.	Forest Dept.	Develop forest management plan based on the current status of forest and prioritized measures that for forest regeneration	10 Lakhs	50 Lakhs
Deforestation Reduction and the carbon market	Undertake pilot projects to capture the Market based opportunities for forest conservation like REDD+, CDM etc	. Forest Dept.	Develop pilot project based REDD and CDM as per the guidelines available	2 Crore	10 crore
	Afforestation and reforestation in the identified degraded forest areas	Forest Dept.	Carry out afforestation programmes for all free land susceptible to afforestation identification of appropriate and valuable species for agroforestry/afforestation according to ecological zones and research, Afforestation programmes in degraded lands using more adaptive and fast growing tree species	2 Crore	10 Crore
Total				**22.48 Crore**	**114.75 Crore**

11. Water Resource

11.1 Background

Kerala is gifted with nature's bounty of water resources, with 44 rivers of small and medium category interconnecting backwaters and canals, several lakes and ponds of diverse capacities, streams, springs, wells and extensive wetlands and paddy field. There are several traditional; sources of water in Kerala. CWRDM (1988) has identified 236 perennial springs in the state, of which about 20 % are being utilized. CWRDM (1989) has also identified 910 ponds and tanks in Kerala with minimum water required rejuvenation. Ground Water in the state occurs under phreatic, semi-confined and confined condition in the geologic formation**.** The rapidly falling terrain, the heavy precipitation and the narrow width of the state have given rise to numerous rivers. There are 44 rivers, most of them having their source in the Western Ghats and draining into the Arabian Sea. Most of these rivers are structurally controlled, short in length, swift in flow and have steep gradient (1/250 or more) in the hill tracts. The longest river is Bharathapuzha(Length = 244 km).

Water Resources in Kerala at a glance		
Type	**Number**	**Area ha**
Rivers	44	85000
Reservoirs	53	42890
Irrigation tanks	852	2835
Check dams	80	260
Private Ponds	35763	21985
Quarry Ponds	870	341
Panchayat Ponds	6848	1487
Holy ponds	2689	480
Village ponds	185	496
Fresh water bodies	9	1620
Bunds/Barrier	0	68000

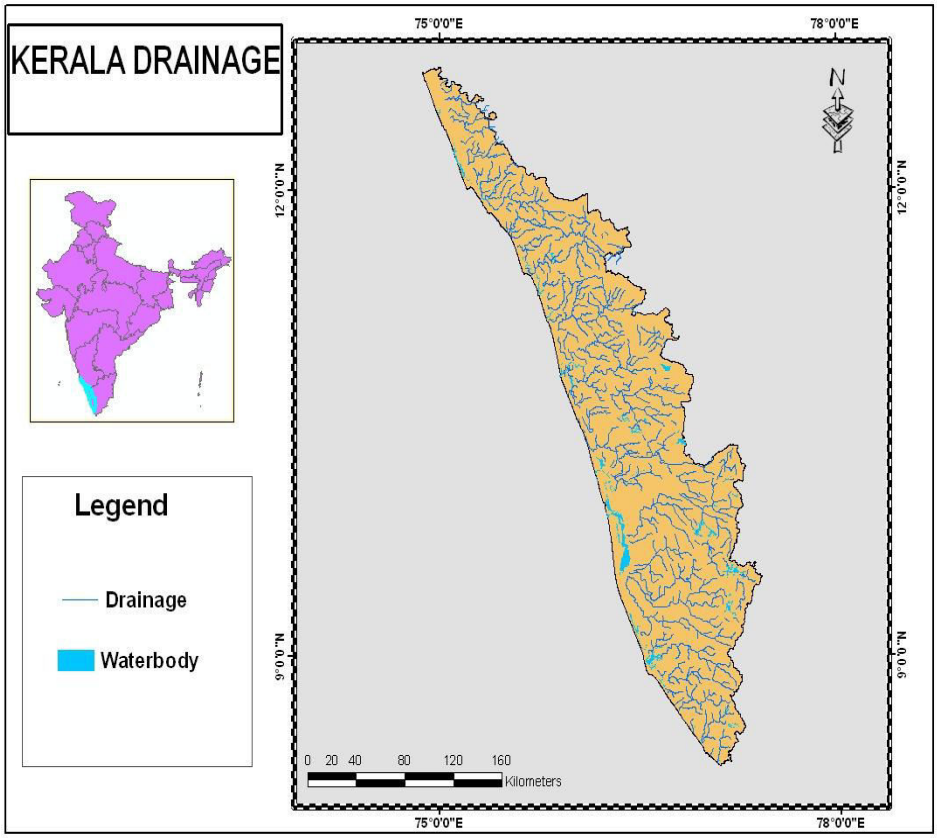


Fig 11.1 Drainage Map of Kerala

The important rivers from north to south are; Valapattanam river (110 kms.), Chaliar (69 kms.), Kadalundipuzha (130 kms.), Bharathapuzha (209 kms.), Chalakudy river (130 kms.), Periyar (244 kms), Pamba (176 kms), Achancoil (128 kms.) and Kalladayar (121

kms.). Other than these, there are 35 more small rivers and rivulets flowing down from the Ghats. Most of these rivers are navigable up to the midland region, in country crafts. Some of these rivers have a portion of their catchments in the adjoining States of Kanataka and Tamil Nadu. In addition, there are three rivers which also originate from the Western Ghats, but they flow eastwards in to the state of Karnadtaka and Tamil Nadu

The backwaters (Kayals) generally run parallel to the coast and having arms extending between the offshore bars occupy extensive area. The total area of estuaries and backwaters is 46128.94 Ha.

Fresh water is also a unique and vulnerable ecosystem in the state. Number of large and inland freshwater bodies is common in the central and southern parts of Kerala[1]; the important ones among these are the Kolelands of Trichur district, the Punchas/ Chals of Alleppey district, the Sasthakota Kayal of Quilon and Vellayani Kayal of Trivandrum. These are important geomorphologic unit in the region and have profound the agro-climatogical influence in the immediate neighborhood. The important Fresh water lakes of Kerala are given in table 11.1.

Major Estuary/ Backwater	*Area (Ha)*
Anchuthengu Kayal	521.75
Ashtamudi Kayal	6424.15
Paravoor Kayal	662.46
Vembanad Lake	5184.66
Kayamkulam Kayal	1511.75
Kochi Backwater	7503.8
Vembanad Lake	2257.89
Chettuva	713.87
Kodungallur	613.81
Ponnani Backwater	757.19
Korapuzha	1038.08
Beypore	783.74
Palakode	598.25
Valapattanam	3077.64
Chandragiri	575.81
Nileswaram	824.69
Cheruvattur	1123.12

Table 11.1 Fresh Water Lakes of Kerala. Source: Department of Fisheries

The annual replaceable groundwater resources and the net groundwater availability in Kerala are estimated at 6841 Mm^3 respectively[2]. As per the monitoring report of Central Ground Water Board, Kerala Region, the depth to ground water level in the state as monitored from the observation stations is widely varying in the range of 0.20 to 20 mbgl except in isolated areas. The present gross groundwater draft for all uses in the state is computed as 2920 Mm^3. Of this, the domestic and industrial draft accounts for 37.6 % (1099 Mm3) and irrigation accounts for 62.4% (1821 Mm^3)

[1] Water Atlas of Kerala, Centre for Water Resource Development and Management, Kozhokhode, Kerala
[2] Dynamics of ground water resource of Kerala. Central Ground Water Board, Ministry of Water Resource.

The major source of irrigation in Kerala is wells (both private and government open wells and tube wells) which irrigate 37 % of the net irrigated area, followed by private and government canals(25 %), private and government tanks /ponds (11%), minor lift irrigation (2%) and other water based-irrigated area in the state has been fluctuating around one lakh ha for the past several years. As per the assessment of the Directorate of Economics and Statistics the net irrigated area in the state as on 2003-04 is 3.81 lakh ha and the gross area irrigated is 4.27 lakh ha. Only 17.36% of the net cropped area is under irrigation. Source wise Irrigated areas is given in the table 11.2.

Source	in ha
Government Canals	94813
Private Canals	2656
Tanks	40851
Wells	125892
Other Sources	122050
Total	386262
Gross Irrigated area	454783
Net area irrigated *	16.34

Table 11.2 Source Wise Irrigated Areas

There are 18 completed and 5 ongoing irrigation projects in Kerala. Out of the 18 completed projects, 13 have storage and 5 are barrages (SPB, 2011). The storage capacity created by major and medium irrigation projects in Kerala is around 1500 Mm^3 and the gross average live storage in the reservoirs at the end of the monsoon is around 1200 Mm^3. The estimated irrigation potential of Kerala is 16 lakh ha, but there are several constrain to achieve this target. So far all the completed projects together have about 2.92 lakh ha of net and 5.51 lakh ha of gross ayacut area.

According to report of CWRDM, safe drinking water is presently accessible to 72.8 % of the total population in Kerala. With regard to the district-wise total population covered by drinking water supply schemes, Ernakulum district has the highest (96.2%) and Kozhikode district has the lowest (52.9%) coverage. In urban and rural areas of the state, 84.8 % (70.1 lakh) and 68.6% (161.6) of the corresponding total population have access to drinking water. Through various water supply schemes cover about 84.8 % of the urban population and 68.8 % of the rural population in the state. Safe drinking water was accessible to 72.77 per cent of the total population in Kerala during the period 2009-10. In urban and rural areas of the State, 84.80 per cent and 68.55 per cent of the population were covered respectively by water supply schemes as on March 2010.

11.2 Policies and Programmes

Policies and legislation related to the conservation, development and management of water resources have been evolved in both state and national levels.

Kerala Water Policy, 2008

Kerala was the first state in the country to bring out a state water policy in 1992. This policy was later modified in 2008. It is a comprehensive policy document containing objective and various issues in Kerala's

water sector. The policy parameters and initiatives are detailed in the document. This policy statement shall be supplemented with implementation strategies and operational action plan for realizing the objective of the water policy. Kerala Water Policy has been formulated for proper planning, thoughtful utilization and sustainable management of water in the state. It calls for a multidisciplinary and holistic approach that considers water as part of the ecosystem for the benefit of all and not as commodity for profit of a few.

The main objectives of the state water policy are to adopt integrated multi-sectoral approach for planning, development and management of water resources; to consider micro water shed as basic unit for water management; to address problems and prospectus of water resources of the state; to emphasis the importance of comprehensive water management practices, and to enable appropriate institutional mechanism and legal measures for sustainable water resource development and management. Stress was given to status of state water resources and various problems faced by it.

Water policy has taken various interventions in policy parameters and initiatives related to climate change. It includes the necessity of conservation, development and management of water resources based on the concept that watershed is inevitable for maintaining the ecosystem, integrity of rivers and river basin of Kerala. Prioritization in water use will be based on consideration of the physical, environmental and social background of the state. Micro watershed planning and intervention for sustainable development of water resources of the state are included in the policy. Water quality management and the safety of drinking water are also emphasized. Rainwater harvesting has been given priority due to rapid decline in ground water level due to various reasons. The delineation of drought prone areas and prioritizing it for every river basins have also been envisaged in the water policy.

Environment intervention in water sector will be given priority through preventing of salt water intrusion into drinking water sources and low lying cultivable lands and also identification of vulnerable areas for taking up remedial measures. The potential for recycling and reusing of water shall be recognized and all water users shall be directed to adopt measures through recycling for incremental reduction in water extraction. The Protection, conservation and management of wetlands shall receive special attention of the Government through legal programme initiatives.

Programmes with State Ground Water Department

- Ground Water Investigation and Development
- Scheme for control and regulation of Ground Water
- Scheme for Training Personnel
- National Hydrology Project
- Rajiv Gandhi Drinking Water Mission
- Conservation and Recharge

- Establishment of Hydrology Data Bank

Kerala Water supply and Environmental Sanitation Project

Kerala Water Authority (KWA) is responsible for the design, construction, execution, operation and maintenance of most of the water supply schemes and also for the collection and disposal of the waste water in the State of Kerala. KWA is also tasked with establishing globally accepted Standards in water supply and sewage.

- **Flood Control under Irrigation Department** The main works for flood control include flood bunds on the banks of the major rivers to bring the flood waters within the river regime thereby reducing to destruction to life and property. Strengthening of river sides by retaining walls is highly essential in Kerala's topographical condition.
- **Anti-sea erosion works** The present scenario is that a total of 331.80 Km of seawall has been newly constructed so far using State funds and Eleventh Finance Commission awards. The balance length of new seawall to be constructed is around 147Km. The reformation works are increasing year by year after every monsoon period so there can be a change in figure as regard to reformation works.

Rural Water Supply & Sanitation Project

The rural water supply & sanitation project implemented by KRWSA -"JALANIDHI" . The primary aim of this agency is to facilitate and support year – round supply of adequate quantities of potable water to the rural Kerala, through the active participation of the user group themselves. The advances made by the Peoples' Planning Programme in Kerala and successful decentralization have made participatory planning a feasible and meaningful tool in adopting a demand driven approach rather than the hitherto followed supply driven approach

11.3 Concerns

- **Salinity Intrusion:** The short, fast flowing, monsoon fed rivers of the state often encounter salinity intrusion on their lower stretches during the summer months[3].
- **Pollution of Water resources:** Rivers in Kerala are highly polluted with effluents discharged from major industries located on the banks. The pollution of groundwater sources are reported from certain urban areas in Kerala[4].

[3] E.J James.1999. Water Resource of Kerala. Status, Problem and Future strategies proceeding.Proceeding. Public Hearing on Environment and Development
[4] Radhakrishnan Nair P.2008. Water Everywhere. Kerala Calling

- **Land use changes-:** Drastic land use change for various development activities during the recent times negatively affected various water resources in the state.
- **Sand Mining:** Sand quarrying in rivers and watersheds lead to bank erosion, lowering the water table and create several environmental problems.
- **Bacterial contamination in drinking water source:** Wide spread bacteriological contamination of fecal origin exists in source of public drinking water supplies viz, traditional open dug wells, bore wells and surface sources.
- **Hydraulic modification of wetlands:**. Changes in the natural landscape through resource extraction, conservation for crops production, urbanization, altered water balance and hydraulic regimes have influenced the state of these wetlands. Various ecological problems occur in these wetlands such as eutrophication, contamination by toxic chemicals, accelerated sedimentation, excessive water diversion, fishery resource depletion, encroachment and habitat alteration.
- **Over exploitation of ground water :** It has been reported that over exploitation of ground water in certain hydrological zones has contributed to permanent lowering of water table and salinity intrusion into coastal acquires.

Climate Change Impacts in Water Resources

Profound effect on hydrological cycle, decline of level of water table, dried up rivers and other water sources, water logging, perennial rivers become seasonal, deterioration and depletion of water resource, erratic flood and drought condition, intrusion of saline water causes severe stress on availability of drinking water

11.4 Vulnerability

The general impact of climate change on water resources have been brought out by the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001). Water is one of the most important sectors on climate on which climate change (increase in temperature, evapo-transpiration, spatial variation in rainfall, and increase in intensity of extreme rainfall and drought events) can have a profound impact, which in turn have cascading impacts on other sectors. The National Water Mission which is part of the National action Plan on Climate Change identifies the threat to water resources and climate change (MoWR, 2010).

In recent times, several studies show that climate change is likely to impact significantly upon the availability of freshwater resources in India (Gosain and Rao, 2007, Mall et al, 2006 and 2007, MoWR, 2009 and 2009; Majumdar and Gosh, 2007 and Singh and Aroa., 2007). Though Kerala is endowed with plenty of rainfall, the state often experience scarcity of water in the midst of abundance. Anthropogenic activities, large scale land

use changes and climate change have serious implication on the sustainability of water resources in the state[5]. Climate change could have significant impacts of water resource in Kerala because of the close connection between the climate and hydrological cycle. Climate change increases the gravity problems in the water resource sector in the state.

According to the 4*4 assessment projections, parts of Karnataka and Kerala Western Ghats the water resources show a decrease of up to 10% in water yield by 2030. Similar reduction in water yield is projected for the Western Coastal Region. Kerala coast yield is determined by the yield of Western Ghats. Therefore an overall decrease can be expected in the state. In this circumstances actions on demand as well as supply management of water, along with adequate conservation measures will be important.

11.4.1 Climate Change impacts and water quality

A climate-related warming of water resources especially lakes and rivers have been observed in the various studies. As a result, freshwater ecosystem has shown changes in species composition, organism abundance, productivity and phonological shifts. Also due to climate variability, many lakes have exhibited prolonged stratification with decrease in surface water nutrient concentration.

11.4.2 Climate change impact on groundwater

Climate change affects groundwater recharge rates and depth of groundwater tables. Increased precipitation variability may decrease groundwater recharge in the state because more frequent heavy precipitation events may result in the infiltration capacity of the soil being exceeded more often.

11.4.3 Climate change and impact on hilly areas

The high volumes of runoff down the hills during frequent extreme rainfall events lead to landslides and hence there is no retention for recharge and there is reduced percolation of water underground. The degradation of vegetation leads to inadequate recharging of water bowls which are charged through soaking of water otherwise water quickly flows

Also the lengthening of dry period during summers has resulted in a higher incidence of forest fires down the valley and be lost and hence this has resulted in denuding of forests and disturbing associated water sheds on the mountain tops.

11.4.5 Climate change impacts on freshwater lakes

Climate change will have its most pronounced effects on inland freshwater wetlands through altered precipitation and more frequent or instance disturbances events (drought and floods). Relatively small increases in precipitation variability can significantly affect freshwater ecosystem. Generally, climate warming is expected to start a drying trend in wetland ecosystem.

[5] Climate Change and Sustainable Water Resource Management in Kerala, CWRDM, Kerala

11.4.6 Climate change impacts on estuaries

Changes in the timing and volume of freshwater runoff will affect salinity, sediment and nutrient availability and moisture regimes in coastal ecosystem. Climate change can affect each of these variables by altering precipitation and locally driven runoff or, more importantly, runoff from watersheds that drain into the coastal zone. Hydrology has a strong influence on the distribution of coastal wetland plant communities, which typically grade inland from salt, to brackish, to freshwater species.

11.5 Strategies to address climate challanges

Strategies	Activities	Implementing Agencies	Deliverables	Budget	
				Annual Plan	Next five year
Linking Irrigation and hydel reservoirs with drinking water supply	Feasibility study of linkage of irrigation and hydel reservoir with drinking water supply schemes.	Centre Water Resource Development / Irrigation Dept.	Report on water resource (domestic water supply) areas with projected water demand Identification of reservoirs near to water scarce areas and quantification temporal storage capacities of the selected reservoir Implementation of the schemes on priority basis	25 lakhs	1 Crore
	Assessment and analysis of potential, supply and demand in all water resources in the state	Centre Water Resource Development	Spatial and temporal water potential of all water resources (Surface & Ground) in all river basins of Kerala The current and projected future spatial & temporal water demand of the study area Spatial and temporal water balance of the study area Region vulnerable to water availability in the study region Management Action Plan of	1.10 Crore	3.30 Crore

			ensuring sustainable water resource availability		
Rejuvenation of rivers	Identification of point and non-point sources of pollution in the catchment area	Centre Water Resource Development	Initial water quality status before the implementation of the programme Methodology for identification of point and non-pint pollution sources Remediation and management measures for improving te water quality on pilot scale basis Identification of suitable models for assess in the pollutant movement within the soil and water bodies	25 lakhs	75 Lakhs
	Eco-restoration and pollution abatement	Centre Water Resource Development	Collection of Water, Soil and Biological Quantity Sanitation Pogramme Information education and Communication activities (IEC) Improvement in quality, prevention of encroachement and clean up pf riveres are the outputs	2 Crore	10 Crore
Revival of polluted lakes and ponds	Identify the source and non-point source pollution along the banks of Kerala	Kerala State Environment Remote Sensing Centre	Generation of location maps of industries/hospitals and other sources of pollution along the banks of river to assess the extent of pollution Generation of spatial data base of water bodies of Kerala Find out water pollution sinks-where pollution has accumulated Track pollution to its source	15 lakhs	75 lakhs
	Control anthropogenic pollution into natural water bodies	Kerala Suchitha Mission/ State Pollution Control Board	Steps shall be taken for the stoppage of pollutants into the system Identify main source of pollution Waste water from hospitals, hotels, industries should be treated according to the type of	5 Crore	30 Crore

			contamination before returning to water bodies		
Implement Water Recharge Programmes	Ground water recharge programme	Ground Water Dept.	Identification of deep aquifers, and recharge zones Increasing base flow of critical streams by ground water recharge techniques are to be implemented especially in over-exploited, critical and semi-critical blocks	2 Crore	10 Crore
	Protection and conservation of open wells and ponds	Environment Dept.	Identification and protection of ponds in the urban areas Open wells shall be protected and conserved. Onsite sanitation is to be encouraged	2 Crore	10 Crore
Promote rain water harvesting	Rain Water Harvesting should be strictly adopted in Government, public sector and private building	Water Resource dept./Irrigation dept.	Introduction of rainwater harvesting schemes in salinity affected areas.		
	Develop spatial data base on rainwater harvesting structures	Kerala State Remote Sening and Environment Centre	Generation of location maps (Panchayat wise) of Rain water Harvesting Structures including the artificial storage structures across the state Generation of maps of ponds/tanks of potential use Collection of non-spatial data of each RWH structures Integrate the non-spatial data into the location data	15 lakhs	75 laks

			Development of spatial data basin on rainwater harvesting structures.		
Recycling and reuse of grey water	Liquid Waste Management	Centre Water Resource Development	Baseline data collection and Planning Selection of Appropriate Technology Implementation of the technology and their evaluation	5 Crore	15 Crore
Increase in water use efficiency	Demonstration and evaluation o drip fertilization system for selected crops	Centre Water Resource Development	Base line crop biometric and yield characteristics, soil properties Impact of drip ferigation on crop characteristics, soil properties, water use efficiency, farm income etc.	50 Laks	2.5 Crore
	Drinking Water Programmes	Kerala Water Authority	Equipment's with highest water use efficiency mandate Leakage control should be taken as a programme and subsidies made available to the consumers concerned Flow measurement of drinking water supply for confirming permitted usage Pricing policy to be formulate which enables optimal utilization of water	1 Crore	10 Crore
	Catchments to be maintained to minimize surface runoff for facilitating percolation and ground water recharge.	CWRDM	Assessing the surface run off and quantification of erosion Methods/models top quantify the surface run off an erosion Measures to minimize the surface run off in the agricultural areas by considering the land use Monitoring the reduction in run off and erosion in the intensive cultivated areas	40 lakhs	1.20 Crore

Assessment of water resource	Integrated river basin abatement plan for Bharatapuzha.	Centre Water Resource Development	Spatial and temporal potential of the river basin Regions vulnerable to water availability in the river basin Hydro-environmental issues of the basin	1 Crore	3 Crore
	Pamba Pilot Project	Centre Water Resource Development	Integrated river basin abatement plan for ensuring sustainable water resource availability in the river bain Formulation and implementation of policies and projects for enabling the sustainable development of water resource and reservoir of the Pamba River Evolve scientific management plan for protecting the ecosystem and the environment containing various species and genetic diversity.	1 Croe	5 Crore
Establish Water data bank	Development of Water Resource data bank and decision support system	Centre Water Resource Development	Develop water resource data bank in GIS platform Status of Spatial & Temporal Water potential : State wise, district wise and river basin wise Region vulnerable to water availability Decision support system for implementing management actions for ensuring sustainable water resource availability	1 Crore	3 Crore
Total				**22.15 Crore**	**106.20 Crore**

12. Health

12.1 Background

Kerala's achievement in health has prompted much analysis to talk about a unique "Kerala Model of Health" worth emulating by other developing parts of the world. The state is much acclaimed outcomes in health care are to be large extent based on its vast network of public health institutions. The State is reported to have the lowest rural-urban inequalities in Public Health Status.

Health Indicators	Kerala	India
Birth rate ('000 population)	14.6	22.8
Death rate ('000 population)	6.6	7.4
Infant mortality rate ('000 population)	12	53
Child mortality rate 0-4 years ('000 population)	3	17
Maternal mortality rate (per lakh live birth)	110	301
Total fertility rate (children per women)	1.7	2.9
Couple protection rate (in percent)	62.3	52
Life at birth a) Male	71.4	62.6
b) Female	76	64.2
c) Total	74	63.5

Table 12.1 Basic Health Indicators of both Kerala and India 2009. Source. Health Department

India's first ever Human Development Report published in 2002, placed, Kerala on top of all the other states in India, because of easy accessibility and coverage of medical care facilities.

Kerala has become a model India state viewed in terms of view achievement in public health surveillance. Health sector development and the illness pattern in Kerala are mostly different from the other Indian states. Public institution in Kerala has played a vital role in the health care services in both urban and rural areas.

Health Infrastructure at a glance	
Primary Health Centre	835
Community Health Centre	230
Medical Colleges	18
District Hospitals	15
Ayurveda Hospitals	124
Homeopathic Hospitals	33

Table 12.2 Health Infrastructure in Kerala

Public institutions in Kerala have played a vital role in the Health Care Services in both urban and rural areas. Kerala can boast of having one of the largest networks of health institutions in the Government sector. There is no other State in India, which has at least one health institution belongs to Allopathy, Ayurveda or Homoeopathy in every Grama Panchayat. It has a three-tier system of health care, the Primary Health Centres and the Community Health Centres (CHC), Taluk and District Hospitals and the Medical Colleges evenly distributed both in the urban and the rural areas. Apart from Modern Medicine, Ayurveda, Homeopathy, and other alternative systems are also very popular in Kerala. Also state has 230 Community Health Centres, 835 Primary Health Centres, 5094 Sub

centres, 41 Sub division Hospitals and 15 district hospitals which cover every nook and corner of the state. Kerala is well equipped in terms of Hospital bed facilities. There are nearly 33 beds per 10,000 populations in the State, which is equal to that in US and other developed regions. Further out of the 1.08 lakh hospital beds in the state as in 2004, 59 per cent are in private sector and remaining 41 per cent in the government sector.

12.2 Communicable diseases scenario in the state[1]

Malaria: Malaria was successfully eradicated from the state in 1965. But the resurgence occurred in the state after a few years following the incorporation of cases from other endemic states coupled with the slow and gradual buildup of vector populations in the absence of complete and regular grounds of indoor residual spray. Malaria is a climate-sensitive disease and its transmission dynamics are greatly affected by climatic conditions. The number of malaria decreased till 2008 and then increased by about 250 cases per year. In 2010 highest number of cases was reported from Malappuram district. Earlier, Trivandrum, Kannur and Kasaragod district reported more number of cases than other districts. In the state, about 90 % of the affected people were males and less than 5 % were children.

Dengue: Dengue fever, which surfaced as a new problem in the state in 1997, assumed epidemic proportion in 2003 and resulted in 3546 cases and 35 deaths. Details of year wise are given in the graph (Fig 12.1). Dengue fever has now become almost perineal in some districts of the state. Although dengue is reported from all districts, it is comparatively higher in Thiruvananthapuram, Kottayam, Idukki, Kannur, and Kasaraghode. In all district except Thrissur, Palakkad and Wayanad the incidence of Dengue fever was higher in 2010 than the previous year. In 2010 Dengue fever outbreaks occurred in Thiruvananthapuram, Kottayam, Pathanamthitaa, Idukki and Kasaragod**.**

[1] Project Report of Integrated Diseases Survelliance Project. Epidemiological Situation of Communicable Diseases in Kerala

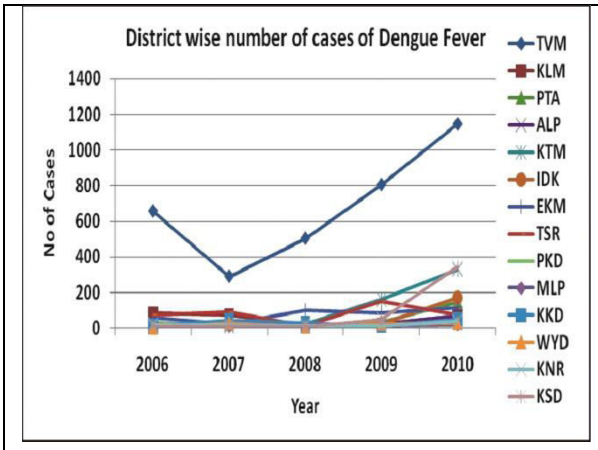
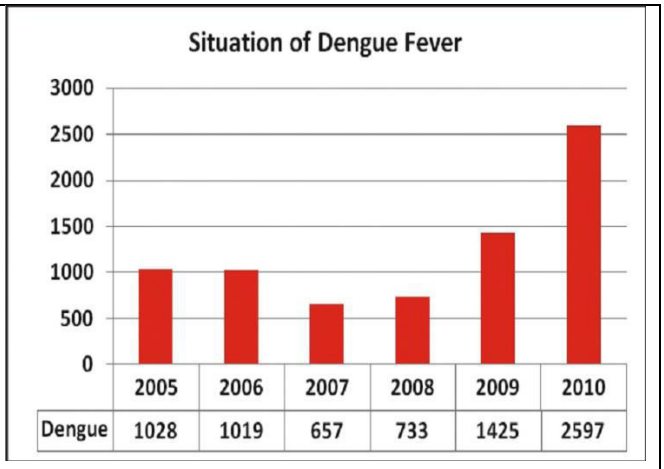


Figure 12.1 Dengue Fever



	2005	2006	2007	2008	2009	2010
Dengue	1028	1019	657	733	1425	2597

Table 12.1 Situation of Dengue Fever

Chikenguinea : In 2008, World health Organization (WHO) reported that an outbreak of Chikungunya in Kerala in the year of 2006 and 2007 was mainly due to climate change. Climate change was one of the key factors of the Chikungunya outbreak in Kerala during this period. There are other reasons of the spread of the disease but climate change cannot be denied as a prime reason. Due to change in climate, it becomes conducive for mosquitoes to spread to new areas and affect people (WHO). Chikungunya is a viral disease that spreads through the bite of infected mosquitoes. It is characterized by severe, sometimes persistent, joint pain, as well as fever and rash. Climate Change may be a major cause of surge in chikungunya, dengue and malaria in Kerala.

Diarrhoeal diseases: High temperatures, water scarcity and water abundance resulting from flooding or heavy precipitation have been shown to be related to diarrhoeal diseases. After a flood-event, rates of diarrhoeal disease, including cholera, may increase, especially in areas where sanitation facilities are poor. Heavy rainfall, even without flooding, may increase rates of diarrhoeal disease as latrines or sewage systems overflow. Increases in soil run-off may contaminate water sources. With heavy precipitation events expected to become more common, rates of diarrhoeal diseases may increase and it is likely that the most vulnerable populations will suffer the greatest burden.

H1N1 is a recent occurring influenza virus causing illness in Kerala. The epidemic probably reported in the state in middle of 2009. This virus is spreading from person to person, probably in much the same way that the regular seasonal influenza viruses spread. The risk factors for this serious pandemic diseases are not known definitely.

Districts	2009		2010		2011		2012	
	Cases	Death	Cases	Death	Cases	Death	Cases	Death
Thiruvananthapuram	336	3	303	22	66	4	8	0
Kollam	53	3	89	15	18	5	6	0
Pathanamthitta	48	3	12	1	10	0	2	0
Alappuzha	83	3	37	5	1	0	0	0
Kottayam	59	0	41	3	15	0	18	0
Idukki	55	2	6	3	40	0	27	0
Enakulam	160	2	255	5	2	0	40	0
Thrichur	128	3	237	10	10	1	79	0
Palaghat	56	3	29	7	6	0	23	3
Malappuram	283	7	158	9	10	0	83	2
Kozhikhode	150	1	181	8	12	0	190	2
Wayanad	53	1	47	1	2	0	27	0
Kannur	103	0	64	1	13	0	59	1
Kasaraghode	10	0	75	2	5	0	61	0

District Wise H1 N1 incidence reported Source: Directorate of Health Service

12.3 Programmes and Policies

- **State- Prevention of Epidemics and Infectious Diseases Cell (PEID CELL)** cell was established by Government of Kerala in 1982 in Medical College Hospital Thiruvananthapuram with a view to strengthen the surveillance system in the state.
- Action Plan form Clean Kerala Mission is being launched for environmental cleanliness, maintenance of public hygiene and prevention of diseases. It is significant that this Mission is being put into action after the State has made efforts to create awareness and to mobilize public opinion on the issue
- Vector borne diseases Malaria, Filariasis, Dengue, KalaAzar, Japanese encepalities Chickungunia etc have brought into the umbrella of National Vector Borne Disease Control Programme (NVBDCP). A system of disease surveillance at the field level and health institution level, laboratory surveillance, case management and control measures of these diseases are being implemented as per the national programme guideline of these diseases in the state
- **Integrated Disease Surveillance Programme.(IDSP)** the integrated disease surveillance Programme is under implementation in Kerala. Syndromic disease surveillance data collected from the field level (in S form) and health institution level data based on the presumptive diagnosis (P form) and Laboratory confirmed case (L form based) data are collected and analyzed at the district level and forwarded to the

state level and from there to the national level. Based on the disease surveillance data appropriate actions for the control of communicable diseases are taken at each level.

- **Vector Surveillance:** Surveillance of the mosquitoes is done at the field level by the field staff. From the district level District Vector Control Units headed by the biologist / senior biologist do the vector surveys at areas with high vector density and execute appropriate vector control measures on coordination with the staff of the peripheral institutions.
- **Water quality monitoring**: Occasional water quality monitoring especially at diarrhea and other waterborne disease prone areas in the pre-monsoons season is also done by the health department and appropriate actions are being taken periodically.
- Most of the National Public Health programmes including the National Vector Born Disease Control Programme (NVDCP), National blindness control Programme, National leprosy elimination programme national Iodine deficiency Disease control Programme etc have been brought under the common umbrella of the NRHM.
- **Ward level health & Sanitation Committees and prevention of communicable diseases:** Formation of the ward level health and Sanitation committees under the leadership of the elected, Ward member, with the filed Health staff as the convener, is one of the new initiatives under this scheme. In Kerala Ward level committees have been formed in all the rural and urban wards, with the related departmental representatives of the social welfare (Anganwadi worker), Kudumbasree health volunteers ,Mahila Swasthya Sangam (MSS) volunteers, ASHA worker school teachers and other NGOs. who are involved in the public health work in the area.
- In each ward under the leadership of the Ward Health and Sanitation Committee, for every 50-100 households volunteer squads have been formed for the coordination of source reduction and vector control.

12.4 Concerns

In terms of the health indices like Infant Mortality rate, Mortality rate, expectancy of life at birth etc. Kerala has made remarkable achievements, which are acclaimed, all over the world. But the public health scenario of Kerala is facing so many unresolved problems including that of the issue of the emerging and reemerging communicable diseases. Since the early 1990s outbreaks of new diseases like Leptospirosis, Japanese Encephalitis, dengue Fever etc. was reposted from some part of the state. The incidence of these diseases has been gradually increasing and the area of occurrence also been become more widespread. Now these diseases are major public Health problem in all districts. Emergence /reemergence of these diseases and the outbreaks/epidemics due to these diseases are very much climate change/ environment related.

The State also faces some other problems which need to be addressed. Mental health problems including higher suicide rates, health problems and death due to road traffic accidents are increasing. The suicide rate of women in Kerala, which stands at 31 per 100,000 is the highest reported anywhere in the World.

Major Challenges to manage vector diseases

- Poor reporting of communicable diseases from private institutions
- Poor implementation of Public Health and allied Acts.
- Water logged areas and lack of proper drainage – This is the major cause for Leptospirosis and some mosquito borne diseases.
- Migration – Labourers from outside states; they change their residence frequently.
- Rubber Plantations – unused latex collection containers.
- No proper waste management – Solid waste causes water contamination, mosquito breeding and rat breeding. No proper management of sullage.
- Lack of regular water supply. (The Aedes mosquitoes & Chikungunya and Dengue breeding increases in water collection tanks and containers)
- The water cutting in the sun shade is a major threat which helps mosquito breeding.
- Plastic wastes (Rain water collected plastic cups, carry bags etc. are the breeding places of

Another disturbing trend is that the Public Health System is getting alienated from the people and only 50% of the people even from the lower income group seek medical help from the Government hospitals. This is because of the fall in the quality of services at then Government hospitals

12.5 Vulnerability

Climate change makes protecting global public health security even more difficult. All of these changes can have impacts far beyond the locations in which they originally occur. Infectious diseases can now spread rapidly throughout the world. There is a need for putting health at the heart of the climate change agenda.

Climate Change Impacts in Health Sector

Outbreak of vector and water borne diseases, newer sites of breeding of the vectors, pathogens and bacteria;, likely occurrence of new and emerging diseases, increase in incidences of morbidities due to extreme heat events, increase in water borne diseases, increase in mortality due to increase in extreme events

Climate Change may cause new challenge for the control of infectious diseases & Public Health Change in pattern of infection. Incidence of Malaria is strongly affected by climate. Dengue prevalence is expanding rapidly. Transmitted by *Aedes* mosquitoes, dengue is a fast growing challenge, particularly in coastal areas of Kerala in recent years. Female *Aedes aegypti* mosquito, erector of dengue Chikungunia and other viral diseases are highly sensitive to climate conditions. Many other diseases are also affected by changing climate. Any disease caused, transmitted or harbored by insects, snails and other cold-blooded animals can be affected by a changing climate e.g. Lyme disease and tick-borne Encephalitis, Salmonella and other food borne infections. When infectious diseases appear in new locations, where people do not have immunity and health services may not have experience in controlling or treating infections, the effects can be dramatic. Also a change in patterns of infectious disease with reference to the climatic factors is expected in coming years in the state. Also geographically people living in coastal regions, water logged areas, and hilly areas are all particularly vulnerable in different ways. In the state lack of access to clean water supply and sanitation, along with poor hygiene is already the main contributor to the burden of diarrhoeal disease.

12.6 Strategies to address climate change challenges

Strategies	Activities	Implementing Agency	Deliverables	Budget	
				Annul Plan	Next five years
Proactive health Adaptation strategies	Identification of most vulnerable area prone to vector and water borne disease	Kerala State Environment and Remote Sensing Centre	Develop models to identify vulnerable geographical locations with increased health impacts due to weather extremes Identify susceptible and vulnerable, populations Provide to the high risk areas requiring vector control intervention.	50 Lakhs	2 Crore

	Improvement surveillance and warning system; strengthening of health infrastructure	Health Dept.	Increased access to health care for vulnerable populations through development and staffing of new health care facilities Improvements in means of physical access to existing facilities. Establishment of entomological units at district level	2 Crore	8 Crore
Preparedness and capacity building for emerging epidemics	Capacity building on epidemic preparedness	Health Dept.	Constitute state level and Rapid response team to respond to the emergence of Dengue or Chikungunya outbreak in State. The capacity of the District task force/epidemic response team will be strengthened. Sensitizing all medical and paramedical staffs about the disease and management of outbreaks of vector diseases.	5 Crore	25 Crore
	Capacity building district vector control units and state entomology units	Health Dept.	Capacity building in public health entomology and vector control as part of a broader assessment extreme weather events Establish institutional arrangements among universities, training and research Institutions to support for entomologists and vector control experts Use datasets with weather and climate information for the surveillance activities.	1 Crore	5 Crore
	Proper Solid and Liquid Waste Management	Kerala Suchitha Mission/Local Self Government	Take measures for the treatment of waste at source itself Provide adequate treatment plant for the liquid and solid wastes generated in flats, hospitals and commercial establishments	1 Crore	5 Crore

Strengthening Vector Control Activities	Ensure supply of fresh water to public	LSGD/ Suchitha Mission	Prevent the disposal of wastes into water bodies. Improved access to safe water and sanitation through development of new infrastructure. Protection of water quality to increase overall resilience of populations to health risks.	25 Crore	2 Crore
	Social Mobilizing Programme	LSGD/ Suchitha Mission/ Health Department	Social mobilization towards the involvement of communities in vector control activities, based on effective community IEC programmes Awareness of the importance of hygiene are the key to reduce a community's vulnerability to extreme weather events and more long-term changes in average water availability or average temperatures Encourage partnerships with NGOs	1 Crore	5 Crore
Strengthen Early Warning System	Strengthen short-term weather forecasts and seasonal forecasts for precautionary action related to health hazards.	Indian Meteorological Resource Centre, Thiruvanathapuram/ Health Dept.	Improve disease monitoring and early warning systems to allow early response to disease outbreaks. Develop Contingency plans for disease outbreaks should. Procurement and pre-positioning of stocks and giving health prevention messages to communities. Improved disaster preparedness, warning and response mechanisms to allow early warning and effective response to natural disasters. Implement online map based diseases mapping an surveillance system	25 Lakhs	2 Crore

	Research for improving the capabilities of healthcare and emergency services to address climate related extremes	SDMA	Developing strategies for linking health databases with real-time monitoring and prospective assessment of weather, climate, better characterize the health impacts of extreme weather events Evaluating and improving the effectiveness of health alert warning systems and other health risk communication tools	25 Lakhs	2 Crore
Set up for Institute of Environmental Health Sciences	Research and knowledge development on human health, environment and climate change	Health department	Studies for underlying early warning signs of communicable diseases in Kerala Systematic vector studies have been proposed Studies on weather related morbidity and mortality Research on Environmental related health issues Development or expansion of infectious disease control programs to respond to new health risks Develop capacities and skills in modeling and prediction; and improving risk communication and public health education health Research particular mosquito species present, the insecticide susceptibility status, vector feeding and resting habits, and larval habitat requirements Develop methods and skill in combining spatial epidemiology with ecological approaches	10 Crore	30 Crore
Total				**21.25 Crore**	**86 Crore**

13. Energy Sector

13.1 Background

In Kerala, energy sector plays a vital role in all developmental activities. High living standard, high density of population and the potential for future economic growth demand a high level of energy supply for Kerala. Power system in the state is comprised of hydro, thermal and wind sources. At present, the state power system includes twenty four hydro stations, two captive power plants, two thermal power stations, three IPPs, five major interstate transmission lines, one 400 KV substation and two 220 KV substation with interconnecting grid. The total power generation capacity of the hydroelectric projects are 1875.6 MW, which produces 7174.28 MU of energy that amounts to 71 per cent of total power and 60.07 per cent of the total energy generated by KSEB[1].

Hydro energy is the most reliable and dependable source in the state and it has 28 hydel power stations. The hydroelectric potential available in the state is estimated to be about 3500 MW. The state has exploited only 40 % of this source. One of the peculiar attributes of the state is the network of river system originating from the Western Ghats, although majority of them are short rapid ones with low discharges which makes state a favorable destination for hyro electric power**.**

Kerala's thermal power station has an internal generation potential of 4764 MU/771.62 MW, which in turn constitute 30 % of the total power, and 39.89 per cent of the total energy generation by KSEB.

Source	Installed capacity in MW	Annual Generation potential in MU
HEP owned by KSEB-28 Nos	1998	7069
Thermal Project- Owned by KSEB	235	1502
Wind farm owned by KSEB	2	5
NTPC Kayamkulam- Thermal	360	2094
IPP-Thermal-s Nos	177	1240
IPP-HEP	43	159
IPP-Wind farm	33	55
From Central Generating Station	1111	8000
Total	3779	19077

Table 13.1 Power Generation in Kerala. Source: Kerala Calling, 2010

[1] Economic Review.2010. State Planning Board. Thiruvananthapuam

Brahmapuram Diesel Power Projects was commissioned during the year 1998, followed by the commissioning of Kozhikhode Diesel Power Projects at Nallalam. The third thermal power project of NTPC at Kayamkulam was also synchronized to the grid 1999. The power output from the Kayamkulam Power Plant is available exclusively to Kerala[2].

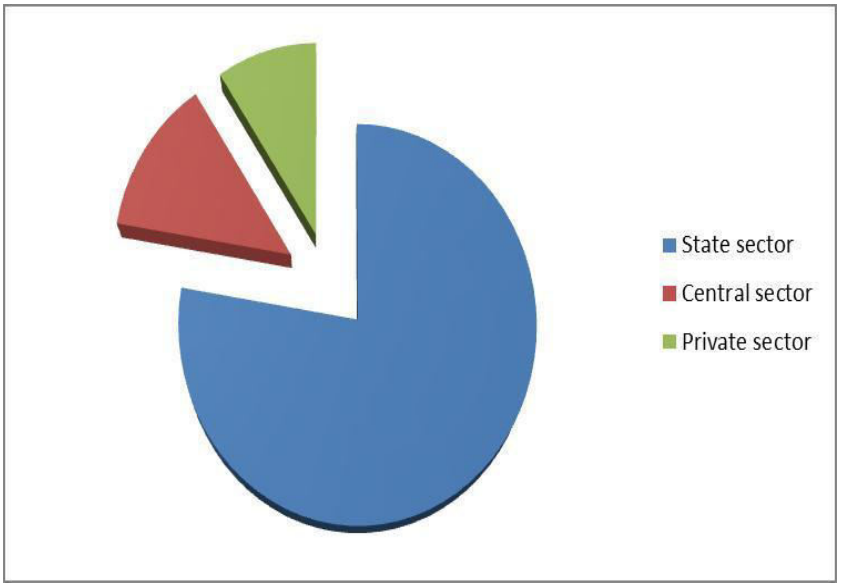


Fig 13.1 Power Generation in Kerala. Source: Economic Review, 2010

Petroleum and natural gas are the most conventional energy sources next to electricity in Kerala. The share of oil in primary energy consumption is almost 30 %. The transport sector almost completely depends on petroleum products, which are growing at the rate of 10 % per year. Petroleum products consumption in Kerala is increasing by 5-6 % a year, the total consumption during 2009-10 was 3.8 million metric tons. While the total consumption of petroleum products in the country was 107.51 million tones. In Kerala, diesel consumption was the highest at 13, 47,000 tons followed by petrol at 4,30,000 tons. The LPG consumption in Kerala has risen to 15 % and has reached now 4,12,000 tons. Furnace oil consumption was increased to 42,000 tons while that of Naphtha has fallen considerably[3].

Kerala has rich endowed with renewable energy resources such as wind energy, solar energy and biomass and having the energy potential (theoretical) of approximately 1715 MW. Several locations in Kerala are identified as ideal for getting up wind energy farms. The state has a capacity of generating 700-800 MW power from wind. The Center for Wind Energy Technology (C-WET) has estimated a wind power potential of 790 MW in Kerala. Wind power capacity of 35 MW has been so far commissioned in the state. But it has only tapped a microscopically small fraction of this. The main wind areas in the state are the eastern mountainous regions of Idukki district along the border of Tamil Nadu and elevated areas in Palakkad.

The state is blessed with vast solar energy potential due to its proximity to the equator. Utilization of solar energy with soar photovoltaic power system/solar farming with concentrated photo voltaic system in vacant

[2] Report.2009. Assessment of Energy Conservation Potential in Kerala. Energy Management Centre, Thiruvananthapuram
[3] Annual Report.2010-11. Bureau of Energy Efficiency. Ministry of Power. Government of India

lands can be effectively used in Kerala. Biomass is very much a traditional energy source. Kerala generates 120-150 lakh MTe of non-timber biomass annually and of this 60-70 lakh Te are burned in domestic sector for cooking.

13.2 Programmes and Policies

Sustainable energy solution and technologies are some of the factors which facilitate adequate industrial growth. Energy efficiency is recognized as a key factor in a sustainable industrial development process. State has initiated several energy conservation and efficiency improvement programmes for the industry sector

- **The Electricity act, 2007:** One of the main features of this act is the central government, joining with the state government will endeavor to provide access to electricity to all areas including villages and hamlets through rural electricity infrastructure and electrification of households
- **Bahat Lamp yoyana :** Kerala is the first state in India to implement this project in the entire state. Under this project, 1,27, 93, 540 CFLs were distributed to domestic consumers and witnessed a reduction of 300 MW electricity during peak hours.
- **Accelerated Power Development and Reform Programme (APDRP):** APDRP is one of the lucrative schemes initiated by the Government of India to strengthen the transmission and distribution segment.
- **Energy conservation Clubs in schools and colleges:** Energy conservation clubs are functioning at schools and college level. Also, during energy conservation month, celebration and several competitions were organized for energy conservation club members at schools, district and state level.
- **First LED village in Kerala :** The village Ayakkurissu in Palakkad district in Kerala is the first LED village in south India for which EMC joined hands with BEE to showcase this as an energy efficient model village. 250 household's bulbs and 50 streetlights were replaced with LED LIGHTS**.**
- **Energy Clinics:** Energy clinic programme of awareness creation among housewives, who are the true energy managers of the household, is being implemented through women volunteers. Energy clinics volunteer plays a consultative role in helping.
- **Energy conservation awards:** To encourage energy conservation activities in the state, there is provision of energy conservation awards which is given by the Government of Kerala. The government decided to give awards in six different categories viz large scale enterprises, medium-scale enterprises, small-scale enterprises, non-profit organization, individuals, and for R&D institution.
- **Transport clinics:** To achieve comprehensive energy efficiency improvement in the transport sector, the state designed the transport clinic programme as the immediate solution. This includes a structured

training programme for drivers with practical driving tests on roads before and after the classroom sessions.

- **Energy clinic programme :** Energy Clinic (EC) is a novel programme of energy conservation activities in the domestic sector through women as agents, a change for creating energy conservation awareness among rural housewives. The energy conservation programme provides valuable information to the rural population on energy conservation, energy-efficient equipment's and gadgets, right methods of energy rise to reduce wastage etc.
- **Energy efficient village programme :** The energy efficient village programme (EEVP) is a model project of EMC. All household in the selected villages were supplied with energy-efficient equipment's and gadgets.

  \Energy Auditing: Kerala made Auditing mandatory for all high/ tension/ extra-high-tension industries and commercial establishment during 1992.
- **Total Energy Security Mission (TESM)**: The TESM programme aims at creating grass root level energy security through intensively drawn out plans for decentralized energy generation and demand side management. Total Energy Security Mission (TESM) was a flagship project of the Government of Kerala for the 11th Five Year Plan period.
- **Kerala Renewable Energy Policy 2002:** Kerala was one of the first states to announce a comprehensive renewable energy policy, in 2002.

13.3 Concerns

- Kerala is poor in natural mineral fuel resource and water is the commercially viable source for power g

Power sector reforms: Reforms in Kerala power sector and KSEB are mandated by Govt of Kerala Power policy 1988. The major reforms being undertaken by the Board is as follows:

- KSEB has targeted to reduce the loss of 2% every year.
- All villages have been electrified.
- Completed 100 per cent metering of all distribution feeders.
- All consumers have metered.
- Energy audit of 11 KV and above metering has been computerized.

All 641 stations have been computerized in open source platform.

1

thin the state.

- Though Kerala is blessed with vast solar energy potential due to its proximity to the equator and there is drastic decline in solar panel prives over the last two years, the utilization of solar energy using grid connected photo voltaic system is yet to be started.
- The availability for fuel for cooking is a major energy security concern in Kerala. The 2001 census of India shows that 47 % of Kerala households use a combination of fuel wood and gas for cooking and 33 % use only fuel wood for cooking.
- The aspect of energy security is the issue of demand and supply balance, where there is short fall in supply.
- Due to lack of addition of new generation capacity, Kerala is suffering from power shortage. Power crisis which is the prime obstacle to start new initiatives in the industrial field has become most important. Monsoon is essential to sustain the hydropower base in the state and the shortage in rainfall usually creates power crisis.
- The development of transmission and distribution system in the state has not kept pace within the addition in generation capacity from time to time. Therefore, there has been a mismatch between transmission and distribution and generation, a gap of which has been widening over the years.
- The consumption of more thermal power and its high cost resulted in KSEB's debt servicing increasing year by year.

13.4 Vulnerability

Energy sector is key to reduce climate change threats and same time sector contributes various gases to the atmosphere while producing energy consequently directly linked with the climate change. Climate change would affect both the demand and supply of energy. High temperature associated with climate change will place considerable strain on the power sector in the state and it is currently configured. Across the state, in summer, drought condition has become more likely, and energy crisis has also become more common. The projected impact of the variations of precipitation on level due to climate change will severely impact the hydropower generation which in turn will change the energy supply scenario at the state level where hydro- generation has a lion's share. For example, drought limits the amount of energy that can be generated from hydel sector, which supply 90 % of states power. Moreover the State's hydroelectric generation varies with precipitation, fluctuating from year to year. In the recent past may time unusual drought have had a severe impact of hydroelectric power. In the state, electricity consumption is closely related to average monthly temperature. The highest demand for electricity comes when temperature is at high during the summer period especially in the month of March and

April. For example first time in the electrical history of the state, first week of March 2012 daily power consumption has touched 60 million units.

On demand side, state face warmer temperature and lower precipitation level which will result in increase of electricity demand because of higher use of electric gadget resulting to knock on effect on energy consumption and will thereby enhance the pressure on electricity distribution on network through increased seasonal demand.

Climate Change Impact in Energy Sector

Increased power consumption and demand due to elevated ambient, emit more greenhouse gas, severely impact on hydropower generation, threat to damage of infrastructure from extreme events, increased pressure on electricity distribution network through increased seasonal demand.

13.5 Strategies to address climate change challenges

Strategies	Activities	Implementing Agency	Deliverables	Budget	
				Annual Plan	Next five years
Utilization of solar energy	Promote micro solar power plants	ANERT/EMC	Utilization of solar energy with standalone and grid interactive solar photovoltaic power system in roof tops Promote solar farming with concentrated photo voltaic system in vacant lands Increase production of photo-voltaic panels	1 Crore	5 Crore
Renewable	Biomass gasification for domestic use as well as power generation based on promoting efficient technologies		Power generation by directly burning general waste (only biomass components) Sewage, food waste, animal waste may be used for methane fermentation (biogas). . Promote Technologies for recovery of energy from waste Feasibility Study need to be done Take up pilot project based	10 Lakhs	1 Crore

Energy Development			Research and development on technology for recover energy from waste		
	Functional Integration of energy efficiency and Renewable energy	Energy Management Centre	Educational and capacity building programme adopting energy efficiency technologies, including process that can be powered by renewable sources Demo projects integrating energy efficiency and renewable in selected Govt. Building or PSU's in Kerala which may be a replicable model Implementation of selected projects as a Model	2 Crore	4.5 Croe
	Promotion of wind energy generation according to the potential of the state	Power Dept.	Direct subsidies allow demonstration or pilot projects to be implemented Feasibility study potential for offshore wind energy Feasibility study location to set harnessing wind energy in the state Draft promotion of wind energy policy for the state	1Crore	10 Crore
Demarcation of hydro power potential	Climate proofing of existing and future hydropower infrastructure	Kerala State Electricity Board	Construction or augmentation of reservoirs, modifications to spillway capacities, installation of controllable gates on spillways, modifications to the number and type of turbines, and/or modification of canals or tunnels	2 Crore	20 Crore
	Assessment of Reservoirs Carrying capacity	Power Dept./ Irrigation Dept.	Study shall be conducted to ascertain the siltation of all reservoirs which is responsible for its reduction in reservoir capacity Hydro power potential in the state with site specific capacity mapping is to be done	2 Crore	5 Crpre

Programmes for enhancing Energy Efficiency	Energy Efficiency Testing and Calibration Centre	EMC	Setting of light testing Lab facility meeting concerned Indian standared code for specification and complying with NABL Accreditation	2 Crore	5 Crore
	Development of technology based products, devices, control and instrumentation for energy efficiency retrofits	Energy Management Centre, Thiruvananthapuram	Setting up of instrumentation and performance analysis facility of various star labeled products such as fans, refrigerators, Air conditioners etc. Setting up of simulation, modeling and performance evaluation for developing energy efficient process and products energy efficiency in old buildings through economically viable retrofits	50 Lakhs	5 Crore
Focused awareness campaign and training and certification	Development of training modules, tutorials, pamphlets etc.	Energy Management Centre	Sector wise training need assessment Developing training kits and modules Interactive training modules, short films, animations, etc./ software and creative works Pamphlets and booklets on energy efficiency and conservation in English and Malayalam Compilation of best practices modules of Kerala State Energy Conservation Award winners Awareness through print and electronic media including interactive programme	2 Crore	10 Crore
Total				**12.60 Crore**	**65.5 Crore**

14. Urban Front and Transport

14.1 Background

The trend of urbanization in the state of Kerala shows marked peculiarities. The main reason for the growth of urban population in the state is the increase in the number of urban areas and also urbanization of the peripheral areas of the existing major urban centers. The urban sector in the state consists of 5 Municipal Corporations and 60 Municipalities. Compared to other states, the urban- rural system in the state have many distinct and peculiar characteristics. There are 19 Urban Agglomeration in the State of Kerala, as per 2011 census, which are continuous urban spreads constituting a town and its adjoining urban out-growths. The urbanization in Kerala is not limited to the designated cities and towns. Barring a few panchayats in the hilly tracks and a few isolated areas here and there, the entire state depicts the picture of an urban-rural continuum.

Urbanization at a glance	
Municipal Corporation	5
Municipality	60
Urban Agglomeration (2011)	19
Largest Urban Agglomeration	Kochi (2117890)
Total Urban Population	15,932,171
Population (%) in 2011	47.72
Population growth	92.72 %
Sex Ratio	1091

Out of total population of Kerala, 47.72% people live in urban regions. An analysis of urbanization trends show the share of urban population in Kerala recorded steady growth from 7.11% in 1901 to 26.39% in 1991, but then declined to 25.96% in 2001. But during the last decade the urban population recorded a sharp growth from 25.96% to 47.72% of the population according to provisional census figures of 2011. The total figure of population living in urban areas is 15,932,171 of which 7,617,584 are males and while remaining 8,314,587 are females. The urban population in the last 10 years has increased by 92.72 percent. Like other cities in India, urban population has been growing at a rapid pace in Kerala as well, but the urbanization is taking place throughout the State in the form of clusters of towns and a few, notably Kochi, Thiruvananthapuram and Kozhikode, emerging as cities, although none of these cities have reached the two million population level. Kannur district, with an urban population of 50.4% is ranked first in urban content, but 11th in per capita income. This is mainly due to the prevalence of low-income generating small-scale industries. Ernakulam District with an urban content of 47.6 % ranked second in urban content and first in per capita income. This is due to production specialization in industrial activities and port induced service sector development. Idukki district though ranks 13th in urban content, is second in per capita income. This is the outcome of production specialization in plantation crops.

Infrastructure forms the foundation on which social, economic and industrial Development is built. Kerala is among the well performing states in India and holds an important position in the industrial front. The state holds significant industrial potential owing to good infrastructure facilities like power, transport system, airports, port and harbours and availability of rare materials. Central agencies like Railways, National Highways, Ports, Post and Telegraph, Telecommunication and Civil Aviation Authorities play a significant role in providing infrastructure facilities. The Kerala ranks high in the infrastructure indices among the Indian states.

14.2 Transport

In the State of Kerala the Public Works Department has a total road length of 33106 km. of State roads and 1542 km of National Highways. The State roads include 4342 km of State Highways and 18900.058 km. of Major District Roads.

Inland Water Transport is a fuel efficient and environment friendly mode of transportation. The State of Kerala, with numerous backwaters, is one of the States in India, where waterways are successfully used for commercial Inland Water Transport. The transportation is mainly done with country craft and passenger vessels. There are 41 navigable rivers in Kerala. The total length of the Inland Waterways in the State is 1687 km.

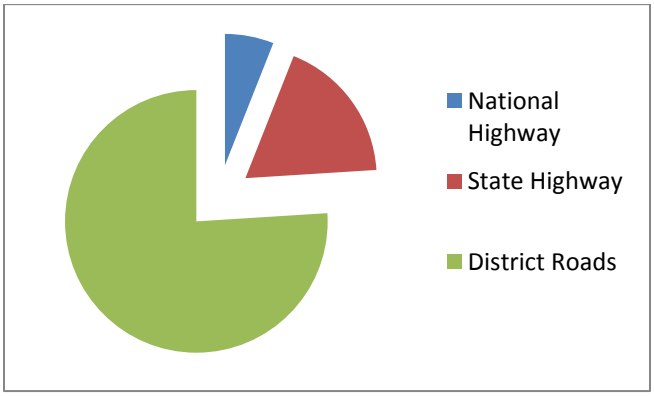


Fig 14.1 Roads in Kerala

Even increasing use of fossil fuel in the transportation and industrial sectors is adversely affecting the air quality in Kerala. These driving forces are also responsible for the increase in ambient noise. The number of vehicles on the roads in Kerala has increased more than 20 times since 1975. Kerala now has over 25 lakh licensed vehicles on the road when the total length of the carriage way is only 21347 km. The last decade has been rapid increase in the number and diversity of vehicles on the roads of Kerala. The number of vehicles increased 2000% from 119720 in 1975 to 2315372 in 2002. The corresponding increase in road length has been only 44% from 14870 km to 21347km. In the state 40% of the vehicles are registered in the three districts of

Ernakulam, Thiruvananthapuram and Kozhikode and vehicular emission and noise from this vehicle are severing in these three major. Development of road infrastructure has not kept pace with rapid increase in number of vehicles. This has resulted in traffic congestion and the resultant increase in air quality deterioration in the state

The State total Railway route has a length of 1257 Km and covers 13 Railway routes. The Railway Divisions at Thiruvananthapuram, Palakkad and Madurai jointly carry out Railway Operations in Kerala. Cochin Port is the only major port in Kerala. It spreads over 827 hectares. It has a water frontage of 7.5 Km. Presently cargo operations take place only in three ports i.e. in Vizhinjam, Beypore and Azhikkal ports. Vizhinjam handles about 1000 tons. Beypore 50,000 tons and Azhikkal about 5000 tons annually.

14.3 Policies and Programmes

14.3.1 Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) : It is centrally sponsored scheme launched by Government of India during the year 2005-06 to improve the infrastructure in small and medium towns in a planned manner. In Kerala, 61 urban local bodies are eligible for getting financial assistance under the scheme.

14.3.2 Development Authorities: Thiruvananthapuram Development Authority (TRIDA) was constituted for the implementation of planned and scientific development for Thiruvananthapuram city and adjoining areas. TRIDA has been appointed as the nodal agency for the land acquisition related works as a part of the Capital Region Development Programme. Under this programme, 12 roads totaling to a distance of 42.6 Km have been taken up for improvements. Greater Cochin Development Authority (GCDA) is an autonomous body constituted under the Local Self Government Department of the Government of Kerala and the jurisdiction of this authority covers an area of 732 sq.km consisting of Cochin Corporation, 9 Municipalities and 29 Panchayaths.

14.3.3 Kerala Sustainable Urban Development Project (KSUDP): The Kerala Sustainable Urban Development Project is an externally aided project funded by the Asian Develop Bank for addressing the challenges thrown up by urbanization. KSUDP involve the improvements, up gradation and expansion of existing urban infrastructure facilities and basic urban environmental services in five Municipal Corporations of the state i.e. Thiruvananthapuram, Kollam, Kochi, Thrissur and Kozhikode.

14.3.4 Jawaharlal Nehru National Urban Renewal Mission (JNNURM): Cities and towns of India constitute the world's second largest urban system. Government of India has approved a mission mode approach for implementation of urban infrastructure improvement programme in a time bound manner in selected cities. The

mission entrusted with this task is known as the Jawaharlal Nehru Urban Renewal Mission.. Corporations of Thiruvananthapuram and Kochi were selected as mission cities from Kerala State.

14.3.5 Ayyankali Urban Employment Guarantee Scheme: Ayyankali Urban Employment Guarantee Scheme proposed in the state is considered as a unique initiative in the State. It is intended to address the unemployment and underemployment problems in the urban society. The objective of the scheme is to enhance livelihood security in urban areas by providing at least 100 days of guaranteed wage employment to every household whose adult members are willing to do unskilled manual labour.

14.3.6 Kerala State Transport Project (KSTP) : Kerala State Transport Project (KSTP) is an initiative of Public Works Department, Government of Kerala, was officially launched in June 2002 to improve 1600 Km of State Road network and 77 Km of Inland Water.

14.4 Concerns

Inadequate urban infrastructure and the provision of basic urban services in Kerala is inadequate and do not meet the Government of Kerala's targets. The poor conditions of the existing urban infrastructure and facilities are mainly because of physical, operation and maintenance and financial constraints

- **Poor transport network:** Deficiencies in the road network (especially in the old town areas), inadequate traffic engineering and management, too little parking, and inadequate and inefficient public transport facilities are common problems in most of the cities in the state
- **Increase in number of vehicles:** It is estimated that there are 25 lakh licensed vehicles on Kerala roads whereas the length of the carriage way is 21,347 km. Kerala recorded an astonishing increase of 2,000 per cent in the number of vehicles during the 1975-2002 period. At the same time, the rate of increase in road length was just 44 per cent during this period.
- **Air Pollution:** According study done by Kerala State Council for Science, Technology and Environment, vehicles and industries are mainly responsible for the deterioration of air quality in the State as both create noise and emit air pollutants.
- **Urban poverty:** There are much higher levels of poverty in urban areas than in rural areas. About 16% of the urban population in Kerala lives in slums.
- **Poor drainage:** Drainage of the cities is not adequate to accommodate the precipitations during the heavy rains. In most Municipal Corporation, there is a lack of properly designed and interconnected drainage channels and network.

- **Increasing energy use** in the urban areas due to the changing pattern of urban livelihood and increasing average temperature/extended summer every year. Urbanization is Kerala resulted high energy use and its consumption than the rural areas.
- **Health Risk:** Rapid urbanization results in the increase of health problems. Increased threat to urban health due to vector borne diseases mainly because various weather anomalies in the state.
- **Coastal Hazards:** Most of the class one cities in the state is located in the coastal areas. Even the unstable coastline has not deterred large urban human settlement in close proximity to the sea. All the coastal area is vulnerable to various types of coastal hazards like erosion, cyclone, tsunami and projected sea level rise.
- **Flash floods:** In the state of Kerala most of urban floods are occurred due to flash flood which becomes very intensive during last few decades in the state. It is resulted as a resulted of heavy rainfall within few days and cause of lack of drainage in the urban area. This urban flash flood in the state are a great disturbance in the daily life of the city
- **Solid waste management**: The management of solid waste has not been systematic because of an absence of clear institutional responsibilities for solid waste management, a lack of skilled staff and equipment's and funding constrains. There is no effective waste collection system in the municipal corporations.
- **Liquid waste management**: The coverage of sewerage facilities, even in the City Corporations, is extremely low of the order of 30% in Thiruvananthapuram and 5% in Kochi Corporation areas, probably one of the lowest in the country

14.1 Vulnerability

Climate Change vulnerability in the urban front sector in the state is manifold. The urban areas in Kerala are always risk of flooding during the monsoons. Climate Change has the potential to increase flooding risk in cities of the state especially in the coastal districts. Most of the urban areas in the state are located in the coastal areas and many of these are also lies 10 metres below Mean Sea Level (MSL). These areas are also exposed to various climate change related to hazards like coastal flooding, sea erosion and projected sea level rise. Moreover, these areas are projected to be exposed to an increase of water stress due to climate change. Any reduction in the availability fresh water resourced caused by climate change will be particularly problematic for those areas where already suffering water scarcity. Because of the projected climate change if the state faces small change in average temperature then it could experience more heat islands in the urban areas where it has several degrees higher temperature than the surrounding areas. The increase the frequency and severity of heat stress events in cities and can affect the health, labor productivity and leisure activities of the human population. Climate Change also likely to bring an increased spatial distribution of the vector and water borne diseases in the urban area. It

can be generated new health hazards and cause disruption to public health services that lead to increased disease incidence. For the once decades it has been observed that many vector and water bone diseases have been increasing the in the cities of the state.

14.2 Strategies to address climate change challenges

Strategies	Activity	Implementing Agency	Deliverables	Budget	
				Annual Plan	Next Five Years
Protection of urban infrastructure	Safeguard plan for the urban infrastructure from the Climate Extremes	National Transportation Planning and Research Centre	Identification, planning, design and implementation of the project to safeguard various infrastructures in the urban areas from the extreme climatic events (urban flood, extreme precipitation and changing temperature) Invest in relevant climate resilient infrastructural projects, particularly an all-weather road network Incorporate projected climate changes on state urban infrastructure into infrastructure planning and design processes Introduce and enforce town-planning standards that take climate change into consideration Implement Building codes for the building industry and infrastructure in potentially vulnerable areas in the urban areas	2 Crore	10 Crore

Implementation of pollution control measures	Measures shall be implemented for the proper collection and segregation of wastes.		Employ efficient and zero waste technologies, practices and design in the all the five Municipal Corporations areas in the state Provide Solid waste management facility namely biogas plant, plastic shredders, vermi compost plant and liquid waste treatment facilities for urban communities.\ Provide proper sanitary facilities for the urban habitat especially slums and coastal habitats	1 Crore	4 Crore
	Improve water quality for urban populations .	Environment Dept./ State Pollution Control Board	Identification, planning, design and implementation of the better drainage facilities Management-point source pollution and other loads, Increase discharge Setting up water-treatment infrastructure Providing training on water treatment Setting up protection perimeters around water sources; Improving public awareness on water hygiene.	1 Crore	5 Crore
	Improve air quality in the Corporation areas	State Pollution Control Board	Reactivate and expand computerized information system Strengthen Traffic Safety Program Decrease lead level in leaded gasoline Decrease maximum allowable sulfur content in diesel and fuel oil. Air Quality Monitoring Increase and upgrade monitoring capability Develop an integrated and comprehensive emission inventory	1 Crore	5 Crore

			procedure		
Programmes for low carbon urban climate friendly transport	Establish an integrated multi-mode urban transport system	KSUDP/ National Transportation Planning and Research Centre	Provide standard facilities to ensure mobility of people public transportation system Encourage the use of non- motorized transport Better investigated green spaces and walking areas within the urban space Guarantee that pedestrian routes are integrated into a comfortable, viable and provide attractive green infrastructure	5 Crore	20 Crore
	Implementing Compressed Natural Gas in the Kerala State Road Transport Corporations	Kerala State Road Transport Corporations	Set up of Compressed Natural Gas (CNG) filling station at Kayamkulam, Haripad, Alapuzha and Kochi Convert 750 KSRTC buses to CNG mode Purchase 250 new chassis	109.56 Crore	125 Crore
Urban Infrastructure Development	Use of waste plastics for construction of Roads	National Transportation Planning and Research Centre	Feasibility study on usage of waste plastics on waste Pilot work of improving road infrastructure development with plastic To collect, segregate clean and shred of waste plastics Wet and dry process of combustion	1 Crore	5 Crore

	Promote Green Development Projects		Support green building R&D by developing leading green building technology. Establish Climate Innovation Centres to support investment in industries producing green technologies and those adopting green technology Providing low-interest loans to improve the energy efficiency of existing buildings.	20 Lakhs	1 Crore
Urban Development Planning and Policy	Develop strategies for climate change resilient cities or climate smart cities and take up pilot projects.	National Transportation Planning and Research Centre	Incorporate the urban green space issues into its planning system and legislation	10 Lakhs	50 lakhs
	Developing CDM projects relevant to Urban sectors	National Transportation Planning and Research Centre	Capacity building to staff and technical capacity for planning for climate change adaptation.	5 Lakhs	25 Lakhs
	Rainwater harvesting/recharging system	National Transportation Planning and Research Centre	Runoff from the roofs of larger buildings such as apartments and office building can be reduced by incorporating rainwater harvesting devices, green roofs and modular rain water retention tanks Use of rain water for non-potable use shall be encouraged.	25 Laks	1 Crore
	Introduce and enforce town-planning standards that take climate change into consideration		Draw up a development plan for the Cochin coastline (to address coastal flooding and projected sea level rise) Identify risk areas of the impact of climate extremes Establishing a town-planning and development master plan of the lowlands, taking into account the risks related to precipitation fluctuations;	25 Lakkhs	1 Crore

Green Urban Strategy	Promote Urban Forestry		Establish trees in public spaces such as parks, along streets and alleys, or in any available open areas that urban local or governments manage extend to green-belts around cities that buffer waterways and regulate development	1 Crore	5 Crore
	Promote more urban open space and parks	Department of Environment an Climate Change	Evaluation of the current status of the open spaces in the each city Preparing the urban green spaces strategic map Design standards designed to ensure that all people in the city have access to good quality green spaces.	1 Crore	5 Crore
	Protection of wetlands	Department of Environment and Climate Change/ State Biodiversity Board	Identify all major wetlands resources (water logged areas, ponds, marshy areas, drainage networks) in the urban areas Structural and nonstructural measures to protect wetlands areas in the urban areas Conservation and rehabilitation of degraded wetlands in the urban areas	2 Crore	10 Crore
Total				**125.21 Crore**	**197.75 Crore**

15. Tourism

15.1 Background

Kerala has the unique advantage to offer a wide variety of tourist attraction within relatively small areas of around 40,000 km^2 thus qualifying for the best venue for multi-destination tourism. Its 580 km long coastline has some of the best beaches in India, the Western Ghats region in the east has some of the finest hill station and wildlife sanctuaries, and much other locations have good potential for eco-tourism and the backwaters also offer good potential for tourism development. The state is considered as one of the important tourist destination in the world. The state received the award for the best performing state in tourism continuously from 1998 to 2001.

Foreign tourist visits in Kerala during 2010 were 659,265 as compared to 557,258 in the previous year and thus registered an increase of about 18.31 percent. Foreign tourist arrivals since 2002 are given in Table 8.1. Domestic tourist visits in Kerala during 2010 were about 8.60 million – as compared to 7.91 million during the previous year. The growth in domestic tourist visits during the year was 8.0 percent. There has been a moderate increase in domestic tourist visits in all the previous ten years except during 2005.

Year	Domestic Tourist	% variance	Foreign tourists	% variance
2002	55,68,256	6.3	2,32,564	11.3
2003	58,71,228	5.4	2,94,621	26.7
2004	59,72,182	1.7	3,45,546	17.3
2005	59,46,423	-4.3	3,43,499	0.27
2006	62,71,724	5.47	4,28,534	23.7
2007	66,42,941	5.92	5,15,808	20.37
2008	75,91,250	14.28	5,98,929	16.11
2009	79,13,537	4.25	5,57,258	-6.96
2010	85,95,075	8.61	6,59,265	1831

Table 15.1. Domestic and foreign tourist arrival. Source. Tourist Statistics, 2010

Despite the general backwardness in industrial development, tourism is the only industry flourishing in Kerala over a number of years. Kerala officially declared tourism as an industry in 1986. According to a recent analysis by the Southern Region of the Confederation of Indian Industry (CII), tourism is one among the top five sectors, which contributed to the State Gross Domestic Product. Moreover, this sector has now become Kerala's core competency sector creating employment, enhancing production, productivity and contributing significantly towards development of the state. The opportunity and to reap the benefit a conducive social atmosphere may be created to develop tourism as viable sector which has greater potential for generating employment and alleviating poverty. Foreign Exchange earnings during the year 2010 are Rs. 3,797.37 cores. Total Revenue generated from tourism in 2010 comes to Rs 17,348 crores and its contribution to state GDP is around 9 % (approximately). Kerala Tourism has recorded remarkable growth in the last few years. The number of foreign tourists and domestic tourists visiting the state has crossed two lakhs and 50 lakhs respectively. The revenue generated in the economy of Kerala due to tourism is estimated to be nearly Rs.4,000 crores which is 6.29% of the State is GDP. Total employment generated from tourism is estimated as 1.2 million

Being a service industry, tourism has higher potential of generate employment for local population. Total employment generated from tourism is estimated as 1.2 million which include skilled, semi-skilled and unskilled laborers. The tourism industry invests approximately Rs 1000 crores per year in Kerala.

15.2 Concerns

Unbridled and indiscriminate growth of tourism will lead to problems of pollution, environmental and ecological hazards and cultural degradation. Present pattern of tourism development is harmful to the local environment.

- Problem of solid waste dumped in public areas
- No waste management plans in tourist locations
- Encroachment of common property resources by tourism businesses
- Destruction of paddy fields for tourism development
- Large-scale tourism related construction detrimental to environment.
- Illegal constructions by tourism industry
- Coastal regulation zone by tourism industry on the rise
- No visitor management plan for ecotourism
- Carrying Capacity studies not done
- House boats exceed carrying capacity limits of Vembanad lake

15.3 Vulnerability

The concern of the tourism regarding the challenges of climate change has visibly increased over the last 10 years. The World Tourism Organization (WTO) and several partner organizations, including UNEP convened the first international Conference on Climate Change and Tourism in Djerba, Tunisia in 2003. The event was a watershed in terms of rinsing awareness about the implications of climate change within the international tourism community.

In Kerala, tourism is more directly linked to climate and natural beauty than other factors and is highly climate sensitive economic sector. Average weather is a resource for tourism and thus a change in climate might reasonably be expected to affect tourist flows directly. Climate change can also influence tourism indirectly, for instance by affecting low lying beaches, backwater and lagoons and biodiversity region of Western Ghats which in turn influence tourism because tourism in the state is highly based these areas.

The tourism industry and destinations are clearly sensitive to climate variability and change. Climate defines the length and quality of tourism seasons and plays a major role in destination choice and tourist spending. In many tourist destinations in the state is closely linked with the natural environment. Most noticeable adverse impacts of climate change on tourism sector will be in the areas of beaches, backwaters and lagoons, wild life sanctuaries, tropical evergreen forest areas which are the hot destination and attraction of tourist. Climate affects a wide range of the environmental resources that are critical attractions for tourism. It also has an important influence on environmental conditions that can deter tourists, including infectious disease, wildfires, insect or water-borne pests and extreme events such as floods and droughts. There are four broad categories of climate change impacts that will affect tourism destinations, their competitiveness and sustainability. Also climate defined the length and quality of tourism seasons and plays a major role in destination choice and tourist spending. All these show the tourism sector is clearly sensitive to climate variability and change.

Climate Change Impact in Tourism

Affecting low lying beaches, backwater and lagoons and biodiversity region of the Western Ghats which in turn influence tourism, average and conformable weather conditions in the state get affected, negative flow of international and domestic tourists, water shortage and water contamination, damage to tourism infrastructure due to climate extremes, change tourism season,

15.3.1 Coastal destinations are highly vulnerable to direct and indirect impacts of climate change (such as extreme climatic events, coastal erosion, physical damage to infrastructure, sea level rise, flooding, water shortages and water contamination), given that most tourism infrastructure in the state is located within short

distance of the shoreline. This high vulnerability often couples with a low adaptive capacity in these areas to address arising challenges. The strong seasonality of beach tourism in the state has to be taken into consideration, as it can be exacerbated by climate change threats.

15.3.2 Changes in temperature: Kerala enjoys comfortable temperature without any extreme monthly variation as it has mild temperature. This average weather is a resource for tourism and thus a change in weather as a result of projected climate change might reasonably be expected to affect tourist flows directly.

15.3.3 Weather anomalies: Unusual floods and droughts could have a considerable and unpredictable influence in tourism. The recent floods and droughts mainly peak tourist season showed largely affected flow of tourists to the state.

15.3.4 Sea Level Rise: Sea level rise might affect coastal tourism in different ways. Inundation and erosion might cause damage to infrastructure such as major tourism infrastructure in the state. Loss of beaches are important for visitors keen on sunbathing, and natural coastline can be altered in their landscape and composition of flora and fauna. What makes tourism particularly vulnerable is the actual location of beaches and backwater resort and hotels which is exposed to the projected sea level rise.

15.3.5 Changes in biodiversity: Biodiversity based tourism is an important and growing type of tourism since state has plenty of tourism spots in the biodiversity region of Western Ghats. Most of these biodiversity region have fragile ecosystem and so very vulnerable to the climate change implications. Consequently changes in species and composition and distribution might affect tourism in the state.

15.4 Strategies to address climate change concern for tourism sector

Strategies	Activities	Implementing Agency	Deliverables	Budgets	
				Annual Plan	Next five years
Tourism sustainability	A strict Certification for Tourism Sustainability (CST) is to be done for all the players in the Tourism Sector in the state.	Tourism Dept./ Environment Dept.	Environmental, economic and social impacts of tourism in various tourist destinations The eco certification may also be made part of this certification. More ecotourism destinations have to be encouraged in the state Strengthening and stabilizing	1 Crore	5 Crore

			ecotourism-based rural livelihoods		
Carrying capacity assessment for all the major destinations	Implement Tourism Carrying Capacity Assessment		Understanding the carrying capacity or constraints of the Destination resources Analysis of various scientific approaches and methodologies developed (case studies and success stories) Tourism Carrying Capacity Analysis of key limiting factors for tourism development for different types of tourist destinations	1 Crore	5 Crore
Protection of tourism infrastructure	Special emphasis shall be given to protection of tourism related infrastructures from events of extreme **events**		Enhance the ability of state to respond to hazard events Support planning to improve land use in hazardous coastal areas. Support activities at the state and local levels to protect natural features that reduce the impacts of natural hazards in the coastal zone	1 Crore	5 Crore
	Protection of beaches		Provide artificial structures (reefs, groynes, near shore break waters and bio-shields) major beaches areas in the state	1 Core	1 Crore

Implementation of pollution control measures	.		Solid waste management facilities namely biogas plant, plastic shredders, vermi-compost plant and liquid waste treatment facilities like effluent treatment plant shall be provided to hotels, resorts and other institutions in the every tourist location. Measures shall be implemented for the proper collection and segregation of wastes from the tourism sites Proper sanitary facilities shall be provided for the tourists as well as for the neighboring community	25 Lkhs	2 Crore
: **Carbon neutral tourism destination**	Green House gas inventory		Conduct tourism sector greenhouse gas inventory and establish baseline for the monitoring and evaluation of progress in energy efficiency and management.	25 Laks	2 Crore
	Develop strategy for making major tourism destination as carbon neutral tourism destinations		Promote wind, photovoltaic, solar biomass and waste as source energy in the all tourism destination sewage is tertiary treated using natural bio-cycle systems Encouraging use of public transport to the centre through the provision	50 Lakhs	3 Crore
Total				**5 Crore**	**23 Crore**

16. Information, Education and Communication, Knowledge management and Governance

16.1 Information, Education and Communications (IEC)

With the expectation of a complete paradigm reorientation in context of climate change, capacity building of the stakeholders becomes very important. The appreciations of the pattern and impacts, their implications in day to day life and long term will need to be ensured through an effective Information, Education and Communication (IEC) strategy. The stakeholders include public, officials, students, scientist, academicians and policy makes. The existing systems of environmental information and education include the ENVIS network National Green Corps in schools and the Environmental Education, Awareness & Training (EEAT) Scheme of Ministry of Environment and Forest (MoEF). Government of India

Following steps will be considered as the strategy in IEC

1) Use of information and Communication Technology (ICT) will be hall mark of the IEC strategy of the state.
2) Information's management mechanism will be established at sectoral levels and will be networked for effective use of the knowledge and information available on relayed aspects and generated by the institution for scientific and socio economic researchers in the fields related to climate change. A component of 2 % of the total sectoral plan allocation will be earmarked for all sectors for management with regular updating of the Information Management Mechanism. The processed information will also be provided in a separate portal in public domain, The database will be provided with spatial and temporal attributes which are relevant and sensitive to changing environmental parametres
3) A nodal centre for monitoring the pattern of climate and impacts on natural resources will be established in the Science & Technology sector in the state. It can have linkages with Indian Network on Climate Change assessment (INCCA) set up by MoEF and other agencies within and outside state for organism information and knodeges in this respect
4) An IEC strategy will be formulated taking into account the capacity and imperatives of corporate sector, education sector, and ICT sector for flow of information for use of stakeholders and for awareness about the implications of various actions and proposals regarding the natural resources of the state.

16.2 Monitoring and Strategic Knowledge Management

Kerala State Council for Science and Technology and Environment is mandated with the task of coordinating knowledge management in terms of organizing research and promoting scientific and technological advances

through its institutions and universities and other scientific institutions in the state. The Centre for Earth Science Studies (CESS), Thiruvananthapuram has been identified by the council as the nodal institution for organizing monitoring network and research on climate change. It will take the following actions in this context

- It will establish multidisciplinary monitoring programmes for climate change cover the natural resource sectors including weather, biodiversity, soil moisture, hydrology, human migration, geological and seismic dynamics, air quality parametres including Green House gases etc. Initial programmes have already been identified to by CESS to be lunched on sea level rise and atmospheric trace constituents and assessment of greenhouse gases.
- It will establish interface with the Indian Networl in climate change assessment so that the national and regional level GHG inventories and other such assessments are undertake on comparable parameters and principles
- It will provide with periodic report to the Council for validation and onward transmission to the government through the Department of Environment and Climate Change for analysis and putting in appropriate proposal before the governmental for any proposed action on policy, legislative or programmatic fronts as a response to the observation or the knowledge gathered
- As a nodal institution, CESS will work on developmental of a dedicated unit for climate change primarily for allocation and coordinate of research, monitoring and modeling for projections of impacts of the state
- Development and promotion of green technologies and ways for achieving green economy can be pursued by the Council through the various institutions within the outside of its purview

16.3 Local Self Governance

Local self-Governance will basically deal with the cross sectoral local issue related to climate change concern in resource mobilization and allocation for sustainable development policies of the state. It has an important role in addressing climate change impacts in the state. It has crucial to implementing for adaptation and mitigation strategies at grass root level. Climate Change activities especially many adaptation plan can be implemented by the Local Self Governance though their successful replication. There is a need to define the role of local self-Government in climate change and sensitize local communities through them to develop coping mechanism in adaptation and mitigation measures to climate change. Following are roles of local governance in SAPCC.

- Coordination shall be established between different departments and the panchayath. At present there is an option of constituting Functional committees on different subjects as per the Panchayat Raj/Municipality Act. With respect to this, Functional committees are to be constituted under each LSG

for planning, implementation and monitoring of various projects and looked into climate change perspective.

- For step of various development programmers initial approval is given by the LSGs. In this sphere local self-Government can be monitor it in a climate change perspective and also look into included various adaptation and mitigation strategies.
- Various community based climate change adaptation programmes are increasingly important elements of vulnerability reduction related to climate change. They are associated with a policy trend that values the knowledge and capacities of local people and builds on local resources,. This may be instrumental not only in formulating local coping and adaptation strategies, but also in situating them within wider developmental planning.
- Every Grama Sabaha, District Panchayat, Municipality and Corporation there should be area specific climate resilient plan must be developed. This plan would identify adaptation needs at the local level that focuses on reducing local level climate risk and vulnerabilities and ways of increasing resilience.
- The state of Kerala has a history of successful implementation of various development plans at grass root levels with the local self-Government machinery and thus climate change perspective can be also be incorporated these development programmes.
- The state emphasizes on the need to enhance capacity of the officials on climate change implications and possible adaptive and mitigation measures so that they could include climatic considerations in their departmental planning as well as day to day operational and monitoring activities.
- Identify policy option for public investment in energy efficiency, GHG emission reduction and clean technologies for activities in local self-government institutions

16. Summary

The State Action on Climate Change has been drafted by the Department of Environment and Climate Change in consultation with various stakeholders departments in the state. It has been prepared based on the inputs received from a National Workshop, three Public Consultation Workshops, and series of Consultation meetings and also various proposals received from various stakeholders in the state. The preparation of SAPCC should be in line with the direction of Ministry of Environment and Forest, Government of India and ensure its implementation at state level and it is endorsed by the State Steering Committee on Climate Change. Key sectors have been indemnified and appropriate sector strategies are proposed to address the current and anticipated climate change challenges of the state. These key strategies are given under sustainable management activities, Research and Develop Initiatives and capacity building of the major stakeholders on climate change.

16.1 Implementation, Monitoring and Evaluation

For measuring the effectiveness of implementation of the State Climate Change Action Plan it is necessary to have a monitoring and evaluation framework. In the context of Kerala, monitoring and evaluation framework will be placed at State, Sectoral and Grass Root Level.

The State level monitoring and evaluation will be done by two ways 1) Department of Environment and Climate shall coordinate state level activities related to climate change 2) State Steering Committee shall be done timely progress review various activities of SAPCC. As a nodal of the state on climate change related activities, the Department of Environment and Climate Change will coordinate the preparation of annual programmes with targets and assigned responsibilities for activities of SAPCC implementation with the state holders and the line departments. The Department will also be responsible to the State Steering Committee for collecting monitoring reports on programme performance based on the Ministry of Environment and Forest frameworks of indicators and common assessment structure. Also, for implementation and coordination activities of SAPCC, Department of Environment and Climate Change shall start a separate Climate Change Activities. Also a State Level Work Plan will be developed by the Department of Environment and Climate Change for the implementation of SAPCC Also SAPCC implementation will be monitored and evaluated at various levels under the auspices of the State Steering Committee will seek timely progress of the various activities of the SAPCC from various stakeholders department of climate change. An annual decentralization implementation review meeting will be organized on key heads by State steering committee with the technical support from the Department of Environment and Climate Change.

The activities contemplated within the individual sectors are envisaged as part of the respective plan programmes of the sectors. Each stakeholder department must be set up a climate change cell to coordinate

activities of climate change for the respective sectors. A sectoral working plan for implementation key priority activities will be also developed by the respective sectors. This would be followed by evolving appropriate sectoral criteria and indicators. The entire exercise is proposed to be participative and consultative, ensuring engagement of the concerning departments and stakeholders. Various line departments of each sectors has to emphasizes on the need to enhance capacity of the officials on climate change implications and possible adaptive and mitigation measures so that they could include climatic considerations in their departmental planning as well as day to day operational and monitoring activities.

With the decentralization of powers to Local self-government Institutions, has an important role to play SAPCC implementation of developmental works at the grass roots level. In the state, LSGIs have already been meaningfully empowered through massive transfer of resources as well as administrative powers. Coupled with a grassroots level approach of Participatory Planning whereby the developmental programmes are identified and implemented through the LSGIs which may be also emerged as effective agencies for the implementation of SAPCC. Functional committees are to be constituted under each LSG for planning, implementation and monitoring of various projects and looked into climate change perspective. Coordination shall be established between different departments and the panchayath. A periodic publication of reports on plan implementation, review of the State Planning Board and a public domain portal for display of information for public will be other aspects of monitoring mechanism.

16.2 Sources of Funding

For implementation of the activities of the SAPCC there are different sources funding available at various levels. As a main source of financial for the component of State Action Plan on Climate Change is the Climate Change Action Progamme (CCAP) under the Centre Budget Scheme. Every year states budget also allots amount for the climate change activities that can be used the implementation few key prioritized activities of the State Action Plan on Climate Change. Taking into account the needs of huge financial liability, NABARD is the main of source adaptation activities of the climate change particularly for enhancing capacities of vulnerable communities. Despite these, state gets support on the climate change related activities of the SAPCC through tie up with various multilateral organizations like UNDP, Swiss Development Agency, DFID etc as an main funding source.

16.3 Sector Wise Key Strategies of the SAPCC

1. Agriculture Sector	2. Animal Husbandry Sector
Crop Improvement and management Mainstream Integrated Pest Management system Sustainable Land Use and Management Promote Organic farming Water Use efficiency in the various agricultural practices Measures for Flood control and Drought management Preserving buffer stock of seeds Efficient Agro processing and cold storages Promote Energy Efficiency and Conservation in Agriculture practice Extend more Crop insurance Schemes Provide better weather forecasting for the farmers Strengthening livelihoods through work and income security of farmers Declare special agricultural zone	Renovation of cattle sheds based on environmental parameters Feed and fodder development Strengthen disease investigation system Refrigerating facility at strategic locations Sustainable Livelihood Approach to the Farmers Research on native species breeding and rearing
3. Fisheries and Coastal Resource Promote Sustainable inland fisheries activities Establish Fish sanctuaries Designate more fish multiplication and rearing centers Mangrove Conservation Management of diseases Carbon footprint reduction methods in the fishery sector Sustainable Livelihood Approach of fishermen Community Set up climate Change Centre at Kerala University of Fisheries and Ocean Studies	**4. Forest and Biodiversity** Special protection of unique eco-systems like shola forests, sandalwood areas, wetlands and other eco-systems Forest profile augmentation Increasing green cover outside the forest areas Develop integrated water resource management plan for the forest areas Preventing man animals conflicts Social advancement of forest dependent communities Forest Fire control measures Information, Education and Communication on Biodiversity Conservation Assessment of climate vulnerability and climate change impacts on state biodiversity and forest resources Develop forest management plans for different forest types in view of Climate Change Deforestation Reduction and the carbon market

5. Water Resource	6. Health
Linking Irrigation and hydel reservoirs with drinking water supply Rejuvenation of rivers Revival of polluted lakes and ponds Implement Water Recharge Programmes Promote rain water harvesting Recycling and reuse of grey water Increase in water use efficiency Assessment of water resource Establish Water data bank	Proactive health Adaptation strategies Preparedness and capacity building for emerging epidemics Strengthening Vector Control Activities Strengthen Early Warning System Set up for Institute of Environmental Health Sciences
7. Energy	**8. Urban Front and Transport**
Utilization of solar energy Renewable Energy Development Demarcation of hyd Programmes for enhancing Energy Efficiency ro power potential Focused awareness campaign and training and certification	Protection of urban infrastructure Implementation of pollution control measures Programmes for low carbon urban climate friendly transport Urban Infrastructure Development Urban Development Planning and Policy Green Urban Strategy
9. Tourism sustainability Carrying capacity assessment for all the major destinations Protection of tourism infrastructure Implementation of pollution control measures Carbon neutral tourism destination	

16.4 Proposed Budget of the implementation of SAPCC

The proposed budgetary estimation for implementation of State Action Plan on Climate Change in different sectors is only a rough estimate. The Total budget has been estimated at INR is 1170.4 Crore for a five year period.

Sl. No	Name of the Sector	Numbers of key priority Activities	Budget (in Crore)	
			Annual Plan	Next Five Years
1	Agriculture	25	24.30	126.5
2	Animal Husbandry	7	7.85	33.50
3	Fisheries and Costal Ecosystem	16	78.79	417.2
4	Forest and Biodiversity	22	22.48	114.75
5	Water Resource	17	22.15	106.20
6	Health	10	21.15	86
7	Energy	9	12.60	65.5
8	Urban Front and Transport	15	125.21	197.75
9	Tourism	6	5	23
10	**Total**	**127**	**319. 53**	**1170. 4**

Annexure 1

List of Participants in the Regional Public Consultation workshop for low land and State Level Inauguration on 6th September 2012 at Thiruvananthapuram

Name and Designation	Department/Institution
Dr. S. Sunil Kumar Assistant Director	Directorate of Animal Husbandry. Thiruvananthapuram
Shri. B. Krishna Kumar Joint Director of Agriculture	Directorate of Agriculture, Thiruvananthapuram
Shri. C. Balakrishanan	Directorate of Mining and Geology. Thiruvananthapuram
Shri. D.P. Sreekumar Deputy Director	Directorate of Mining and Geology Thiruvananthapuram
Smt. Sakeena. I Assistant Director of Agriculture	Directorate of Agriculture Thiruvananthapuram
Shri. Jayakumar. C Additional District Officer	Directorate of Economics and Statistics Thiruvananthapuram
Shri. T.V. Johny Research Officer	Directorate of Economics and Statistics Thiruvananthapuram
Dr. M.P. Nayar Former Director	BSI
Shri. S. Madhavan Namboothiri Dy. Chief Engineer	Harbour Engineering Department Thiruvananthapuram
Dr. Sindhu C. Unni Scientist	Kerala State Council for Science, Technology and Environment, Thiruvananthapuram
Shri. P. Kalaiarasam Scientist	NATPAC Thiruvananthapuram
Shri. Jose Issac Director	Kerala State Remote Sensing and Environmental Centre Thiruvananthapuram
Dr. Anilkumar Scientist	Kerala State Remote Sensing and Environmental Centre, Thiruvananthapuram
Shri. C. Radhakrishana Kurup Joint Director	Urban Affairs Department Thiruvananthapuram
Dr. Vijith H Senior GIS Specialist	State Disaster Management Authority Thiruvananthapuram
Dr. Suja. G Senior Scientist	Centre for Tuber Crops Research Institute Thiruvananthapuram
Dr. Mini Jose Assistant Director	Avian Disease Diagnostic Lab, Thiruvalla
Shri. Nandanan M.K Joint Director	Dept. Of Soil Survey & Soil Conservation Thiruvananthapuram
Smt. Sarojini. K.T Director	Directorate of Diary development, Thiruvananthapuram
Dr. Sureshkumar Assistant Director	Directorate of animal husbandry Thiruvananthapuram
Dr. Oommen John	State Institute of Rural Development Kottarakara
Shri. M.Unnikrishnan District Forest Officer	Forest Division Punalur
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Shri. Dr. P.R. Unni Krishna Pillai Principal Scientific Officer	Kerala State Biodiversity Board Thiruvananthapuram

Shri. Thomas Cherian Dy. Director	Directorate of Soil Survey & Conservation, Thiruvananthapuram
Shri. P. Sreekumaran Nair Deputy Chief Superintendent	Kerala Water Authority Thiruvananthapuram
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Shri. Rajasree J Technical Assistant	State Horticulture Mission Thiruvananthapuram
Shri. A.G. Gopakumar Hydrogeologist	Ground water Department Thiruvananthapuram
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Shri. C. Pradeep Secretary,	District Tourism Promotion Council Aalappuzha
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Shri. P. Sahadevan Executive Director	FIRMA, Thiruvananthapuram
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Dr. Keshav Mohan Director	Institute of Land and Disaster Management, Thiruvananthapuram
Dr. C.P. Shaji	Kerala State Biodiversity Board Institute of Land and Disaster Management, Thiruvananthapuram
R. Radhakrishnan Nair	Mining and Geology Department, Thiruvanathapuram
Shri. T.S. Anilkumar	Kerala State Environmental and Remote Sensing Centre, Thiruvananthapuram
Shri. K.N. Syam Mohan Lal	Divisional Forest Office, Thenmala, Kallam
Shri. M. Rajsekhar Joint Director	Irrigation Department Thiruvananthapuram
Dr. P.N. Premachandran Director	Department of Soil Survey & Soil Conservation Thiruvananthapuram
Dr. C.K. Jagadeesa Assistant DHS (PH)	District Office Thiruvananthapuram
Dr. B. Sreelatha Deputy DHS, (PH)	Directorate of Health Service Thiruvananthapuram
Dr. B. Shivaraju Additional P.C.C.F	Forest Department, Thiruvananthapuram
Shri. Rajeev. G Additional Secretary	Environment Department, Thiruvananthapuram
Shri. Alex John Oomman Executive Engineer	Irrigation Department, Thiruvananthapuram
Shri. Praveen. S.R Assistant Editor,	ISPRD Directorate Secretariat, Thiruvananthapuram
Smt. Divya Vasanthan. K.N	I & PRD, Secretariat, Thiruvananthapuram
Shri. Krishna Kumar T.V Under Secretary	Dept. Forest & Wild life, Thiruvananthapuram

Smt. Smitha R. Nair Deputy Director	Directorate of Fisheries Thiruvananthapuram
Shri. Sujith Kumar. J	Fire & Rescue Services, Thiruvananthapuram
Shri R. Ramesh	Kerala State Electricity Board, Thiruvananthapuram
Dr. Indu. P.S Additional Professor	Community Med. Representative, Directorate of Medical Education, Thiruvananthapuram
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Smt. Sindhu S	Environment. Department, Thiruvananthapuram
Smt. Shahina. P.K.	Environment. Department, Thiruvananthapuram
Smt.Maya. S	Environment. Department, Thiruvananthapuram
Smt. Sonima V.S	Environment. Department, Thiruvananthapuram
Smt. Smitha. A.S	Environment. Department, Thiruvananthapuram
Smt. A.Padmavally	Environment. Department, Thiruvananthapuram
Smt. Sarala	Environment. Department, Thiruvananthapuram
Dr. V. Ravi	Centre Tuber Crops Research Institute CTCRI (ICAR)
Dr. K.V. Mohammed Kunju	STED, Kozhikode
V.K. George Director	SEDO, Sasthamcotta
Shri. MADHU S Programme Manager	ANERT, Thiruvananthapuram
Fr. Thomas Peelianickal	Kuttanad Vikasana Samithy Ramankary
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Prof. V.K. Damodharan	INGCORE, Trivandrum-35
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Shri.Aravind Balakrishnan	WWF – India Thiruvananthapuram
Dr. Narayan Head	Energy Management Centre, Thiruvananthapuram
Prof. M.A. Rasheed	Prof. Of Botany (Rtd.), University College
Maya. K.	Amrita TV
Shri.J. Ramakrishanan	PTI
Shri.N.K. Girish	Manorama News
Shri.Nelvi Alan David	Asianet
Shri.Pratheesh D	Kerala Kaumudi
Shri.Sreenath P.S	Metro Vartha.
Shri.Vishnu	Veekshanam
Smt. Sheeja	Kairali TV
Shri. Biju V.S	Kairali TV
Shri.Jisha. S	The New Indian Express
Shri.Sreekiran. P.L	Media One TV
Shri.Anand Sagar. S.B	ANI
Shri.Varun Kumar T	Malayalamanorama
Shri.Prince George	Dept. Of Environment. Science University of Kerala
Shri. Stephan Saju	Wayanad
Shri.Leena S. Rani	Envt. Department
Adv. A. Jerome	Vanchiyoor
Shri. S. Harshid	Health Inspector Municipal Office Mavelikara

Smt. Vimala Gurudas Municipal Chairperson	Punalur Municipality
Smt. Suseela Ramachandran	Health Chair person, Punalur Municipality
Smt S.R. Santhi	Health Supervisor, Nedumangad Municipality
Adv. T.P. Salini kumar	Karunagappally Municipality
Shri. Renjith	Jaihind TV
Shri. Vishnu	Veekshanan
Shri. B. Ansari Vice chairman	
Shri. V.R. Suresh Babu	Kadakampalli

Annexure 2

List participants in the Regional Public Consultation workshop for midland on 27th September 2012 at Thrissur

Name and Designation	Institution/ Department
Dr Rekha J Nair, Scientist	CMFRI, Kochi
Dr Sathiaratham C.V Senior Medical Officer	Govt Ayuveda Hospital, Manaheri
Dr A Raghunathan Senior Medical Officer	Govt Ayurveda Hospital, Ponnani,
Shri. Padma Chandra Kurup Junior Superintend t	Collectorate Malappuram
Shri Sudhakaran, Municipal Engineer	Chavakkad Municipality
Dr Sajan Joseph V.S Medical Office	Govt Ayuveda Hospital, Valappad
Dr N.S Rekha Medical Officer	Govt Ayuveda Dispancery,Trichur
Shri. Rajeev P Goerge Deputy Director	Coconut Development Board, Kochi
Shri. C.K Varghee Chairman	Angamally Municipality
Shri Vridhanath M.C Project Fellow	HRVA Cell, Thrissur
Shri. Sudhakumari S Chairperson,	Perithalmanna Municipality
Shri. Jose K Syriak Deputy Town Planner	Town Planning Office Kottayam
Shri. Sudheer P Sukumar Assistant Town Planner	Town Planning Officer, Kottayam
Shri. Jhonson Goerge Junior Superintend	Collectorate Palakkad
Dr. D Ajay Scientist	Indian Cardamom Research Institute, Idukki
Shri. Manoj Ommen Scientist	Indian Cardamom Research Institute, Idukki
Prof. K.V Jayakumar	Dean, KUFOS, Kochi
Prof V.R Rahgunandhanan	IRTC Mundur
Smt M.M Sheea Deputy Town Planner	Regional Town Planning Office, Ernakulum
Smt V.K Jayasree Assistant Town Planner	Town Planning Office, Ernakulum
Shri Shaji j Ukkan Tahsildar	Mukundapuram, Trichur
Dr K.T Thomson	School of Industrial Fisheries CUSAT
Dr Manoj C.K	Sub Inspector of Fisheries Peechi
Shri. Jackson Chacko Public Relation Officer	District Tourism Promotion Council, Thrissur
Fr Jose Payyippilly Secretary	KESS, Thrissur
Shri P Rajan, Deputy CE	KDRB, Trichur

Regina Davis	Social Action, Thrichur
Shri K.J Sohan, Chairman, Standing Commitee	Cochin Corporation Cochin
Jhony John Assistant Town Planner	Town Planning Office, Idukki
Smt Sathi Abhamam P Deputy Tahsildhar,	Taluk Office, Thrissur
Shri Madhu A.K Secretary	District Tourism Promotion Council Malappuram
Shri Madhu V.R Scientist	Centre Institute of Fisheries Technology, Kochi
Dr V Madhu Assistant Professor	Department of Atmospheric Science, CUSAT
D R Sajeev Head	Department of Physical Oceonography, CUSAT
Dr A.N Balchand	Dept. of Physical Oceanography, CUSAT
Dr Jimmichen Mathew Deputy Town Planner	Office of Town Planner, Idukki
Dr N Mini Raj Professor,	College of Horticulture, Kerala Agriculture University, Vellani
Dr. P Indira Devi, Professor	, Kerala Agriculture University
Dr Justin Mammen Medical Officer	GAD, Kottakkad Palakkad
Shri. P Sarangain Deputy Director	Principal Agriculture Office, Civil Station, Malappuram
Shri E.V Sojeer	Deputy Collector, Thrissur
Dr C Ravindran Principal Scientist	National Institute of Oceanography Cochin
Dr K.K Balachandran Technical Officer	National Institute of Oceanography Cochin
Shri M.V Justin Exe Engineer	
Dr G Nandhini Deputy DMO	Thissur
Smt T Leela Deputy Director	Thrissur
VA Gopi	Town Planner, Palakkad
Beevi P Chairperson	Ponnani Municipality

Annexure 3

List of participants in the Public Consolation Workshop for Highland on 4th October 2012 at Sulthan Bathery, Wayanad

Dr. E.J. Joseph Head, Water Management	Centre for Water Resource Development and Management, Kozhikode
Smt. C.N. Anithakumari Deputy Director	Department of Tourism Wayanad
Shri. Biju Joseph Manager	District Tourism Promotion Council Kalpetta North
Dr. K.S. Krishnamurthy Senior Scientist	Indian institute of Spice Research Calicut
Shri. T.S. Jagannathakumar Forest Section Officer	North Wayanad Division
Shri. P.K. Asoka Scientist	Central Marine Fisheries Research Institute Calicut
Dr. P. Kaladharan Principal Scientist	Central Marine Fisheries Research Institute Calicut
Shri. T.K. Naushad Chairman	
Shri. M.C. Sreeja Chair Person	Kannur Municipality
Smt. Meera Valsan P.H.S.C Chair Person	Kannur Municipality
Smt. Roshini K Lalid Development S/C Chair person	Kannur Municipality
Shri. Sathyababu. K. Deputy Town Planner	Town Planning Office, Kannur
Dr. G. Girishvarma Professor	Veterinary College Mannuthy
Shri. I.P. Rajesh Member	District Panchayath, Kozhikode
Shri. V.M. Vijayan	
Shri. K. Jasyasree Director	Centre for Youth Development Kalpatta
Smt. K.G. Pushpa	Adivasi Youvajanasamithy, Meenangadi
Shri. Usman C Health Inspector	Thalassery Municipality
Dr. Jeevan Medical Officer	Govt. Ayurveda Dispensary, Thirunelli
Dr. Mahesh. P.U Medical Officer	, Govt. Ayurveda Dispensary, Kottathara
Shri. Sooraj. T.C Asst. Town Planner	Kasaraghod