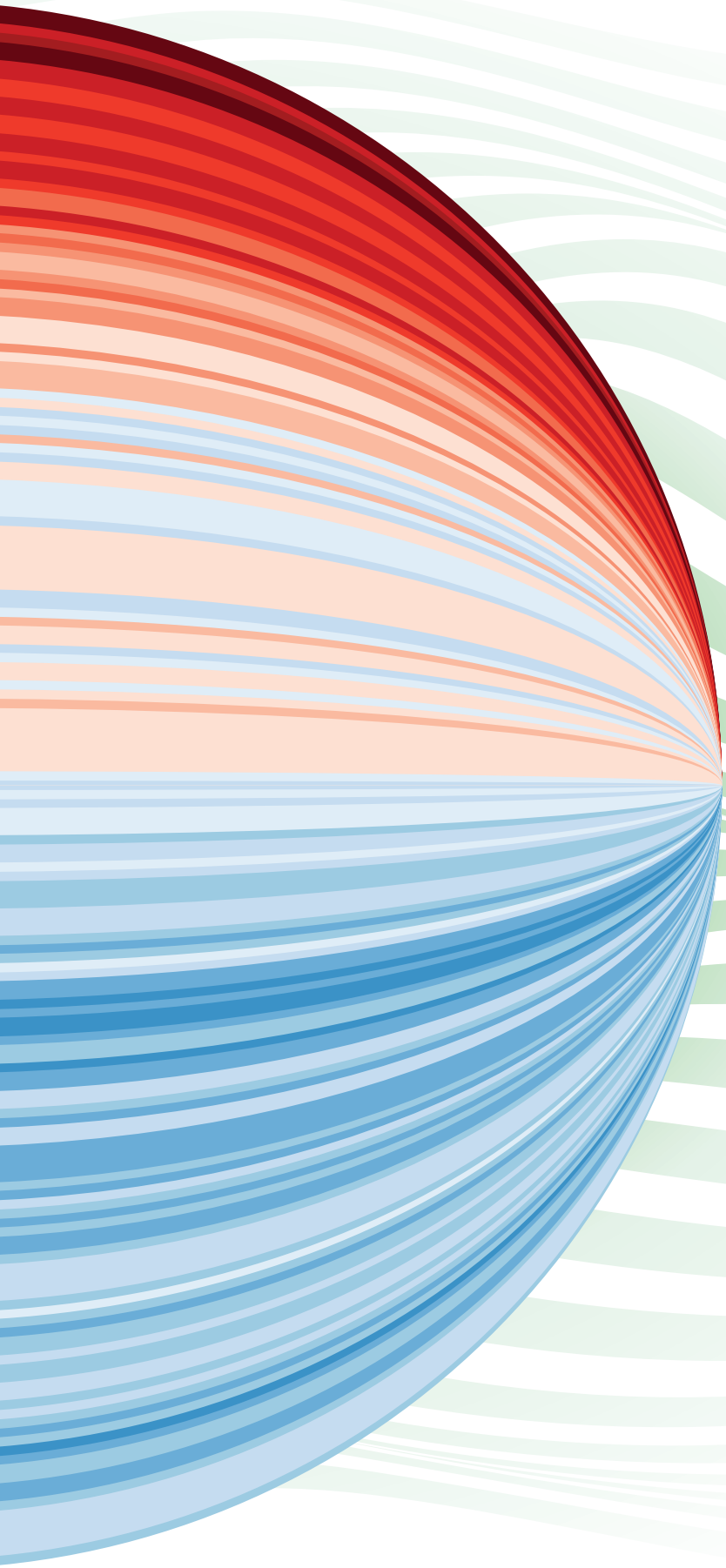

KERALA STATE ACTION PLAN ON CLIMATE CHANGE

2023 - 2030

DIRECTORATE OF ENVIRONMENT AND CLIMATE CHANGE

Department of Environment
Government of Kerala

Directorate of Environment and Climate Change
F-IV, KSRTC Terminal Complex,
Thiruvananthapuram-01, Kerala

www.envt.kerala.gov.in

The Directorate of Environment and Climate Change (DoECC) is under the Department of Environment, Government of Kerala.

DoECC is the nodal agency in the administrative structure of the Environment Department, Government of Kerala for the planning, coordination and overseeing the implementation of the Environment and Climate Change policies and programmes of the Central and State Governments.

The State Climate Change Action Plan (SAPCC) was first formulated in 2014, and the revised SAPCC (Kerala SAPCC 2.0) was approved by the State Level Steering Committee on 02.12.2022.

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State Action Plan on Climate Change (2023 - 2030)

KERALA STATE

State Action Plan on Climate Change 2023 - 2030

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Directorate of Environment and Climate Change
Department of Environment, Government of Kerala
2022

GOVERNMENT OF KERALA

PINARAYI VIJAYAN
Chief Minister

No.874/Press/CMO/22
05 December, 2022

I am pleased to see that the "Kerala State Action Plan on Climate Change" has been revised by the Department of Environment, Government of Kerala. This Plan is extremely important since it identifies actions to safeguard the State's diverse geographic settings, which include the Western Ghats and coastal lowlands, from the effects of global warming and climate change.

The Government of Kerala is dedicated to continuing its efforts to address the problems faced by the people due to climate change and associated climate extremes. We will continue to support local innovation and affordable clean energy technologies, innovative practices of climate adaptation, and resilience building. I believe that this Action Plan will serve as the pivot of climate action in the State, establish linkages at national and international levels and serve as a conduit for coordination between various stakeholders. I'm confident that the implementation of the Kerala State Action Plan on Climate Change will help to address the issue of climate change vulnerability and build resilience, particularly in sectors such as agriculture, livestock, coastal fisheries, health, water resources, forests, and biodiversity.

I congratulate the team of experts in the Directorate of Environment and Climate Change for bringing out this revised "Kerala State Action Plan on Climate Change 2022".

Pinarayi Vijayan

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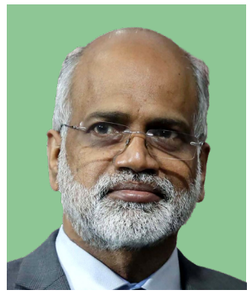

GOVERNMENT OF KERALA

Dr. V.P. JOY IAS
Chief Secretary

05 December, 2022

Kerala state is blessed with rich and diverse natural capital, providing sustenance and livelihood for a sizeable population. A series of natural calamities in the State, in recent times in the form of extreme rainfall, flood, and landslides, have necessitated enhanced and coordinated actions to address the climate change vulnerabilities and risks holistically.

The State has an outstanding record of achieving excellent results in the Human Development Index and Sustainable Development Goals. The initiatives like digital governance at various levels have not only increased efficiency and transparency in administration but also helped to avoid carbon emissions by way of reduced transportation demand and increased ease of living.

Climate-induced disasters have presented the State with emerging challenges that need continuous attention and action. The revised State Action Plan on Climate Change formulated by the Department of Environment has crystallized the framework for actions up to 2030 by various departments to address climate change-related issues. I hope the revised SAPCC will provide an opportunity and platform for meaningful action in all sectors. The spirit of collaborative and constructive effort shall play an essential role in achieving the targets.

The Ministry of Environment, Forest & Climate Change, Government of India, has extended support in bringing out this document. I compliment the entire team headed by the Additional Chief Secretary (Environment), for preparing this comprehensive Kerala State Action Plan on Climate Change incorporating relavant scientific and policy perspectives.

Dr V.P. Joy

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GOVERNMENT OF KERALA

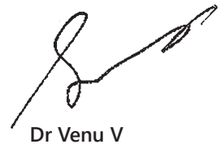
Dr. VENU V. IAS
Additional Chief Secretary

Most nations across the globe and States in India are facing the impacts of Global Warming and climate change, and Kerala is no exception. Effects of climate change are already being felt, as evidenced by the recent natural disasters, and may continue to increase in severity and frequency. The Conference of Parties 27 held at Sharm el-Sheikh reiterated the importance of enhanced and coordinated climate action implemented in a manner that is fair and inclusive. The Government of India has launched eight Missions as part of the National Action Plan on Climate Change (NAPCC) in specific areas and envisioned the interventions needed to address the impacts of climate change. Following this, Kerala prepared and adopted its 1st State Action Plan on Climate Change (SAPCC) in 2014. Now the Department of Environment has revised the SAPCC through rigorous consultations and advanced assessments, following the Common Framework given by the MoEFCC, in line with the Nationally Determined Contributions (NDCs) and Sustainable Development Goals (SDGs).

This Plan is focused on enhancing the adaptive capacity, strengthening resilience, and reducing the vulnerability of the systems, both natural and socio-economic, through adaptation actions that are inclusive and participatory. Although the Greenhouse Gas emission contribution of the State is much lower than many of the States, State has proactively devised strategies to reduce emissions. I am confident that the revised SAPCC document will mainstream climate change actions in all sectoral schemes and programs and will serve as the basis for attracting various sources of climate finance and improved climate governance in the State.

On behalf of the Department of Environment, Government of Kerala, I extend our gratitude to the Ministry of Environment, Forest & Climate Change, Government of India, and GIZ India through the SPIPA program for providing financial and technical assistance to revise SAPCC. I appreciate the exceptional support provided by the government departments, other stakeholders, research institutions, organizations that helped the Department devise the Plan successfully.

I want to place on record a special word of appreciation for Sri. Suneel Pamidi IFS, Director, and his team members in the Directorate of Environment and Climate Change, who have put in their best effort to develop this Action Plan.



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DIRECTORATE OF ENVIRONMENT
AND CLIMATE CHANGE
GOVERNMENT OF KERALA

SUNEEL PAMIDI IFS
Director

The Kerala State Action Plan on Climate Change (SAPCC) was first prepared by Department of Environment in 2014 as per the framework of the National Action Plan for Climate Change (NAPCC). Since the formulation of SAPCC, the science, knowledge, and understanding of climate change and the policy setting at the national and international levels have evolved which has necessitated the revision of the action plan.

Climate change planning is a dynamic process that should evaluate the changing climate, and vulnerabilities of the systems to climate change to identify adaptation actions. This plan, therefore, has been prepared after extensive multi-tier consultations with various departments, agencies, and stakeholders. This plan will be useful in prioritizing various mitigation and adaptation actions and leveraging various climate finance sources.

The efforts put in by all the technical team of the Directorate of Environment & Climate Change (DoECC) in bringing out such a comprehensive document are appreciable. The commitment shown by Dr Jude Emmanuel, Environmental Scientist, Dr John C Mathew, Environment Program Manager, Mr. Toms Augustine, Asst. Environmental officer, Dr Shiju Chacko, GIS Specialist, and Dr Kannan N., Research Associate deserve a special mention. The dedication shown by Dr Jikku Kurien at various levels during the preparation of this comprehensive document is commendable.

I acknowledge the technical support received from GIZ (India), Centre for Study of Science, technology, and Policy, (CSTEP), and guidance received by the officers of the various departments and institutes.

Suneel Pamidi

Acknowledgement

The SAPCC Revision Team in the Directorate of Environment and Climate Change (DoECC) has received tremendous support from stakeholders including scientists, administrators, professionals, and reviewers.

We gratefully acknowledge the MoEFCC for the guidance and financial support for the Plan revision in the state. We thankfully acknowledge the technical partnership provided by the European Union and the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety, and Consumer Protection through the Strategic Partnerships for the Implementation of the Paris Agreement (SPIPA). The support of Mr. Edwin Koekkoek, First Counsellor, Energy, and Climate Action, EU Delegation to India, Mr. Jai Kumar Gaurav, Senior Advisor-Climate Change, and Mr. Nidhin Davis K, Junior Technical Expert-Climate Change from GIZ India is gratefully acknowledged.

We acknowledge the immense contribution of the expert team from the Centre for Study of Science, Technology and Policy (CSTEP), Bengaluru under the able guidance of Dr. Indu K. Murthy which included Ms. Tashina Madappa Cheranda, Roshna N., Kaveri Ashok, Vidya S. Gadpayle and Trupti P. Deshpande.

We are thankful to Dr. J Sanjay, Scientist F of IITM Pune, Dr. Jaishankar, Head of the Department and Ms. Anjali Unnikrishan, Research Scholar of the CV Raman Lab of the Kerala University of Digital Sciences, Innovation and Technology, and Dr. Sivananda Pai, Director, Institute of Climate Change Studies, Kerala, for their valuable insights. It is highly commendable that Ms. Anjali Unnikrishnan could spare time on the climate profile assessment of this plan apart from her academics.

The dedication, knowledge, and expertise of the 220 nodal officers from 91 departments / agencies who comprise the Core Group of the Plan revision have made the Plan a reality.

The exceptional support provided by the administrative and ministerial employees of the DoECC and SWAK, especially during the multi-tier consultative meetings is acknowledged.

We acknowledge the dedication and commitment shown by Dr. Jikku Kurian, Scientific Coordinator, GIZ (India) in coordinating with numerous stakeholders to finalize this plan.

SAPCC Revision Team
State Climate Change Cell

Executive Summary

The Paris Agreement adopted by the Conference of Parties 21 in 2015 resulted in a fresh wave of climate action around the globe. The scientific community and policymakers were compelled to enhance the resilience, mitigation, and adaptation measures to address climate change. Climate change planning became the central point of these measures and became a prerequisite to coordinate with global actions to address climate change. In India, at the national level, climate change planning synthesizes the State Action Plans on Climate Change (SAPCCs). The Ministry of Environment, Forest and Climate Change has formulated a common framework for revision of SAPCC in 2019, directing States to envisage inclusive and sustainable development along with climate-resilient low-carbon development. The Kerala SAPCC 2.0 is based on this common framework. A core group of 220 nodal officers from 91 sectoral stakeholder departments through three tiers of consultation sessions has helped to devise this Action Plan. The SAPCC Revision Team coordinated the entire planning exercise at the Directorate of Environment and Climate Change, Government of Kerala. The Action Plan has adopted improved climate model projections and vulnerability assessments to suggest strategies, actions, and monitoring mechanisms.

Climate Change Base Case and Projections

Historically, a moderate warming trend has been recorded in the State's summer maximum, and the winter minimum temperatures and the mean annual rainfall shows a decreasing trend in all districts except Idukki, Palakkad, Kozhikode, and Wayanad. It is projected that the region's temperature may increase between 1°C to 2°C in the near term under Representative Concentration Pathways 4.5 and 8.5 scenarios. District wise rainfall during both scenarios is projected to increase during the pre-monsoon, monsoon, and winter seasons. There is variability between the southern and the northern districts. In the post-monsoon period under the assumed scenarios, the southern districts have a projected decrease in rainfall, and the northern districts have increasing trends. Extreme rainfall events are projected to increase, indicating changes in the magnitude, frequency, and timing of these events, all with implications for natural resource sectors such as fisheries, forests, water resources, and socio-economic systems such as agriculture and health and communities in various districts. The climate projections in different scenarios are detailed in ***Section 3*** of the Plan.

Climate Change Vulnerabilities

Composite vulnerability profiles were developed for the State and sector-specific vulnerabilities were assessed to measure systemic preparedness. *Wayanad, Kozhikode, Kasaragod, Palakkad, Alappuzha, Idukki, Kannur, Malappuram, and Kollam* districts were identified as highly vulnerable districts. These districts have high disease prevalence, a large population of very young, very old, and differently-abled, and reduced availability of healthcare facilities and relief shelters. In most districts, insufficient irrigation coverage and poor groundwater/surface water quality are fuelling the decline in adaptive capacity. The vulnerability information aids the prioritization of hotspot districts for investment, helps develop a nuanced understanding of vulnerability drivers in sector-specific hotspot districts, and develop targeted interventions to lower sensitivity and build adaptive capacity. The vulnerability assessments are detailed in ***Section 4*** of the Plan.

Climate Change Mitigation

Climate change mitigation actions can be either reducing the emissions of Greenhouse Gases (GHGs) or increasing the carbon sequestration process through various natural systems. Kerala is the fifth least GHGs emitting State in India. This low share of emissions is mainly due to its extensive forest cover and activities in energy conservation and energy efficiency improvements. Emissions from energy sectors — power generation, transport, industries, agriculture (energy use), and buildings, which account for 80% of the emissions from the State, had grown significantly over the last two decades. Within the energy sector, transport (54%) was the highest contributor to GHG emissions, followed by the building sector (21%).

Proposed Mitigation Strategies and Actions (2023-2030)

Based on electricity demand projections by the Central Electricity Authority, the demand is projected to increase by 50% in Kerala by 2030 from 2015 levels. The Action Plan envisages prudent emission reduction targets to avoid higher GHG emissions in the future due to an increase in energy demand. This may also reduce emissions from other states, as Kerala is importing a large share of energy resources from other states.

The planned mitigation strategies for the 2023–30 period under the Action Plan could avoid ~ 57000 $ktCO_2$ in 2030 from various sectors (compared to the Base case), with an investment of around INR 52,238 Crore across the period. Out of this, the State's share is estimated at about 5%, and Central Government share is at 23% Among the quantified strategies planned, the major mitigation measures are:

- the installation of RE-based electricity projects,
- energy efficiency improvement in significant industries,
- Transmission and Distribution infrastructure (T&D) improvement, and
- the increased adoption of Electric Vehicles (EVs).

The proposed significant mitigation measures for 2030 include; increasing RE-installed capacity to 3.46 GW and reduction in T&D loss to 8.8%, pegging 53% of the lighting points in the residential sector with energy efficient lighting, higher share of EVs in public transport and intermediate public transport, increased installation of solar based and energy efficient agricultural supports and improving the energy efficiency of Non- PAT (Perform Achieve and Trade) industries and micro, small and medium enterprises. The detailed strategies and actions for climate change mitigation in the State are provided **in** ***Section 5*** of the Plan.

Climate Change Adaptation

Climate change adaptation is adapting to life in changing climate scenario, and it is fundamentally to reduce risk from the impacts of climate change. Adaptation planning has been done for the sectors identified as vulnerable in the Vulnerability Assessment. The significant drivers of the vulnerability were identified, and the observable impacts of climate change on each sector were used to devise the adaptation actions.

Proposed Adaptation Strategies and Actions (2023–30)

Agriculture*:* Adaptation actions for the agriculture sector are aimed at improving climate resilience in agriculture and profitability along the entire value chain in the least productive farmlands within the most vulnerable districts. They aim to enhance and climate-proof production practices, minimize post-production losses and build the capacities of supporting institutions and service providers - Krishi Bhavans, markets, storage, credit, and insurance providers.

Livestock: Actions in the livestock sector are aimed at lowering climate stress on livestock with a focus on animal/bird nutrition, safe housing, breeding, and health to enhance their productivity. The outcomes of the projects envisioned are climate-resilient livestock and farm income, lower emission intensity of milk production, and higher farm income supplemented by income from backyard poultry, circular economy - conversion of poultry waste into animal or fish feed, reduced livestock mortality due to disease and decreased incidence of diseases.

Coastal Fisheries: Actions are targeted at amplifying both coastal and inland aquaculture production to ensure food security and sustainably enhanced income; development of climate resilient coastal villages with safe housing for fishing communities, climate proofing of fisherfolk livelihood by diversifying income sources and loss and damage reduction due to coastal hazards; and development of post-harvest infrastructure essential to minimize losses.

Forest and Biodiversity: Although the forest coverage across the State is impressive, few districts have relatively lower biodiverse forest area and coverage, insufficient forest protection, and fewer waterbodies in their forests. Inadequate field-level human resources and establishments for forest conservation, as well as a higher number of forest fires and human-wildlife conflicts, increase the vulnerability in the sector. Improving the forest biodiversity, controlling invasive species, and managing forest fires and human-wildlife conflict are essential to build adaptive capacity in the sector.

Health*:* Palakkad, Malappuram, and Kasaragod are classified as highly vulnerable in the health sector. The vulnerability may be lowered by adopting no-regret adaptation strategies to improve healthcare infrastructure and service provisions, water supply and insurance coverage, and emergency healthcare services for inherently sensitive populations. This would involve developing and integrating climate data into disease surveillance and warning systems; strengthening emergency healthcare services in regions at risk of increased mortality due to climate extremes; improving critical infrastructure, and developing enhanced solid and liquid waste management, including biomedical waste treatment and management facilities.

Water Resources*:* The districts of Wayanad, Alappuzha, Kottayam, and Kozhikode were ranked as being highly vulnerable in terms of water resources due to poor drainage density and irrigation coverage, the insufficient storage capacity of reservoirs, poor surface water quality, and fewer surface water and meteorological monitoring stations. High population density exacerbates water stress, and many people living below the poverty line have limited access to treated water supply throughout the year. Interventions aimed at improving resilience in terms of water resources are conceived to address the significant drivers of vulnerability, including access to safe drinking water, development of sustainable drainage systems, and the development of a Water Resource Information System.

Priority Interventions

In addition to the sectoral interventions, adaptation strategies in priority areas are identified, and projects are devised based on the Composite Vulnerability Assessment, the climate

profile, and stakeholder recommendations. These adaptation projects are essential to build resilience against the risks of climate change that are of priority concern and have cross-sectoral implications. The major interventions include land use planning and zoning, sustainable shore protection and riverbank stabilization, rehabilitation of vulnerable communities, sustainable drainage systems for better flood management, integrated coastal zone management, climate change monitoring mechanism, climate proofing of local government's development plans, and climate education and awareness.

The detailed strategies and actions for the key sectors and priority interventions are mentioned in ***Section 6*** of the plan.

Finance

The proposed mitigation strategies for the State of Kerala require an outlay of INR 52,238 Crore, and the adaptation outlay is estimated at INR 38,407 Crore. Guidelines for funding State Action Plan on Climate Change by the MoEFCC prescribe the detailed path for financing the SAPCCs. A prudent blend of Central, State and external finance is essential to fund the planned actions under SAPCC. However, the State Government shall allocate the resources for implementing the SAPCC in the plan outlay for the respective within the fiscal space available. The Central Government shall make additional resources available to the State to help them meet the incremental/full cost of the mitigation and adaptation activities.

An increment in the annual budget allocation for tackling climate change actions may be required to aid climate financing in various sectors. Details of climate finance of the State are mentioned in ***Section 7*** of the Plan.

Institutional Mechanism

The Chief Minister's Governing Council on Climate Change, supported by the State Level Steering Committee (SLSC), shall act as the apex mechanism. The SLSC will continue to function as the top-level executive body supported by the State Climate Change Cell (SCCC) and the Working Groups. In addition to these functional bodies, it is proposed to constitute a high-level advisory committee with members from the State Planning Board, reputed academic and research institutions, and international and national level sectoral experts. Regular convening of the SLSC, along with the independent advisory committee, focusing on monitoring and evaluating the various strategies, is inevitable for any course correction required for further implementation. The detailed institutional mechanism is proposed in ***Section 8*** of the Plan.

Monitoring and Evaluation

The monitoring and evaluation proposed in the Plan is indicator based. There shall be separate M&E for mitigation and adaptation actions. Comprehensive financial and economic analyses are envisaged to assess the potential annual and incremental benefits and returns of project activities even after project completion. For natural resource-based adaptation projects, particularly for agriculture, livestock, fisheries, and forestry sectors, GHG accounting of proposed project interventions may be assessed using tools such as the Ex-Ante Carbon Balance Tool (EX-ACT v9, FAO) to assess mitigation co-benefits. The M&E framework is detailed in ***Section 9*** of the Plan.

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Abbreviations

ADB	Asian Development Bank
AEU	Agro Ecological Unit
AF	Adaptation Fund
AFOLU	Agriculture, Forestry and Other Land Use
AHD	Animal Husbandry Department
AMI	Agricultural Marketing Infrastructure
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
ANERT	Agency for New and Renewable Energy Research and Technology
AOGCM	Atmosphere/Ocean General Circulation Model
AT&C	Aggregate Technical & Commercial
ATMA	Agricultural Technology Management Agency
BAU	Business as Usual
BEE	Bureau of Energy Efficiency
BHS	Biodiversity Heritage Sites
BPCL	Bharat Petroleum Corporation Limited
BRT	Bus Rapid Transit
CAGR	Compounded Annual Growth Rate
CAMPA	Compensatory Afforestation Fund Management and Planning Authority
CCAP	Climate Change Action Programme
CCCR	Centre for Climate Change Research
CDM	Clean Development Mechanism
CEA	Central Electricity Authority
CER	Corporate Environment Responsibility
CERC	Central Electricity Regulatory Commission
CERES	Crop Estimation through Resource and Environmental Synthesis
CETP	Common Effluent Treatment Plant
CGWB	Central Ground Water Board
CIAL	Cochin International Airport Limited
CMFRI	Central Marine Fisheries Research Institute

CMIP	Coupled Model Intercomparison Project
CORDEX	Coordinated Regional Climate Downscaling Experiment
CPCRI	Central Plantation Crops Research Institute
CPSU	Central Public Sector Undertaking
CRZ	Coastal Regulation Zone
CSM	Cropping System Model
CSR	Corporate Social Responsibility
CSS	Centrally Sponsored Schemes
CUF	Capacity Utilisation Factor
CWRDM	Centre for Water Resources Development and Management
CZMP	Coastal Zone Management Plan
DADFW	Department of Agriculture Development and Farmers Welfare
DCCC	District Climate Change Cell
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana
DFID	Department for International Development
DHS	Directorate of Health Services
DISCOM	Distribution Company
DME	Directorate of Medical Education
DoECC	Directorate of Environment and Climate Change
DPC	District Planning Committee
DPR	Detailed Project Report
DSM	Demand Side Management
DSSAT	Decision-Support System for Agro-technology Transfer
DT	Distribution Transformer
E&ITD	Electronics and Information Technology Department
E-BRT	Electric Bus Rapid Transit
ECBC	Energy Conservation Building Code
EESL	Energy Efficiency Services Limited
EIA	Environmental Impact Assessment
EMC	Energy Management Centre
EQM	Empirical Quantile Mapping
ESA	Ecologically Sensitive Area
ESCerts	Energy Saving Certificates
ESCO	Energy Service Companies

ESGF	Earth System Grid Federation
ESZ	Ecologically Sensitive Zone
ETF	Enhanced Transparency Framework
EV	Electric Vehicle
FACT	Fertilizers and Chemicals Travancore Limited
FAME	Faster Adoption and Manufacturing of Electric Vehicles
FAO	Food and Agricultural Organization
FMCG	Fast Moving Consumer Goods
FMIS	Forest Management Information System
FRA	Forest Rights Act
FSI	Forest Survey of Indian
GCF	Green Climate Fund
GCM	Global Climate Model
GDVA	Gross District Value Added
GEF	Global Environment Facility
GHG	Green House Gas
GHGPI	Greenhouse Gas Platform India
GIM	Green India Mission
GIS	Geographical Information System
GIZ	German International Cooperation
GoI	Government of India
GSDP	Gross State Domestic Product
GSVA	Gross State Value Added
GWD	Ground Water Department
HVAC	Heating, Ventilation, and Air Conditioning
HVBA	High Value Biodiversity Area
ICCS	Institute for Climate Change Studies
ICDP	Intensive Cattle Development Programme
ICF	International Classification of Functioning, Disability and Health
ICT	Information and Communication Technology
IDRB	Irrigation Design and Research Board
IDSP	Integrated Disease Surveillance Programme
IESS	India Energy Security Scenarios
IIM	Indian Institute of Management

IIPS	International Institute for Population Studies
IITM	Indian Institute of Tropical Meteorology
IKI	International Climate Initiative
IMAGE	Indian Medical Association Goes Eco-Friendly
IMD	India Meteorological Department
IMR	Infant Mortality Rate
IPCC	Intergovernmental Panel on Climate Change
IPDS	Integrated Power Development Scheme
IPPU	Industrial Processes and Product Use
IPZ	Island Protection Zone
ISAM	Integrated Scheme for Agricultural Marketing
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
JLG	Joint Liability Group
JNTBGRI	Jawaharlal Nehru Tropical Botanic Garden and Research Institute
KASP	Karunya Arogya Suraksha Padhathi
KAU	Kerala Agricultural University
KERC	Kerala State Electricity Regulatory Commission
KFD	Kerala Forest Department
KIIFB	Kerala Infrastructure Investment Fund Board
KMRL	Kochi Metro Rail Limited
KPDNA	Kerala Post Disaster Need Assessment
KRWSA	Kerala Rural Water Supply and Sanitation Agency
KSAMM	Kerala State Agricultural Mechanization Mission
KSBB	Kerala State Biodiversity Board
KSCADC	Kerala State Coastal Area Development Corporation Limited
KSDMA	Kerala State Disaster Management Authority
KSEBL	Kerala State Electricity Board Limited
KSPB	Kerala State Planning Board
KSPCB	Kerala State Pollution Control Board
KSRTC	Kerala State Road Transport Corporation
KSUDP	Kerala Sustainable Urban Development Project
KVASU	Kerala Veterinary and Animal Sciences University
KVK	Krishi Vigyan Kendra

KWA	Kerala Water Authority
LAPCC	Local Action Plan on Climate Change
LDCF	Least Developed Countries Fund
LFPR	Labor Force Participation Rate
LPA	Long Period Average
LPJ	Lund-Potsdam-Jena
LSGD	Local Self Government Department
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MIS	Management Information Systems
MMR	Maternal Mortality Rate
MMTPA	Million Metric Tonnes Per Annum
MNRE	Ministry of New and Renewable Energy
MoEFCC	Ministry of Environment, Forest and Climate Change
MoP	Ministry of Power
MRI	Meteorological Research Institute
MSME	Micro, Small & Medium Enterprises
$MtCO_2e$	Million tonnes of CO2 equivalent
NABARD	National Bank for Agriculture and Rural Development
NaBFID	National Bank for Financing Infrastructure and Development
NAFCC	National Adaptation Fund for Climate Change
NAP	National Afforestation Programme
NAPCC	National Action Plan on Climate Change
NASA	National Aeronautics and Space Administration
NBSSLUP	National Bureau of Soil Survey and Land Use Planning
NCCR	National Centre for Coastal Research
NCESS	National Centre for Earth Science Studies
NDC	Nationally Determined Contributions
NFDB	National Fisheries Development Board
NFHS	National Family Health Survey
NHAI	National Highways Authority of India
NHR	Net Heat Rate
NIE	National Implementing Entity
NMEEE	National Mission for Enhanced Energy Efficiency
NMSA	National Mission for Sustainable Agriculture

NMT	Non-Motorized Transport
NPP	Net Primary Productivity
NRGF	National Resources Governance Framework
NTFP	Non-timber Forest Products
NTPC	National Thermal Power Corporation Limited
O&M	Operations and Maintenance
OECM	Other Effective Area based Conservation Measures
PACS	Primary Agricultural Credit Societies
PAT scheme	Perform Achieve and Trade scheme
PFM	Participatory Forest Management
PKVY	Paramparagat Krishi Vikas Yojana
PLF	Plant Load Factor
PMKUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
PMUY	Pradhan Mantri Ujjwala Yojana
PPAC	Petroleum Planning & Analysis Cell
PPPs	Public Private Partnerships
PSDF	Power System Development Fund
PSU	Public Sector Undertaking
PWD	Public Works Department
R&M	Renovation and Modernisation
R-APDRP	Re-structured Accelerated Power Development and Reforms Programme
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
RE	Renewable Energy
REC	Renewable Energy Certificate
RIDF	Rural Infrastructure Development Fund
RKDP	Rebuild Kerala Development Programme
RKI	Rebuild Kerala Initiative
RKVY	Rashtriya Krishi Vikas Yojana
RLNG	Regasified Liquid Natural Gas
RPO	Renewable Power Obligations
RRT	Rapid Response Team
RTPV	Roof Top Photovoltaic
SAARC	South Asian Association for Regional Cooperation

SAPCC	State Action Plan on Climate Change
SAPCCHH	State Action Plan for Climate Change and Human Health
SCCC	State Climate Change Cell
SCCF	Special Climate Change Fund
SDC	Swiss Agency for Development and Cooperation
SEAP	Sustainably Enhancing Agricultural Productivity
SEC	Specific Energy Consumption/Use
SeCCC	Sectoral Climate Change Cell
SHG	Self Help Group
SLBC	State Level Banker's Committee
SLNP	Street Lighting National Programme
SLSC	State Level Steering Committee
SPV	Solar Photovoltaic
SSP	Shared Socioeconomic Pathways
STP	Sewage Treatment Plant
T&D	Transmission and Distribution
TCC	Travancore Cochin Chemicals Limited
TERI	Tata Energy Research Institute
TOD	Transit-Oriented Development
TPPs	Thermal Power Plants
UDAY	Ujjwal DISCOM Assurance Yojana
UIDSSM	Urban Infrastructure Development Scheme for Small and Medium Towns
UJALA	Unnat Jyoti by Affordable LEDs for All
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WAPCOS	Water and Power Consultancy Services
WFP	World Food Programme
WII	Wildlife Institute of India
WMO	World Meteorological Organization
WPR	Worker Population Ratio

1. Introduction

1.1. Context

The major thrust of this Plan is to address the impacts of global warming and climate change in the State. As per the United Nations Intergovernmental Panel on Climate Change, global warming refers to the change in global surface temperature relative to a rational baseline. Specific global warming levels, such as 1.5°C, 2°C, 3°C or 4°C, are defined as changes in global surface temperature relative to the years 1850–1900 as the baseline which is the earliest period of reliable observations with sufficient geographic coverage over the globe. These levels are used to assess and communicate information about global and regional changes, linked to various scenarios[1] and are used as a common basis for assessments. The Assessment Report-6 of the IPCC reports that, there has been an estimated rise of 1.07°C from 1850 - 1900 to 2010 - 2019 and this temperature rise is predominantly human-induced (**Figure 1.1**).

Climate Change is referred to as the change in the state of the climate that can be identified by changes in the mean and variability of climate properties that persist for an extended period, typically decades or longer. Such changes in the climate may be due to natural internal processes or external forcing, changes in the composition of the atmosphere, or land use due to anthropogenic causes. Since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil, and natural gas.

There are concerns regarding equity and justice of the gains, costs and impacts of climate change as there is a wide disparity in the per capita contribution to global warming among the nations. This, however, is not a deterrent factor to act in the right manner to address climate change. Joining hands with global humanity to move in tandem with the inter-governmental coordinated efforts is a pressing need. The Paris Agreement has aimed to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels. Even if the most ambitious targets are met, it is expected that the 1.5°C target might be traversed. Thus, it is imperative to install readiness along with other measures into the systems to adapt to the possible impacts of any temperature rise of that magnitude.

This Plan is primarily built upon the region-specific assessments made regarding the systemic vulnerabilities of various sectors to

1 *Scenarios in climate change context are alternative images of how the future might unfold and are tool which analyse the influences of driving forces on the future Greenhouse Gas emission outcomes. This is used to assess the associated uncertainties as well. Scenarios assist in climate change analysis, including climate modelling and the assessment of impacts, adaptation, and mitigation. Refer Section 3, Box 3.1*

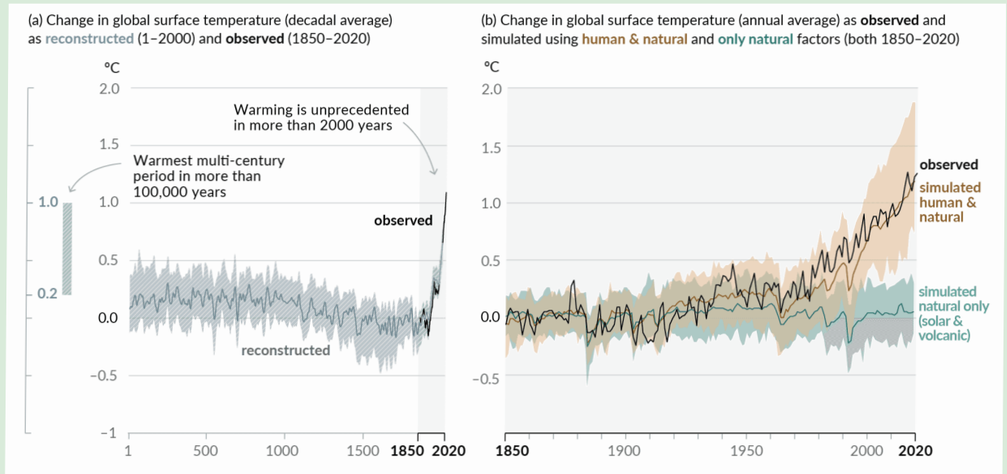


Figure 1.1: **Changes in global surface temperature relative to 1850 - 1900**
Source: UNIPCC AR-6 WG-I (SPM)

the climate change scene taking district as the basic unit of all such assessments and on the multi-tier level consultative process employed to formulate strategies, interventions and actions to address climate change in the two dimensions of adaptation and mitigation. The sector level vulnerabilities and the driving factors identified are detailed in *Section 4* of the Plan.

Concentrations of major Greenhouse Gases (GHGs) have continued to increase in the atmosphere reaching annual averages of 410 ppm[2] for carbon dioxide (CO_2), 1866 ppb[3] of methane (CH_4), and 332 ppb of nitrous oxide (N_2O) in 2019 (IPCC, 2021). Mitigation as a climate change response strategy is to limit the emission of these GHGs into the atmosphere. Land and oceans act as sinks and have taken up a proportion of the CO_2 emissions from human activities over the past decades[4]. Mitigation actions can be either reducing the sources of such emissions or enhancing the "sinks" that accumulate and store these gases such as the oceans, forests, and soil. *Section 5* of this Plan deals with mitigation actions to be taken up in the State. Adaptation on the other hand is adapting to life in a changing climate scenario. This might involve adjusting to the actual or expected future climate. Adaptation is fundamentally to reduce our risks from the impacts of climate change like sea-level rise, more intense extreme weather events, or food insecurity. India ranks 7 in the Global Climate Risk Index-2021 (Eckstein et al, 2021) and its vulnerability is due to the high dependency on climate-sensitive sectors and the high exposure to climate-related disasters (68% of cultivable land in India is drought prone; 12% flood-prone), and the resource inadequacy to cope with the impacts. *Section 6* of the Plan deals with actions to be taken up for adaptation.

Under the Paris Agreement, countries came forward to hold the increase in global average temperature to well below 2°C above pre-industrial levels, increasing the ability to adapt to the adverse impacts of climate change, and lowering greenhouse gas (GHG) emissions, while promoting climate-resilient development. Countries submitted Nationally Determined Contributions (NDC) goals and targets[5]. The Government of India also submitted NDC goals and targets. India is also committed to the United Nations (UN) Sustainable Development Goals (SDGs). The 2030 agenda for global sustainable development envisions the development and application of technology that is climate-sensitive, addresses biodiversity concerns, and climate resilient.

2 *parts per million*
3 *parts per billion*
4 *IPCC observes that this has happened in near constant proportion at around 56% per year over the past six decades*

1.2. The Common Framework

Ministry of Environment, Forest & Climate Change (MoEFCC) issued a Common Framework for the revision of State Action Plan on Climate Change (SAPCC) in 2019, outlining the broad principles of revising the SAPCC (**Annexure 1.1.**). The framework emphasise the States to align their climate change actions with the NDC goals and complement the prevalent national development and policy initiatives including National Forest Policy, Biodiversity Goals, National E-Mobility Programme and Swatch Bharat Mission to reap greater developmental co-benefits.

The Common Framework has brought uniformity in climate planning among the States and has enhanced the scope of coordination and progress tracking. Keeping track of the SDGs and aligning them with the goals of the NDCs compels coordinated efforts at the sub-national, national and global levels. Within the Paris Agreement, the Enhanced Transparency Framework (ETF) has been established. Under ETF, starting in 2024, countries will report transparently on actions taken and progress in climate change mitigation, adaptation measures, and support provided or received. Action plans based on the latest climate science is an imperative at this point to synergize with the coordinated efforts to address climate change and to monitor the progress at required intervals.

5 *Nationally Determined Contributions, are actions that countries have communicated that they will take to reduce their Greenhouse Gas emissions to reach the goals of the Paris Agreement. Countries also communicate in the NDCs actions they will take to build resilience to adapt to the impacts of rising temperatures.*

1.3. Kerala State Action Plan on Climate Change 1.0

The National Action Plan on Climate Change (NAPCC) was formulated by the Government of India in 2008, as an inclusive and sustainable development strategy that was sensitive to climate change, thus providing a directional shift to the development pathway. The NAPCC aimed at enhancing current and planned programmes to address climate change through appropriate institutional mechanisms, and by building effective linkages with civil society, local government institutions, and public-private partnerships. NAPCC, through its sectoral missions, provided a detailed road map and the SAPCCs prepared by States aimed at realizing the objectives. The Kerala State Action Plan on Climate Change 1.0 (KSAPCC 1.0) developed by the Department of Environment was approved in 2014 with a vision to 'place climate change concerns at the forefront of sustainable development and for maintaining the quality of life of the people of the State'.

1.4. Imperatives for updating the State Action Plan on Climate Change

Human induced climate change is already causing many weather and climate extremes in every region across the globe. Evidence of observed changes in extreme events such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and their attribution to human influence, has strengthened. The global mean sea level increased by 0.20 m between 1901 and 2018. The average rate of sea level rise was 1.3 mm yr^{-1} between 1901 and 1971, increasing to 1.9 mm yr^{-1} between 1971 and 2006 and further increasing to 3.7 mm yr^{-1} between 2006 and 2018. Human influence was very likely the main driver of these increases since at least 1971 (IPCC, 2021).

There have been significant advancements in the perceptions and scientific understanding of climate change ever since SAPCC 1.0. Especially the regional concerns about climate change have changed. The Vulnerability Atlas of India identifies ~15.7 percent of Kerala as flood-prone.

In 2018, Kerala witnessed a set of unprecedented rainfall extremes and massive flooding. Kerala experienced an abnormally high rainfall from 1 June 2018 to 30 August 2018, leading to severe flooding in 13 districts in the State. The State received an excess of 96% during the period from 1 August to 30 August, and 33% during the entire monsoon period till the end of August (KSDMA, 2018). Though rainfall was the main factor for the flood; local terrain, unplanned land use and drainage system infrastructure, all played a major role in the loss that occurred. Therefore, it is imperative to rethink the adaptability and resilience of the State to such extremes, especially in light of what the global projections of climate change have identified.

Climate science on its end has advanced, ever since the Kerala SAPCC 1.0 and there have been many developments in international climate negotiations and commitments of countries around the world, including India. India is a signatory to the Paris Agreement and is bounded by this agreement to reduce GHG emissions and promote adaptation to climate change.

A revised SAPCC based on the latest climate science and aligned with the Government of India's developmental and other priorities will serve as the basis for better climate finance and governance in the State.

1.5. Kerala SAPCC 2.0 – Procedures and Organizations

Kerala SAPCC 2.0 is based on the Common Framework devised by the MoEFCC. The process document has referred to the latest IPCC Assessment Report 6 (AR6) working group outcomes. However, the Plan document is founded on the methodologies and scenarios stipulated by AR4 and AR5. The major leap forward from the SAPCC 1.0 is that the Plan is methodically framed and validated. The State has adopted a multi-tier method of plan preparation to ensure the sequential flow of the planning process. A core group of 220 nodal officers from 91 sectoral stakeholder institutions have been formed exclusively for the Kerala SAPCC 2.0. (**Annexure 1.2.**) Three tiers of Consultations were methodologically held; the approval of the parties was mooted through proper minuting of the events. The Tier-I consultation sessions were specifically for completing the sectoral vulnerability assessments. All the sectoral departments from the seven key sectors were consulted to discuss the indicators chosen and the drivers identified. The methodological preferences and the changes required were incorporated after the completion of consultations. Tier-II-A consultations were for the mitigation assessments and devising the mitigation strategies. The data gaps were listed and the data pooled to complete the mitigation assessment. The approval of the parties was mooted through proper minuting of the events.

Tier II-B consultations were completed further for devising adaptation strategies based on the vulnerability drivers. Tier III-A consultations were convened to devise the adaptation objectives/ projects based on the strategies and to map the financial outlay for the proposed interventions/ actions for the Plan period. Tier III-B consultations were carried out to identify the priority interventions required for the State and to map its finance. Each level of consultations was followed by departmental core group discussions and expert reviews. The final Plan and the assessments have been peer-reviewed by the scientific community and sectoral experts. The process of scoping, drafting and reviewing has been coordinated by the Directorate of Environment and Climate Change.

The leap forward from the Kerala SAPCC 1.0

- Use of improved climate model projections using CMIP5 CORDEX ensemble of models
- Assessment of impacts of climate change on the forest sector using a dynamic global vegetation model - LPJ
- Adoption of risk framework from the Intergovernmental Panel on Climate Change (IPCC, 2014)
- Policy stocktakes post Kerala SAPCC 1.0
- Suggested strategies and monitoring mechanisms for Kerala SAPCC 2.0

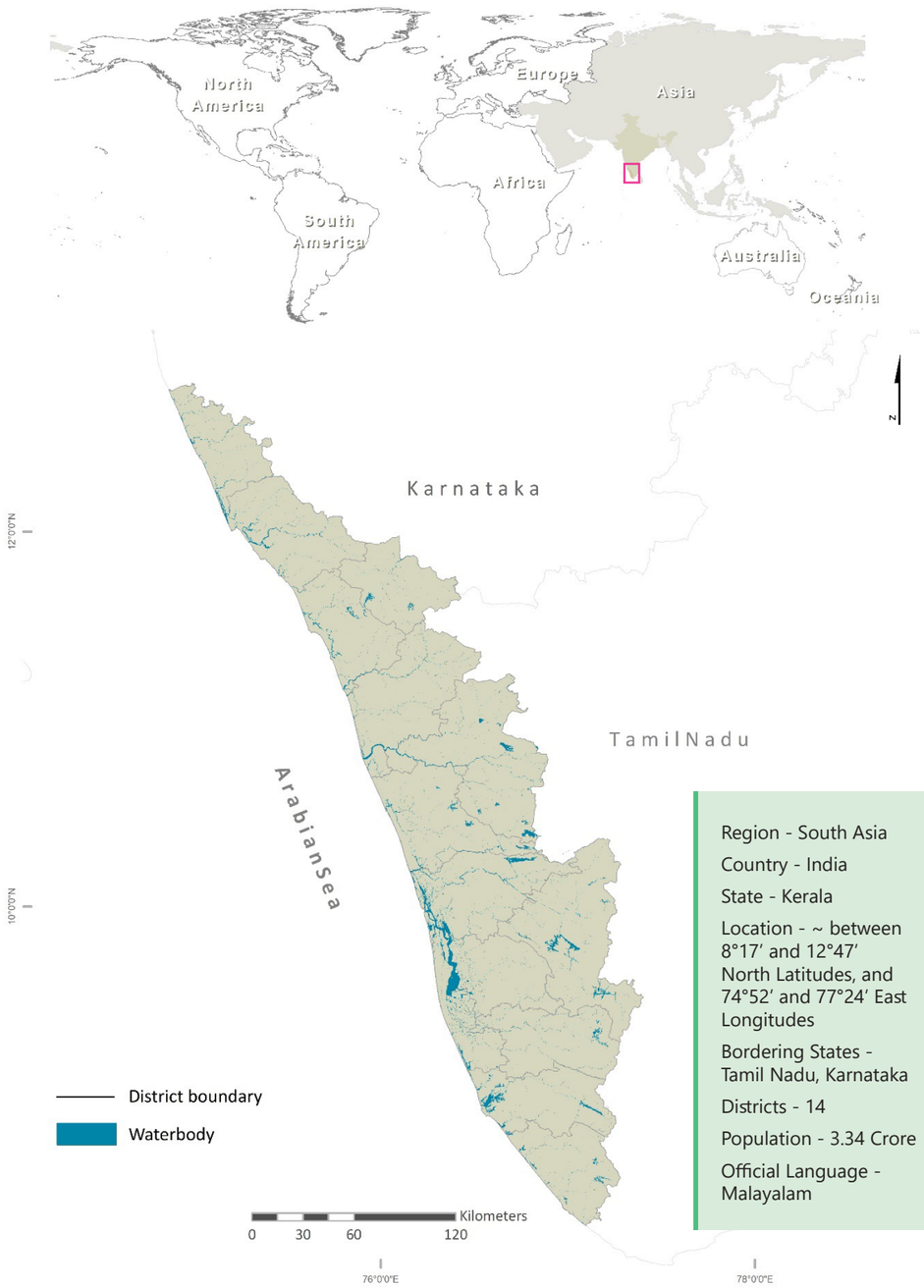
2. State Profile

2.1. Overview

Positioned between the Arabian Sea in the west and the Western Ghats in the east, occupying a total landmass of 38863 km^2, the State of Kerala in the southern tip of the Indian Peninsula, represents ~1.18 per cent of the Indian physiographic identity and ~0.75 per cent of the South Asia region[1] (**Figure 2.1**). From North to South, the extent of the State represented by its coastline is 592.9 km (NCCR, 2022). East to West, the width of the land ranges from 30 to 120 km. Within this spatial spread, the State endows three specific physiographic regions (**Figure 2.2**) identified as the eastern highlands represented by the mountain landscapes of the Western Ghats, the central midlands represented by undulating hills and valleys that are intensively cultivated and the western lowlands represented by estuaries, backwaters and the coastal regions. The Western Ghats forming the eastern border of the State is a unique mountain landscape that houses the highest peaks south of the Himalayas and represents its own ecological attributes and socio-economic profile. In the lowland region, there are many pristine estuarine systems and sub sea-level wetlands, forming a unique socio-ecological system. Across these landscapes, the State accommodates 3.34 Crore human lives with a density of 860/km^2 (Census of India, 2011), which is more than twice the national average. From the paddy and coconut predominant coastal lowland to the spices-dominated eastern highlands, the State holds unique diversity of cultural and ecological landscapes.

Kerala is bounded by Tamil Nadu to the East and Karnataka to the North. The State is networked by 44 rivers, of which 41 are west-flowing and joining the Arabian Sea. There are 14 districts, and the area of the districts ranges from 1,415 km^2 (Alappuzha) to 4,482 km^2 (Palakkad). The 14 districts are further classified into 78 taluks, 27 revenue divisions, 1,666 villages, 941 panchayats, 87 municipalities, and 6 municipal corporations for administrative purposes. The capital of the State is Thiruvananthapuram.

1 *https://data.worldbank.org/indicator (considering the SAARC nations)*



Region - South Asia

Country - India

State - Kerala

Location - ~ between 8°17′ and 12°47′ North Latitudes, and 74°52′ and 77°24′ East Longitudes

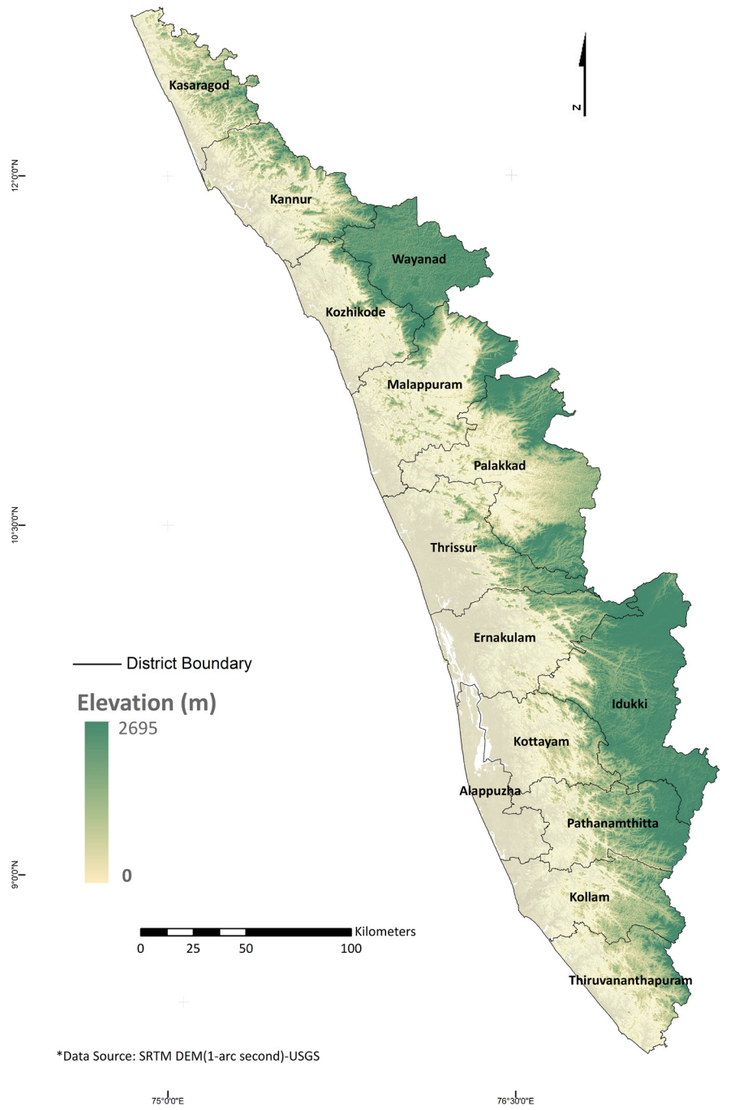
Bordering States - Tamil Nadu, Karnataka

Districts - 14

Population - 3.34 Crore

Official Language - Malayalam

Figure 2.1: The State of Kerala



Physiographically, Kerala has three regions, namely, Highland, Midland, and Lowland. It exhibits diverse geomorphic features, such as the tall mountain peak of Anaimudi (2695 m), 41 short-run west flowing rivers, and a coastal plain studded with several estuaries.

The Highland (>76.0 m) is the area on the eastern side of the state, stretching from extreme north to south, which follows a general trend along the Western Ghats.

The Midland (7.6-76.0 m) is the area between the Highland and Lowland (<7.6 m), constituting the undulated western fringes of the Highlands and the lateritic rocky spurs pointing westwards.

The Lowland is the coastal region consisting of inter-connected brackish canals, estuaries, rivers and are important for the state's economic activities.

Figure 2.2: Kerala - Physiography

2.2. Land Use Pattern

The land area of the State has been identified into thirteen different uses (**Table 2.1**). Agriculture occupies the majority share with a net area under cultivation in the State or the net sown area of 20,26,064 ha, forming about 52.13% of the total geographic area. Forests constitute the second largest land use class with 27.83 %.

2.3. Demographic Profile

In terms of population, Kerala is the 13th largest State in India. As per the Census of India (2011), Kerala had a population of 3,34,06,061 individuals (1,60,27,412 males and 1,73,78,649 females).

2.3.1. Population trends - Rural and Urban

During the decade 2001–11, the state's population witnessed a net addition of 15,64,687 persons to its 2001 population of 3,18,41,374. The male population increased by 5,58,798 and the female population increased by 10,05,889. Continuing the population growth trends of previous censuses, the State registered a growth rate of 4.91% over the 2001 Census, recording a decline of 4.52% in comparison with the growth of 9.43% registered during the 2001 Census over the 1991 Census **(Figure 2.3)**.

Among the 14 districts, Malappuram district has witnessed the highest decennial growth rate of 13.39%, followed by Kasaragod with 8.81%. Pathanamthitta and Idukki are the two districts in the State which have registered a negative growth rate of 3.12 and 1.93%, respectively. Only five districts have registered decennial growth rates higher than the State average.

2.3.2. District-wise population: Rural and Urban

In Kerala, Malappuram district is the most populated with 41,12,920 persons and accounts for 12.31% of the State's total population, while Wayanad district with a population of 8,17,420 and a population share of 2.44%, is the least populated district. Of the 3,34,06,061 persons enumerated in the State 1,74,71,135 persons reside in rural areas and 1,59,34,926 persons reside in urban areas (**Figure 2.4**). In terms of percentage, 52.3% are rural residents and 47.7% are urban residents (Census of India, 2011), while in 2001, the urban population was only 25.96%, which indicates that urbanization is taking place in the State at a fast pace.

Among the districts, Ernakulam is the most urbanized district with 68.01% of its population residing in urban areas, followed by Thrissur (67.16%), Kozhikode (67.15%), Kannur (65.04%), and Alappuzha (53.95%) districts. The least urbanized district in the State is Wayanad with 3.86%.

Table 2.1: **Land use pattern in Kerala (2019-20)**

Sl. No.	Category	Area (Ha)	Percentage to total Geographical Area
1	Net area sown	2026064	52.13
2	Forest	1081509	27.83
3	Land put to non-agricultural use	455897	11.73
4	Barren and uncultivable land	10619	0.27
5	Land under miscellaneous tree crop	2143	0.06
6	Cultivable waste	99810	2.57
7	Fallow other than the current fallow	46931	1.21
8	Current fallow	57387	1.48
9	Marshy land	11	0.00
10	Still water	100160	2.58
11	Water logged area	3077	0.08
12	Social forestry	2679	0.07
13	Permanent pastures and other grazing lands	0	0.00

Source: Directorate of Economics and Statistics, 2021

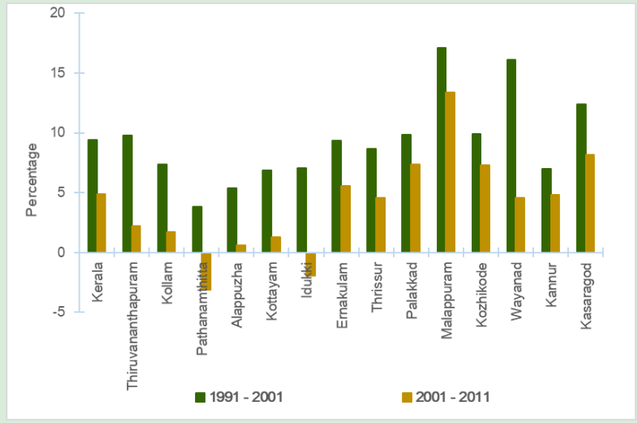


Figure 2.3: **Kerala - Percentage decadal growth rate of the population**
Source – Census of India, 2011

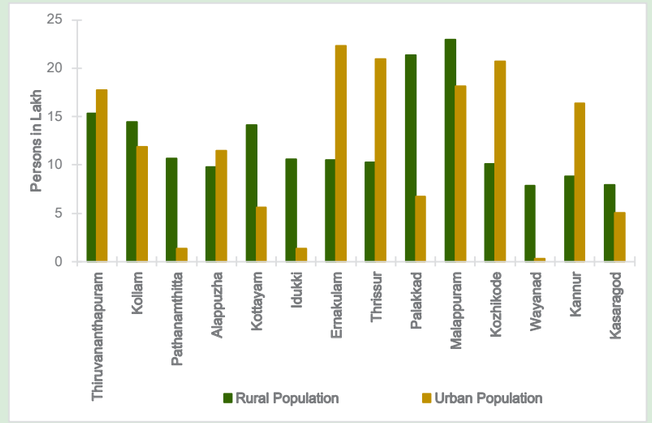


Figure 2.4: **District-wise population (Census of India, 2011)**

2.3.3. Occupation pattern in Kerala

The socio-economic development of a region is reflected in the proportion of workers engaged in various occupations. Occupation is invariably related to agriculture, industry, and service sectors (Prasad and Pratap, 2017). In Kerala, the different sectors of occupation include Agriculture and allied sectors, Mining and Quarrying, Manufacturing, Electricity and Water, Construction, Trade, Hotel and Restaurant, Transport, Storage and Communication, etc.

As per Census 2011, the total number of workers in the State is 1,16,19,063, out of which 93,29,747 are main workers and 22,89,316 are marginal workers. Among the total workers, 6,70,253 are cultivators and 13,22,850 are agricultural labourers. The total number of workers engaged in the agriculture sector is 19,93,103, which is 17.15% of the total number of total work force in the State. Around 2.35% of the total workers, that is, 2,73,022 are working in Household Industries and the remaining 80.5% (93,52,938) are under the domain of Other Workers.

The Labour Force Participation Rate (LFPR) indicates the percentage of persons in the labour force among the population. As per the Kerala Economic Review 2020, the LFPR in the State was 39.5% in the year 2018–19 compared to the LFPR of 36.6% in 2017–18. The male LFPR for the year 2018–19 was 56.6% and the female LFPR was 24.6% (**Table 2.2**).

The Worker Population Ratio (WPR) indicates the proportion of workers/employed persons in the total population. According to the Kerala Economic Review 2020, the WPR for 2018–19 for the State was 35.9%, more than the all-India average of 35.3%. The State average male and female worker population ratios are 53.8% and 20.4%, respectively (**Table 2.3**).

2.4. Economic Profile

The Gross State Domestic Product (GSDP) at constant prices (2011–12) was ₹5.68 Lakh Crore in 2019–20 whereas it was ₹5.49 Lakh Crore in the year 2018–19. At the current prices, the State GSDP is estimated at ₹8.54 Lakh Crore in the year 2019–20. The Gross State Value Added (GSVA) comprising GSVA of primary, secondary, and tertiary sectors at constant prices (2011-12) was estimated to be ₹5.01 Lakh Crore for the year 2019–20 (**Table 2.4**).

According to the Kerala Economic Review 2020, Ernakulam ranks first in terms of per capita income and it has shown a growth rate of 1.8% in the year 2019–20 as compared to the year 2018–19. Ernakulam is followed by Kollam

Table 2.2: Labour force participation rate in Kerala

Age Group	Rural (%)			Urban (%)			Total (%)		
	Male	Female	Person	Male	Female	Person	Male	Female	Person
	Kerala 2017–18								
15–29 years	55.1	20.8	37.2	48.4	27.6	37.8	52.2	23.6	37.4
15–59 years	79.5	31.1	53.6	78.1	33	53.6	78.9	31.9	53.6
15 years and above	71.1	25.9	46.6	68.9	27.3	46.4	70.1	26.5	46.5
All ages (0+)	54.1	20.7	36.4	53.6	22.1	36.8	53.9	21.3	36.6
	Kerala 2018–19								
15–29 years	43.3	23	32.9	51.6	29.1	39.9	47	25.8	36
15–59 years	76.5	35.5	54.6	79.9	35	55.4	78.1	35.2	55
15 years and above	71	31.3	49.7	71.4	29.7	48.8	71.2	30.6	49.3
All ages(0+)	56.9	25	39.7	56.3	24.2	39.2	56.6	24.6	39.5

Source: Kerala Economic Review, 2020

Table 2.3: Worker population ratio in Kerala

Age Group	Rural (%)			Urban (%)			Total (%)		
	Male	Female	Person	Male	Female	Person	Male	Female	Person
	Kerala 2017–18								
15–29 years	43.8	7.9	25.1	35.1	9.6	22.1	40.1	8.6	23.8
15–59 years	74.3	24.5	47.6	72.2	23.4	45.7	73.4	24	46.8
15 years and above	67	20.8	41.9	64.4	19.8	40.2	65.8	20.4	41.2
All ages	50.9	16.6	32.7	50	16	32	50.5	16.4	32.4
	Kerala 2018–19								
15–29 years	33.1	9.7	21.1	39.7	13.7	26.1	36.1	11.5	23.4
15–59 years	72.2	29.2	49.2	75.1	27.7	49.3	73.5	28.5	49.3
15 years and above	67.6	26.4	45.5	67.7	24.1	44.1	67.7	25.3	44.9
All ages	54.2	21.1	36.4	53.4	19.7	35.4	53.8	20.4	35.9

Source: Kerala Economic Review, 2020

Table 2.4: Trends in the Gross State Domestic Product of Kerala

Year	1980–81	1990–91	2000–01	2009–10	2017–18	2018–19	2019–20
GSDP (Crore) at constant prices (2011-12) (Crore)	3823	12195	63715	180812	516189.8	549672.9	568635.5
Primary Sector (GSVA) (Crore)	1682	4756	14017	15966	47619.23	46004.41	42373.83
Secondary Sector (GSVA) (Crore)	841	3171	14017	38249	129866.3	138034	141805.6
Tertiary Sector (GSVA) (Crore)	1300	4268	35680	126597	283268.5	305303.8	317781.2
Per Capita Income (in Rupees)	1508	4207	19951	47360	149650	158564	163216

Source: Kerala Economic Review, 2020

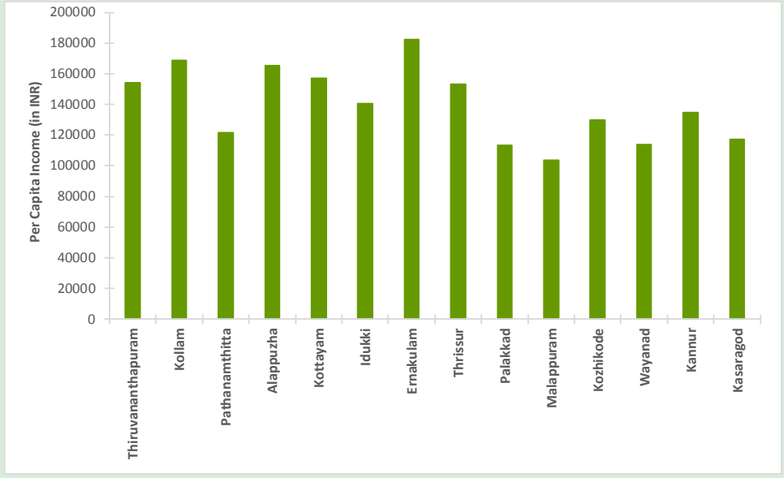


Figure 2.5: **District-wise per capita income (Kerala Economic Review, 2020)**

and Alappuzha, which rank second and third, respectively (**Figure 2.5**).

2.5. Water Resources

Expanding population, urbanization, agriculture/ irrigation, food production, energy demand, macroeconomic process, and changing consumption patterns determine the water resources use pattern in Kerala. Per capita annual availability of freshwater declined from 14443m^3 in 1951 to 5301m^3 in 2021. Even though Kerala's population is expected to stabilize in near future, the water demand may not decline due to the high growth of urbanization, rising living standards, growth of per capita income, and high levels of consumption and energy use. The groundwater scenario of the State is provided in **Table 2.5**. The climate change-induced extremes may exacerbate the issues in the water sector in the State.

The major sources of irrigation in Kerala are canals, tanks, and wells. In the year 2017–18, the

Table 2.5: **Groundwater scenario of Kerala**

Total Annual Groundwater Recharge	5.65 BCM
Net Annual Groundwater Availability	2.13 BCM
Annual Groundwater Draft	2.64 BCM
Stage of Ground Water Development	51.68%
Categorization of Blocks - based on stage of groundwater extraction	
Over Exploited	0 Blocks
Critical	3 Blocks
Semi-Critical	29 Blocks

Source: GWD, Government of Kerala & CGWB, 2022

Table 2.6: **Irrigation pattern in Kerala**

Area ('000 hectares)			2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18
Geographical Area			3886	3886	3886	3886	3886	3886	3886	3886
Net Area Irrigated	Canals	Government	86	82	81	80	86	89	63	77
		Private	6	2	2	1	1	1	1	1
		Total	91	84	83	81	87	90	64	77
	Tanks		51	47	44	45	47	48	50	50
	Wells	Tube-Wells	20	25	26	30	30	35	42	42
		Other Wells	138	137	122	125	133	134	122	123
	Other Sources		115	116	121	116	117	107	99	99
Net Irrigated Area			415	409	396	397	414	414	378	392
Area Irrigated more than once			52	137	62	71	55	70	120	148
Net Unirrigated Area			1656	1631	1652	1654	1629	1609	1638	1648

Source: Directorate of Economics and Statistics, 2021

net irrigated area was 3,92,000 ha, out of which 77,000 ha was irrigated through government canals, 50,000 ha through tanks, and 42,000 ha through tube wells (**Table 2.6**).

2.6. Cropping Pattern

The cropping pattern is influenced by agro-climatic conditions such as humidity, temperature, elevation, topography, vegetation, rainfall, soil structure, etc. Based on climate, geomorphology, land use and soil variability, the State is categorized in to five agroecological zones and 23 agroecological units (**Figure 2.6**). Kerala has a predominance of small and marginal farms; the average holding size, as per the Agricultural Census, is 0.18 ha or 0.4 acres (KSPB, 2021). The dominant crops grown in Kerala are cereals, pulses, oilseeds, and cash crops. Among cereals, rice is the dominant crop. Many condiments and spices are also grown in the State, such as black pepper, cardamom, ginger, turmeric, clove, and nutmeg. There are plantations of rubber, coffee, tea, coconut, banana, and pineapple. The area under the dominant principal crops in Kerala is provided in **Table 2.7**.

The area under paddy production has almost reduced to one-fourth as compared to the 1980s. (**Figure 2.7**) However, many other crops such as rubber, coconut, and arecanut have an increased value in the gross area under production. Kerala stands first in terms of the area under production for coconut in the country.

2.6.1 Trends in crop production and productivity

The crop productivity or crop yield is defined by the crop produced in kilograms per hectare. According to the data available in the Kerala Economic Review 2020, rice is the highest-yielding crop with a crop yield of 3073.82 kg/ha. It has seen a growth in the crop yield as it was 2920.45 kg/ha in the year 2018–20. Although

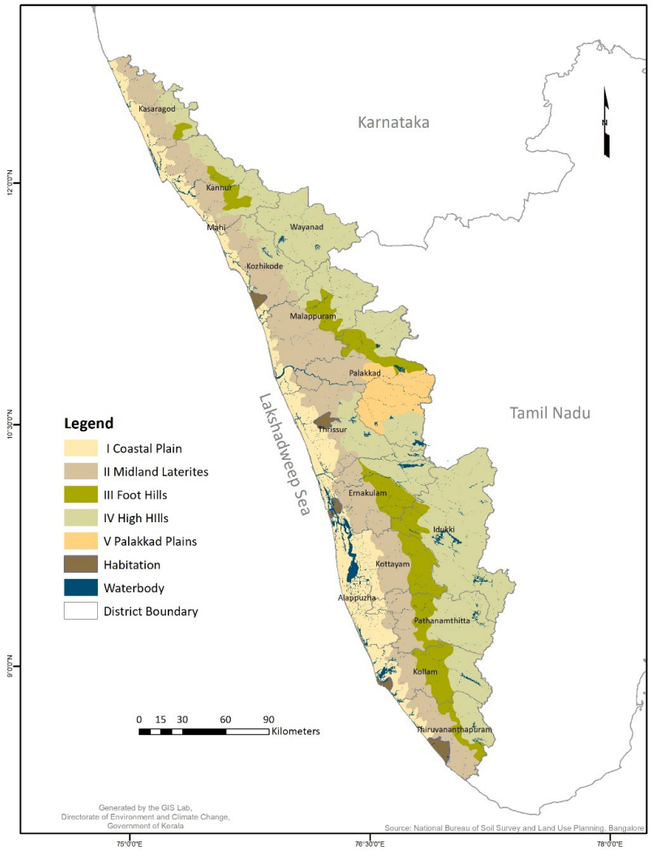


Figure 2.6. Kerala - Agroecological Zones (NBSSLUP, 2012)

Coastal Plains, comprises the near level to gently sloping lands along the coast, lying between the sea and the midlands. It includes sandy beaches, sandy plains, coastal laterites, and areas such as estuaries, backwaters, submerged lands, swamps, marshes, kayal lands, and broad valleys. The zone covers 5,09,246 ha (13.10 %) in the State.

Midland Laterites, comprises the undulating to rolling lands interspersed with narrow valleys, between the coastal plain on the west and foothills and hills on the east. Extending from the southern end to the northern end of the State, the zone covers 10,56,385 ha (27.18 %) in the State. The elevation ranges from 30 to 300 metres.

Foothills, constitutes the undulating to rolling lands and low hills, between the midland laterite on the west and high hills on the eastern side. The terrain has only very narrow valleys. The zone covers 4,60,074 ha (11.84 %) and the elevation ranges from 300 to 600 metres.

High Hills, the hilly region comprising Western Ghats and plateaus, extending from south to north. The Western Ghats and highland plateaus rise 600 m amsl, with a number of peaks well over 1800 m. The mountains are essentially plateau remnants of two or three altitudinal zones. Slopes of hill ranges can be as high as 80 per cent. The zone covers 15,53,225 ha (39.97 %) in the State.

Palakkad Plains, an inland plain with low elevation, is a prominent physical feature along the valley of the Bharathapuzha River. The gently sloping lands of Palakkad, east of Kuthiran hills, flanked on the south and north by Nelliyampathy hills and Attappady hills, respectively and merging to Tamil Nadu uplands through the gap in Western Ghats constitute the agro-ecological zone, covering 1,60,006 ha (4.12 %).

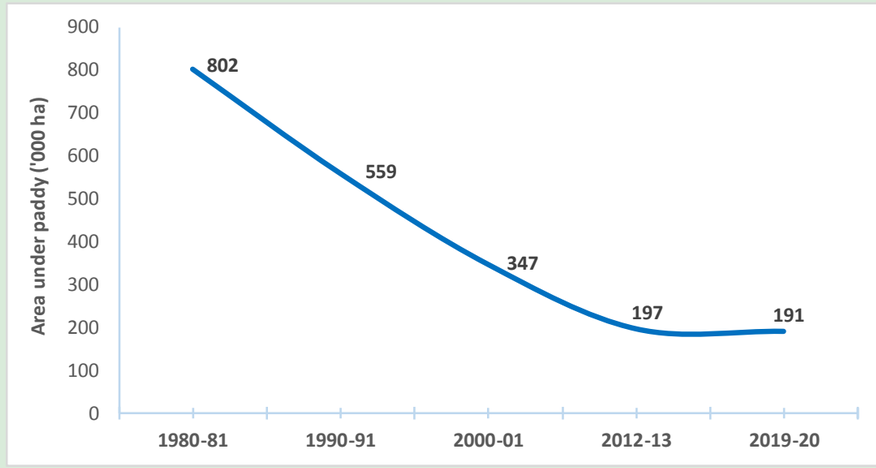


Figure 2.7: Trends in the area under paddy cultivation (Kerala Economic Review, 2020)

Table 2.7: Gross area under principal crops in Kerala

	1980-81	1990-91	2000-01	2012-13	2017-18	2018-19	2019-20
Paddy (Wetland) ('000 ha)	802	559	347	197	189	198	191
All Pulses ('000 ha)	34	23		3	1.9	2.5	2.3
Sugarcane ('000 ha)	8	8	3	2	1.05		
Rubber ('000 ha)	238	384	474	545	551	551.2	551.03
Tea ('000 ha)	36	35	37	30	30	36.47	35.87
Coconut ('000 ha)	651	870	926	798	760.4	760.9	760.77
Arecanut ('000 ha)	61	65		102	94.6	95.7	96.92
Groundnut ('000 ha)	9	13		0.7	0.27		
Pepper ('000 ha)	108	169	202	85	85.1	82.7	83.76
Cardamom ('000 ha)	56	67	41	42	39.1	38.8	39.69
Ginger ('000 ha)	13	14	12	5	4.37	3.27	2.82

Source: Kerala Economic Review, 2020

Table 2.8: Production of principal crops in Kerala

	1980–81	1990–91	2000–01	2012–13	2017–18	2018–19	2019–20
Rice ('000 tonnes)	1272	1087	751	509	521.3	578.25	587.1
All Pulses ('000 tonnes)	22	17		3	2.04	2.3	2.1
Sugarcane ('000 tonnes)	48	52	28	17	11.5		
Rubber ('000 tonnes)	140	308	560	800	540.7	492.5	533.5 (P)
Tea ('000 tonnes)	48	63	69	63	62.23	60.76	59.26
Coconut (in million nuts)	3008	4232	5536	5799	5230	5299	4814
Arecanut ('000 tonnes)	11	13		118	108.5	99.92	92.75
Groundnut ('000 tonnes)	8	10	10	9	0.38		
Pepper ('000 tonnes)	29	47	61	46	37.9	36.77	34.54
Cardamom ('000 tonnes)	3	3		10	18.3	11.53	10.07
Ginger ('000 tonnes)	32	46	42	22	18.9	15.12	11.91

Source: Kerala Economic Review, 2020

Table 2.9: Crop yield of principal crops in Kerala

	1980–81	1990–91	2000–01	2012–13	2017–18	2018–19	2019–20
Rice ('000 tonnes)	1586	1945	2164	2584	2758	2920	3074
All pulses ('000 tonnes)	647	739		1000	1074	920	913
Sugarcane ('000 tonnes)	6000	6500	9333	8500	10952		
Rubber ('000 tonnes)	588	802	1181	1468	981	893	968
Tea ('000 tonnes)	1333	1800	1865	2100	2074	1666	1652
Arecanut ('000 tonnes)	180	200		1157	1147	1044	957
Groundnut ('000 tonnes)	889	769		12857	1407		
Pepper ('000 tonnes)	269	278	302	541	445	445	412
Cardamom ('000 tonnes)	54	48		238	468	297	254
Ginger ('000 tonnes)	2462	3286	3500	4400	4325	4624	4223

Source: Kerala Economic Review, 2020

Table 2.10: Forest cover trends in Kerala state (km²)

Forest type		ISFR 1991	ISFR 1999	ISFR 2001	ISFR 2011	ISFR 2019	ISFR 2021
Dense forest	Very Dense Forest	8421	8429	11772	1442	1934	1944
	Moderately Dense Forest				9394	9508	9472
Open forest		1871	1894	3788	6464	9701	9837
Total forest cover		10149	10323	15560	17300	21144	21253
Scrub		109	91	71	58	13	30

Source: ISFR (FSI, 1991; 1999; 2001; 2011; 2019; 2021)

the production of rice crops has significantly decreased, there is an increase in the crop yield (**Table 2.8**).

In terms of percentage, the production and productivity of paddy have increased by 1.52% and 5.24%, respectively, in the year 2019–20 as compared to the 2018–19 levels (**Table 2.9**). Cardamom had the lowest crop yield of 253.7 kg/ha in the year 2019–20.

2.7 Forests

The total forest cover[2] of Kerala is 21,253 km², which is 54.68% of the geographical area of the State (FSI, 2021). The total forest area in Kerala is 11,524 km², which is 29.65 % of the geographical area of the State (KFD, 2021). The forest canopy density classes in the State have 1,944 km² under Very Dense Forest, 9,472 km² under Moderately Dense Forest, 9,837 km² under Open Forest, and around 30 km² come under Scrub (**Table 2.10**). The State has also been carrying out afforestation under the National Mission for Green India. So far, about 12,298 ha have been afforested.

2.8 SDGs in Kerala

Kerala ranks first in SDG India Index Report. This is mainly because of its performance in providing good health, hunger reduction, gender equality and quality education. Overall, Kerala occupies *Forerunner* position in 8 SDGs, *Performer* position in 4 SDGs. Kerala has secured first rank in SDGs 2 (Zero Hunger), 4 (Quality Education) and 7 (Affordable and Clean Energy). The State stand second in SDGs 1 (No Poverty), 5 (Gender Equality) and 13 (Climate Action).

2 *There exists a conceptual difference between Forest Cover and Forest Area. The term 'Forest Area' (or recorded forest area) generally refers to all the geographic areas recorded as forests in government records. On the other hand, the term 'Forest Cover' refers to all lands more than one hectare in area, having a tree canopy density of more than 10%. (FSI, 2021)*

3. Climate Profile

3.1 Overview

Following Koppen's Climate classification, Kerala has a dominant tropical monsoon climate with seasonally excessive rainfall and hot summer except over Thiruvananthapuram, where the climate is tropical savanna with seasonally dry and hot summer weather. The year could be divided into four seasons[1]. The period from March to the end of May is the hot season (Pre-monsoon). This is followed by the southwest monsoon season (Monsoon) that continues till the beginning of October. October to December is the northeast monsoon season (Post-monsoon) and the two months of January and February comprise the winter season (Winter). The entire State is classified as one among the 36 meteorological sub-divisions in India for climatological purposes.

The geographical diversity of the State has resulted in a corresponding diversity in climate. The High Ranges have a cool and bracing climate, while the plains are hot and humid. The winds have westerly components during the day and easterly components during the night. In the Palakkad Gap region, the winds are seasonal, predominantly from the east in the period from November to March and from west in the rest of the year. In general, the State experiences high percentage humidity throughout the year. During hot seasons, the afternoon humidity may reduce to 60-63% and the diurnal variation is maximum and ranges from 4 to 16%, depending upon the proximity of the sea. The relative humidity in the monsoon period rises to about 85% for the State (IMD, 1986).

Day temperatures are more or less uniform over the plains throughout the year except during monsoon months when these temperatures drop down by about 3 to 5°C. March and April are the hot months with a mean maximum temperature of about 33 °C (Vijay and Varija, 2022). The diurnal range of temperature is maximum during summer months. Kerala receives high average annual rainfall compared to other Indian states. The mean annual rainfall over Kerala from 1871 to 2016 is 2816mm[2].

1 *The standard seasonal classification followed by the IMD for Kerala is used for all assessments in this plan.*

2 *Monthly, Seasonal and Annual Rainfall Time Series for All-India, Homogeneous Regions and Meteorological Subdivisions: 1871-2016, IITM, Pune.*

Table 3.1: Procedures in historical temperature analysis

	Task	Data and Analysis
1	Estimate district-level averages of temperature for the past 30 years	Source: IMD, Pune (http://imd.gov.in/)) Dataset: Gridded daily temperature. Spatial Resolution: 1° x 1°
2	Conduct analysis of trends and variability in observed temperature at the district level	Trends in monthly mean maximum and minimum temperature
Historical (Baseline) Period: 1990 - 2019		

Table 3.2: Procedures in historical rainfall analysis

	Task	Data and Analysis
1	Estimate district-level averages in rainfall for the past 30 years	Source: IMD, Pune (http://imd.gov.in/)) Dataset: Gridded daily rainfall Spatial Resolution: 0.25° x 0.25°
2	Conduct analysis of trends and variability in observed rainfall at the district level	Annual and seasonal variations and trends
Historical (Baseline) Period: 1991 - 2020		

Climate is a complex phenomenon and requires variables like rainfall, temperature, humidity and wind monitored for long periods to undertake analysis and frame scientific inferences. The need and scope of understanding the adaptability of the State and its systems to the variabilities in the parameters as an indicator of changing climate are very much significant. For the scope of this plan temperature and rainfall, as two independent variables are taken for all assessments. Also, the climate projections done using the latest methodologies are to estimate the spread and pattern than deriving absolute inferences. Three major analyses were done in this section. First is the historical analysis of temperature and rainfall for its annual and seasonal variations. Second is the projections for temperature and rainfall for the near-term and mid-term. Third is a comparison between the historical and the projected scenarios.

3.2 Historical Climate Characteristics

The temperature analysis was done for the pre-monsoon (summer - MAM: March to May) and winter (JF: January and February) seasons. For rainfall, annual to seasonal trends and variability were analysed. The procedure adopted for historical climate analysis is presented in **Table 3.1 and 3.2.**

3.2.1 Trends in temperature

A moderate warming trend has been observed in the summer maximum and the winter minimum temperatures during the historical period (**Figure 3.1a and 3.1b**).

3.2.2 Trends in rainfall and rainfall variability

In general, a decreasing trend in the mean annual and monsoon rainfall is observed over the State during the historical period (**Figure 3.2a**). Mean annual rainfall showed a decreasing trend in all districts except Idukki, Palakkad, Kozhikode and Wayanad (**Figure 3.2b**).

The annual rainfall variability was in the range of 14% (Alappuzha) to 31% (Wayanad). The rainfall variability ranges from 17% (Kasaragod) to 39% (Wayanad) during monsoon, 31% (Pathanamthitta) to 58% (Kasaragod) during pre-monsoon, and 30% (Kottayam) to 40%

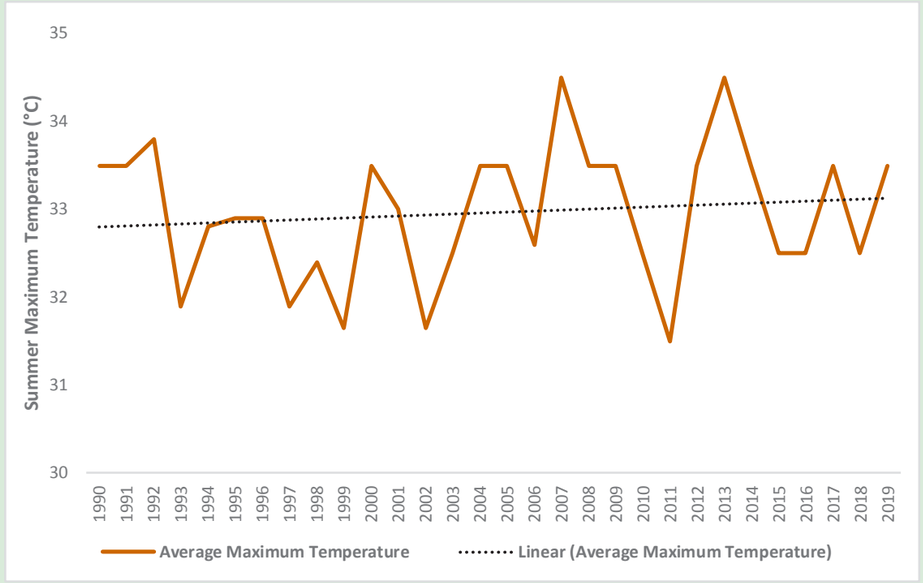


Figure 3.1a: Mean summer maximum temperature during the historical period

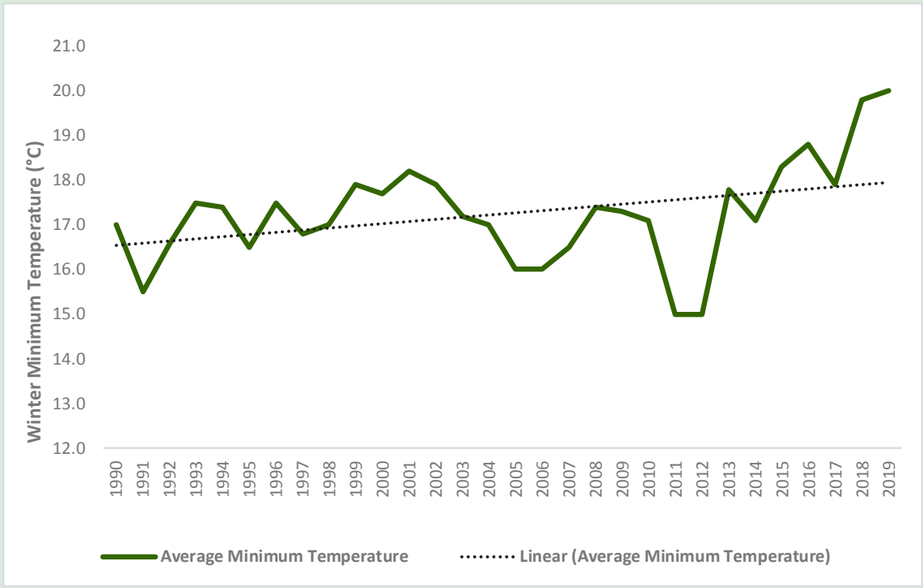


Figure 3.1b: Mean winter minimum temperature during the historical period

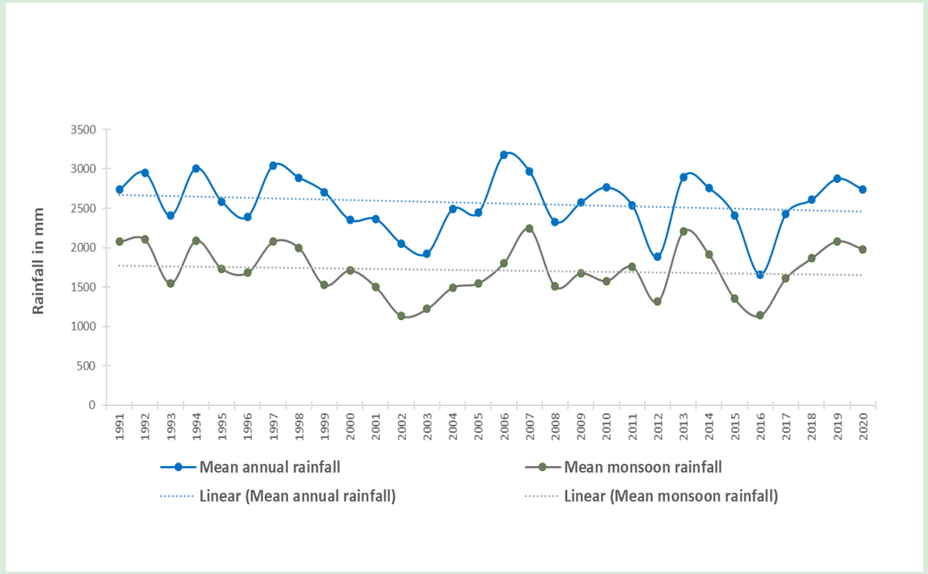


Figure 3.2a: Mean annual and monsoon rainfall during the historical period

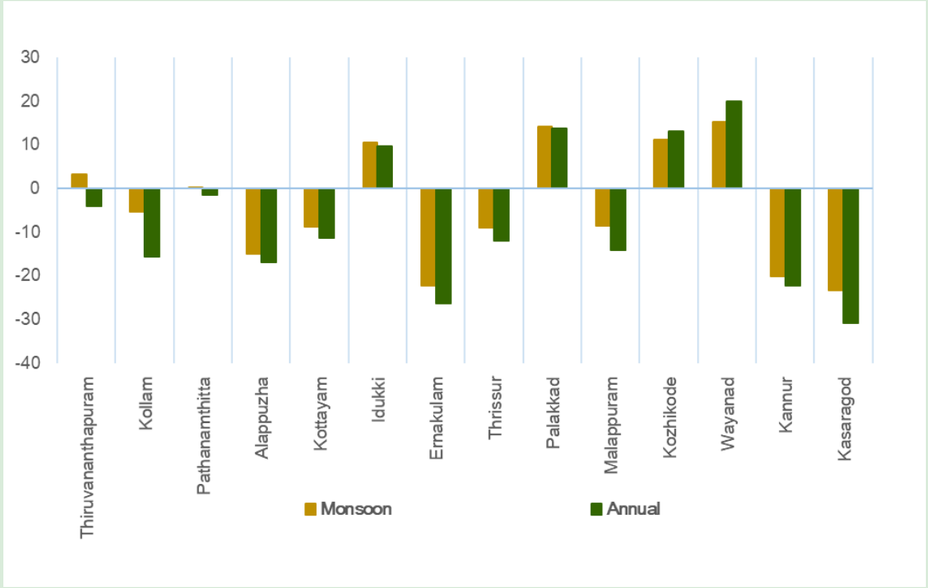


Figure 3.2b: District-wise annual and monsoon rainfall trend during the historical period

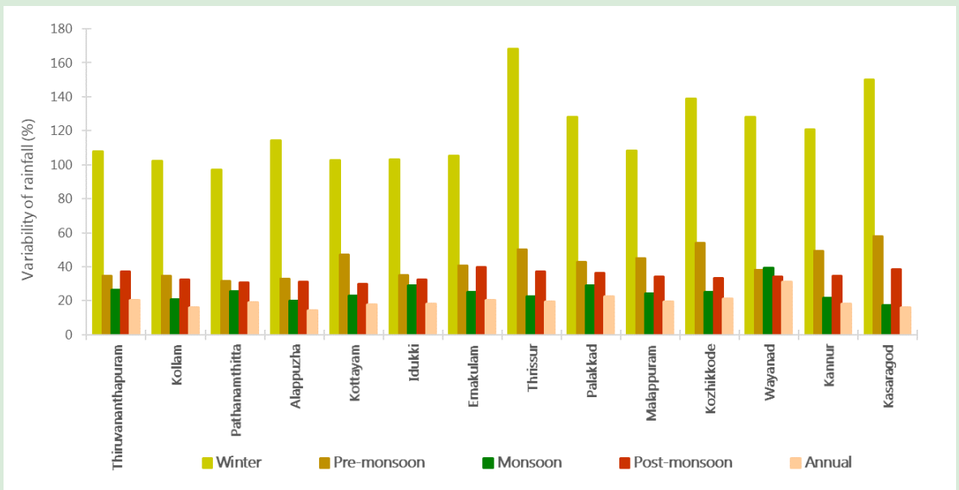


Figure 3.3: **District wise annual and seasonal rainfall variability during the historical period**

(Ernakulam) during post-monsoon. Compared to other seasons, very low rainfall, unequal spatial distribution and high variability were observed in the winter (**Figure 3.3**).

3.3 Climate Projections

Climate projections are simulations of the climate of a specific region in future decades, usually based on assumed 'scenarios' for the concentrations of GHGs, aerosols and other atmospheric constituents that affect the planet's radiative balance. Climate projections are arrived at by running numerical models, which may cover either the entire globe or a specific region. The models covering the entire globe are referred to as Global Climate Models (GCMs) and the downscaled region-specific models are called Regional Climate Models (RCMs). The assessment made here is aligned with the World Meteorological Organization (WMO) baseline approach, which is 30 year averages[3] (WMO, 2017).

Under this plan, temperature for both summer maximum (pre-monsoon; March to May), potentially causing heat stress, and winter minimum (January to February), critical for human comfort and winter crops, were analysed for the projected period of near-term (2021 – 2050)[4]. For rainfall projections, season-wise percentage change and variability of rainfall, number of rainy days and extreme rainfall events were analysed for the projected climate of near-term (2021 – 2050) and mid-term (2051 – 2080) periods.

3 *Referring to the most recent 30 year period finishing in a year ending with zero.*

4 *For temperature, projections are made for the near-term (2021-2050) only.*

Table 3.3: **List of CORDEX models used for temperature projections**

CORDEX simulation	RCM	GCM boundary condition
CNRM-CERFACS-CNRM-CM5_SMHI-RCA4	SMHI-RCA4	CNRM
NOAA-GFDL-GFDL-ESM2M_SMHI-RCA4	SMHI-RCA4	GFDL
MOHC-HadGEM2-ES_ SMHI-RCA4	SMHI-RCA4	HadGEM2
CCCma-CanESM2	SMHI-RCA4	CCCma
CSIRO-QCCCE-CSIRO-Mk3-6-0	SMHI-RCA4	CSIRO
IPSL-CM5A-MR_SMHI-RCA4	SMHI-RCA4	IPSL-CM5A
MIROC-MIROC5_SMHI-RCA4	SMHI-RCA4	MIRCO
MPI-M-MPI-ESM-LR_SMHI-RCA4	SMHI-RCA4	MPI-M
CNRM-CERFACS-CNRM-CM5	IITM–RegCM4-4	CNRM
IPSL-CM5A-LR	IITM–RegCM4-4	IPSL-CM5A
CCCma-CanESM2	IITM–RegCM4-4	CCCma
CSIRO-QCCCE-CSIRO-Mk3-6-0	IITM–RegCM4-4	CSIRO
NOAA-GFDL/GFDL-ESM2M	IITM–RegCM4-4	GFDL-ESM2M
MPI-M-MPI-ESM-MR	IITM–RegCM4-4	MPI-M

3.3.1 Data and Methodology

The high-resolution, downscaled climate projections for different climate scenarios provided by the Centre for Climate Change Research (CCCR)[5] at the Indian Institute of Tropical Meteorology (IITM) under the Coordinated Regional Climate Downscaling Experiment (CORDEX) South Asia programme are utilised to investigate the future change in temperature and rainfall over the State of Kerala. The global climate projections are dynamically downscaled to 50 km spatial resolution using Regional Climate Models (RCM) over the larger domain (19.25° – 116.25°E; 15.75°S – 45.75°N) covering CORDEX South Asia (Sanjay et al., 2017). The CORDEX regional models are driven by data from the Atmosphere-Ocean Coupled General Circulation Model (AOGCM) runs conducted under the Coupled Model Inter-comparison Project Phase 5 (CMIP5) for Representative Concentration Pathways (RCP) scenarios (Taylor et al., 2012). For this analysis, the CORDEX South Asia simulations for the two pathways - RCP4.5 and RCP8.5 were used (See Box 3.1).

Temperature: 14 bias–corrected CORDEX South Asia modelled simulations were used for temperature projections (**Table 3.3**). Results from these bias-corrected model simulations were used to produce the ensemble mean to assess the future temperature change. Change in temperature during the projected period was computed as a difference between the 30 year historical period and the models simulated ensemble average of the 30 year projected period.

District-level averages of climatic variables were prepared using the outputs from the re-gridded 0.25° x 0.25° resolution (~ 25 km x 25 km) data. The mean value for the district was obtained by considering the mean of the multiple grids that may cover a district. Only grids that fall fully within a district and grids with >60% area falling within a district were considered for computing the mean. If a district falls within only one grid

5 *http://cccr.tropmet.res.in*

cell, that single grid cell value is used for the analyses. All the analyses were performed using these district means. However, temperature changes were plotted on the district maps at 0.25° x 0.25° grid resolution.

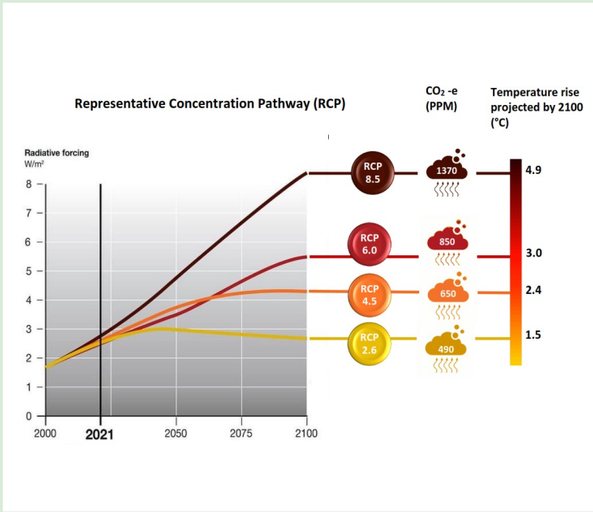
Rainfall: Nine downscaled RCM outputs for South Asia (**Table 3.4**) available on Earth System Grid Federation (ESGF) were adopted to analyse the future rainfall over Kerala, of which six were contributed by CCCR, IITM.

The gridded daily rainfall dataset for the resolution of 0.25° latitude x 0.25° longitude provided by the India Meteorological Department (IMD) for the historical period of 1991–2020,

Table 3.4: **List of CORDEX models used for rainfall projection**

CORDEX South Asia RCM	RCM Description	Contributing CORDEX Modeling Centre	Driving CMIP5 AOGCM	Contributing CMIP5 Modeling Centre
IITM-RegCM4	The Abdus Salam International Centre for Theoretical Physics (ICTP) Regional Climatic Model version 4 (RegCM4; Giorgi et al., 2012)	Centre for Climate Change Research (CCCR), Indian Institute of Tropical Meteorology (IITM), India	CCCma-CanESM2	Canadian Centre for Climate Modelling and Analysis (CCCma), Canada
			NOAA-GFDL-GFDL-ESM2M	National Oceanic and Atmospheric Administration (NOAA), Geophysical Fluid Dynamics Laboratory (GFDL), USA
			CNRM-CM5	Centre National de Recherches Me´te´orologiques (CNRM), France
			MPI-ESM-MR	Max Planck Institute for Meteorology (MPI-M), Germany
			IPSL-CM5A-LR	Institut Pierre-Simon Laplace (IPSL), France
			CSIRO-Mk3.6	Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia
SMHI-RCA4	Rossby Centre regional atmospheric model version 4 (RCA4; Samuelsson et al., 2011)	Rossby Centre, Swedish Meteorological and Hydrological Institute (SMHI), Sweden	NOAA-GFDL-GFDL-ESM2M	NOAA, GFDL, USA
			MIROC-MIROC5	Model for Interdisciplinary Research On Climate (MIROC), Japan Agency for Marine-Earth Sci. & Tech., Japan
			MPI-ESM-LR	MPI-M, Germany

Box 3.1. Representative Concentration Pathways



Representative Concentration Pathways (RCPs) are trajectories of greenhouse gas concentration in the atmosphere adopted by the IPCC for its Fifth Assessment Report. It refers to the development of a scenario set containing emission, concentration and land use trajectories. Four concentration pathways based on four different global developmental paradigms are represented by RCP2.6, RCP4.5, RCP6.0, and RCP8.5. Each of the numbers next to the RCPs, represent the radiative forcing (W/m2) in the year 2100. RCP8.5 is a highly energy-intensive scenario as a result of high population growth and a lower rate of technology development. However, depending on penetration of low carbon technologies including renewable technologies and carbon capture and storage into the economy, the concentrations can correspond to intermediate scenarios -RCP2.6 to RCP6.0 (IPCC, 2014).

was used as the reference for bias correction[6]. Empirical Quantile Mapping (EQM) method was used to correct the biases in the rainfall simulated by the RCM over the State. The empirical quantiles have proved to be an excellent option to correct the bias of rainfall data (Enayati et al., 2021). EQM estimates values of the empirical Cumulative Distribution Function (CDFs) of observed and modeled time series for regularly spaced quantiles. Accordingly, EQM uses interpolations to adjust a datum with unavailable quantile values (Osuch et al., 2017). Ensemble mean of the bias-corrected 9 CORDEX simulations were used for estimating rainfall projections. While the multi-model ensemble mean are used to reduce climate model uncertainty, however multiple sources of uncertainty remain (Sharma et al., 2018) and that projections reported here are consequently subject to such uncertainties.

Rainfall has been projected for the near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios. The historical data for the period 1991 – 2020 were used as observation dataset to assess the variability and trend in rainfall. Percentage change and variability (coefficient of variation) of rainfall were analysed for four seasons viz., winter (January-February), pre-monsoon (March-May), monsoon (June-September), and post-monsoon (October - December) (IMD, Pune). Additionally, the number of rainy days and extreme rainfall events were also analysed (**Table 3.5**).

6 *The projected changes in some of the eastern districts may not be very robust as IMD weather station data for these districts are limited.*

Table 3.5: **Terminology used in the assessments**

Term	Description
Rainy day	A rainy day, according to the IMD, is defined as any day receiving 2.5 mm or more rainfall
Extreme rainfall events	
Heavy rainfall	Any day receiving rainfall of 64.5 mm to 115.5 mm
Very heavy rainfall	Any day receiving rainfall of 115.6 mm to 204.4 mm
Extremely heavy rainfall	Any day receiving rainfall of 204.5 mm or more

3.4 Climate Projections – Outcomes and Inferences

3.4.1 Temperature

The projected changes in summer maximum and winter minimum temperatures for all the districts of Kerala are presented in **Figure 3.4** and **Annexure 3.1**. The summary of projected changes during the historical (1990–2019) and near-term (2021–2050) periods is as follows:

Climate scenarios	Summer maximum	Winter minimum
RCP 4.5	Increases by 1°C to 1.5°C	Increases by 1C to 2°C
RCP 8.5	Increases by 1.5°C to 2°C	Increases by 1°C to 2°C

RCP 4.5 scenario, 2021–2050

RCP 8.5 scenario, 2021–2050

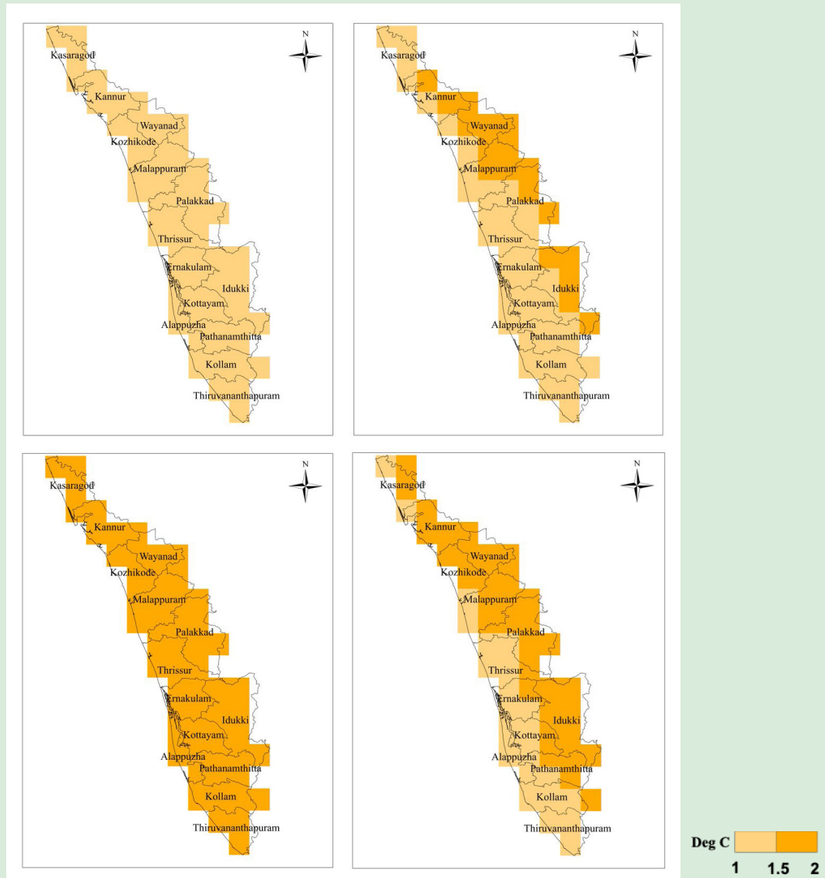


Figure 3.4: Projected change in the summer maximum and winter minimum temperature (°C) during the near-term period under RCP 4.5 and RCP 8.5 scenarios. The changes are calculated by subtracting the mean over 1990–2019 from the mean over 2021–2050.

3.4.2 Rainfall

3.4.2.1 Mean annual rainfall and rainfall variability

The mean annual rainfall is projected to increase under both climate scenarios in the projected periods when compared to the historical period (**Annexure 3.2**). **Figure 3.5** represents the district-wise near-term and mid-term percentage changes of mean annual rainfall and **Figure 3.6** represents the corresponding variability (coefficient of variation) of rainfall under both climate scenarios.

Climate Scenarios		Mean Annual Rainfall	Rainfall Variability
Near-term (2021-2050)	RCP 4.5	Increases in all the districts with maximum in the northern districts (Wayanad, Malappuram, and Thrissur). Minimum increase in Idukki and Kasaragod.	Decreases in most of the northern districts, except Kannur and Kasaragod. Increases in the southern districts with maximum in Kollam and Alappuzha.
	RCP 8.5	Increases in all the districts with the maximum in Wayanad, Malappuram, and Thrissur. Minimum increase in Idukki and Kasaragod.	Increases in all the districts except Wayanad with maximum in Kollam and Alappuzha.
Mid-term (2051-2080)	RCP 4.5	Increases in all the districts with maximum in Thiruvananthapuram Thrissur, Malappuram and Wayanad. Idukki and Kasaragod show the lowest increase.	Increases in all the districts except Wayanad with maximum in Kasaragod, Kannur, and Alappuzha.
	RCP 8.5	Increases in all the districts with maximum in Thiruvananthapuram Thrissur, Wayanad, and Alappuzha. Idukki and Kasaragod show minimum increase.	Increases in most of the districts. Maximum increase in Kollam, Thiruvananthapuram, and Alappuzha. Wayanad shows a decrease in variability.

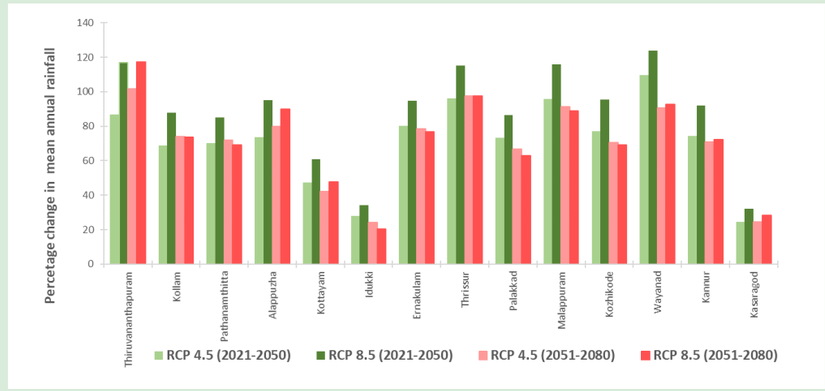


Figure 3.5: Percentage change in mean annual rainfall during the near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios compared to the historical period (1991–2020)

Figure 3.6: Change in the variability of mean annual rainfall during the near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios compared to the historical period (1991–2020)

3.4.2.2 Winter - Mean rainfall and rainfall variability

Compared to the historical mean rainfall, the winter rainfall is projected to increase in the State under both climate scenarios in the projected periods (**Annexure 3.2**). **Figure 3.7** represents the district-wise near-term and mid-term percentage changes of winter rainfall and **Figure 3.8** represents the corresponding variability (coefficient of variation) of rainfall under both climate scenarios.

Climate Scenarios		Mean Annual Rainfall	Rainfall Variability
Near-term (2021-2050)	RCP 4.5	Increases in all the districts with maximum in the northern districts (Kozhikode, Malappuram, Kannur and Wayanad).	Decreases in all the districts, except Thiruvananthapuram, Kollam, Pathanamthitta, Alappuzha and Malappuram.
	RCP 8.5	Increases in all the districts with the maximum in Kannur followed by Kozhikode and Malappuram.	Increases in all the districts except Thrissur and Kozhikode.
Mid-term (2051-2080)	RCP 4.5	Increases in all the districts with maximum in the northern districts (Kozhikode, Kannur and Malappuram).	Increases in all the districts except Thrissur.
	RCP 8.5	Increases in all districts except Kollam and Pathanamthitta with maximum in Kannur and Kozhikode.	Seven districts show an increasing variability with maximum in Kasaragod.

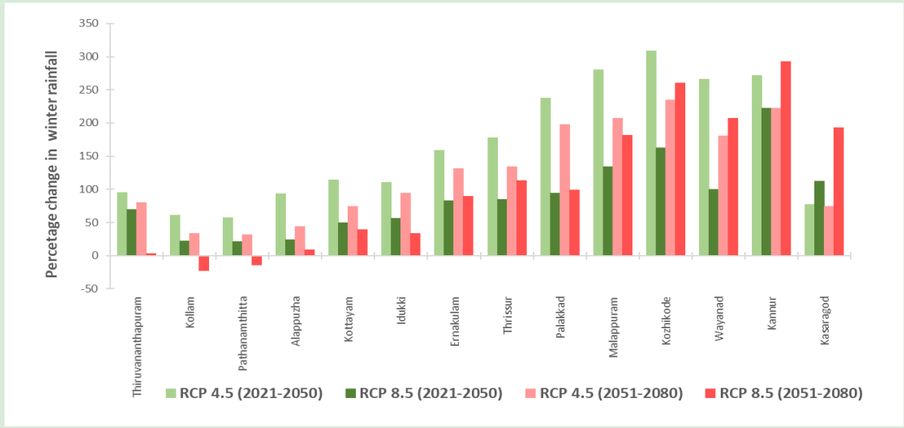


Figure 3.7: Percentage change in winter rainfall in the near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios compared to the historical period (1991–2020)

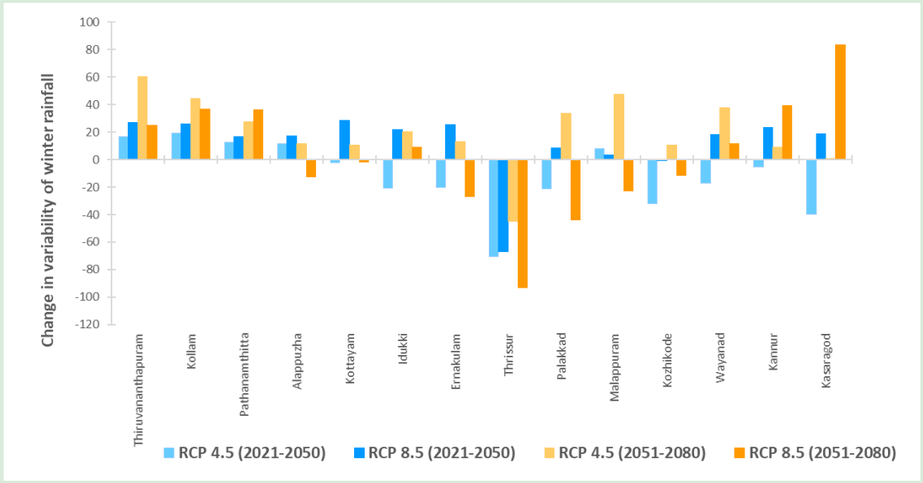


Figure 3.8: Change in variability of winter rainfall during the near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios compared to the historical period (1991–2020)

3.4.2.3 Pre-monsoon - Mean rainfall and rainfall variability

The pre-monsoon rainfall is projected to increase in all the districts under both climate scenarios over the projected periods (**Annexure 3.2**).

Figure 3.9 represents the district-wise near-term and mid-term percentage changes of pre-monsoon rainfall and **Figure 3.10** represents the corresponding variability (coefficient of variation) of rainfall under both climate scenarios.

Climate Scenarios		Mean Annual Rainfall	Rainfall Variability
Near-term (2021-2050)	RCP 4.5	Increases in all the districts except Kasaragod with maximum in Malappuram.	Increases in most of the districts except Palakkad and Wayanad.
	RCP 8.5	Increases in all the districts with maximum in Malappuram.	Increases in all the districts with maximum in Alappuzha.
Mid-term (2051-2080)	RCP 4.5	Increases in all the districts with maximum in Malappuram.	Increases in all districts with maximum in Kasaragod and Kannur.
	RCP 8.5	Increases in all the districts with maximum in Malappuram.	Increases in all districts with maximum in Kannur.

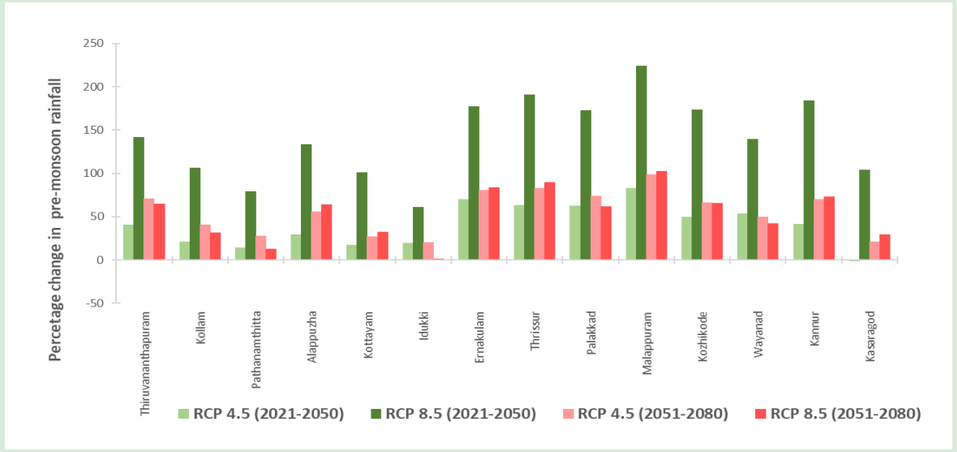


Figure 3.9: **Percentage change in pre-monsoon rainfall in the near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios compared to the historical period (1991–2020)**

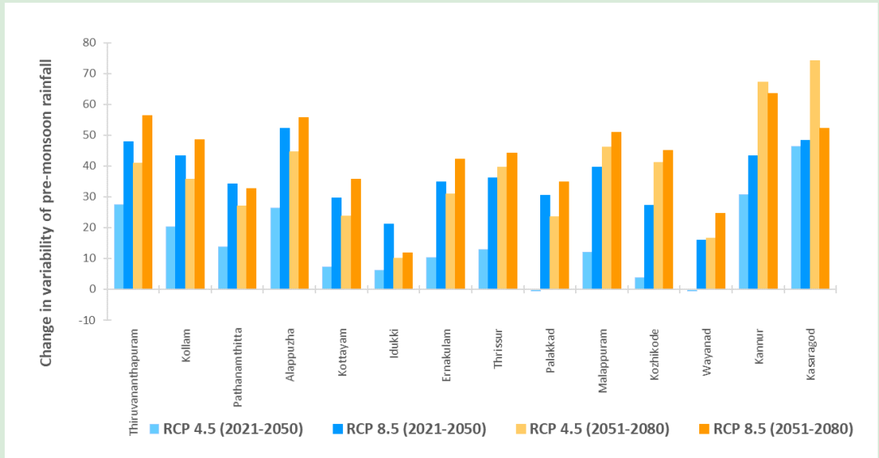


Figure 3.10: **Change in variability of pre-monsoon rainfall during the near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios compared to the historical period (1991–2020)**

3.4.2.4 Monsoon - Mean rainfall and rainfall variability

The monsoon rainfall is projected to increase in all the districts under both climate scenarios over the projected periods (**Annexure 3.2**). **Figure 3.11** represents the district-wise near-term and mid-term percentage changes of monsoon rainfall and **Figure 3.12** represents the corresponding variability (coefficient of variation) of rainfall under both climate scenarios.

Climate Scenarios		Mean Annual Rainfall	Rainfall Variability
Near-term (2021-2050)	RCP 4.5	Increases in all the districts with maximum in the southern districts (Thiruvananthapuram, Pathanamthitta and Kollam).	Decreases in the central and northern districts with maximum in Wayanad.
	RCP 8.5	Increases in all the districts with maximum in the southern districts.	Increases in most of the districts with maximum in Kollam.
Mid-term (2051-2080)	RCP 4.5	Increases in all the districts with maximum in the southern districts (Thiruvananthapuram, Pathanamthitta and Kollam).	Increases in majority of the districts with maximum in Kollam, Alappuzha, and Kasaragod.
	RCP 8.5	Increases in all the districts with maximum in the southern districts.	Increases in majority of the districts with maximum in Kollam.

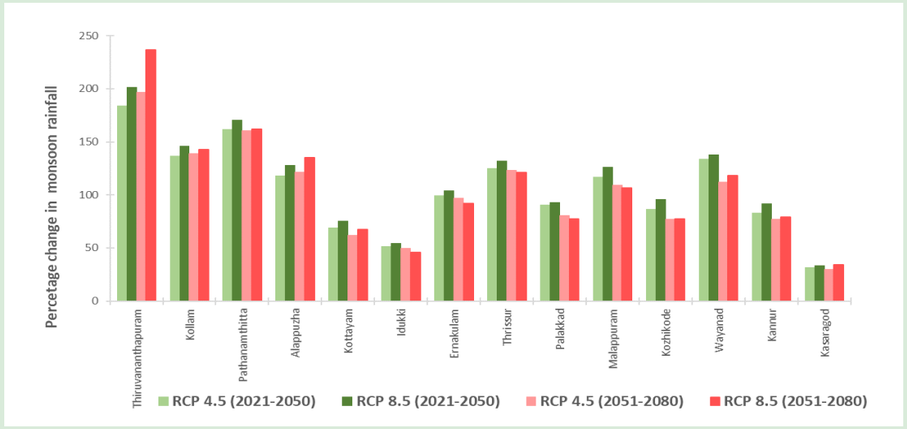


Figure 3.11: Percentage change in monsoon rainfall in the near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios compared to the historical period (1991–2020)

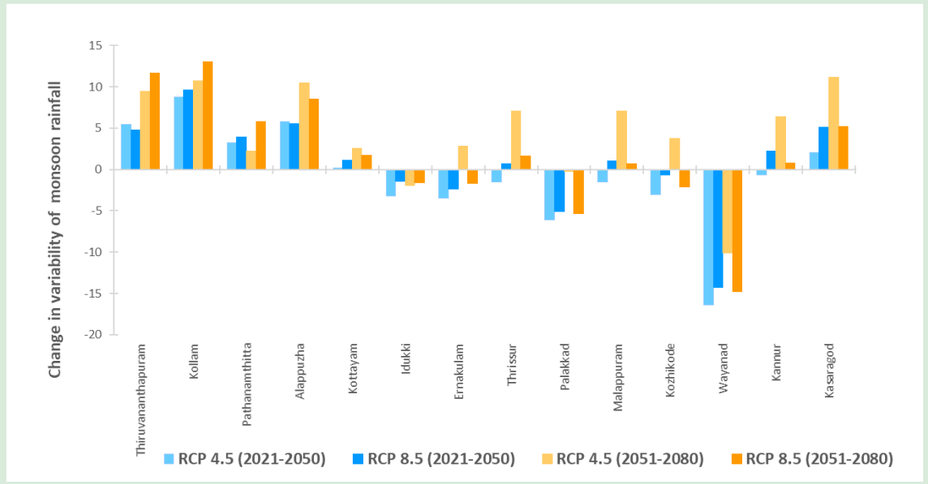


Figure 3.12: Change in variability of monsoon rainfall during the near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios compared to the historical period (1991–2020)

3.4.2.5 Post-monsoon - Mean rainfall and rainfall variability

The post-monsoon rainfall is projected to decrease in the southern districts under RCP 4.5 scenario, which declines further under RCP 8.5 scenario. However, the northern districts show an increasing trend under both climate scenarios (**Annexure 3.2**). **Figure 3.13** represents district-wise changes in post-monsoon rainfall, and **Figure 3.14** represents changes in the variability (coefficient of variation) of rainfall under both climate scenarios.

Climate Scenarios		Mean Annual Rainfall	Rainfall Variability
Near-term (2021-2050)	RCP 4.5	Decreases in southern districts with maximum in Kollam, Pathanamthitta and Idukki and an increase in the northern districts except Kasaragod with a maximum in Wayanad.	Increases in all the districts, except Ernakulam, with maximum change in Kozhikode and Kannur.
	RCP 8.5	Decreases in southern districts with maximum in Pathanamthitta and Idukki and an increase in the northern districts except Kasaragod with a maximum in Wayanad.	Increases in all the districts with maximum in Alappuzha, Kollam, and Thrissur.
Mid-term (2051-2080)	RCP 4.5	Decreases in southern districts with maximum in Idukki and an increase in the northern districts except Kasaragod with a maximum in Wayanad.	Increases in all districts with maximum in Malappuram, Alappuzha, and Kozhikode.
	RCP 8.5	Decreases in southern districts with maximum in Idukki and an increase in the northern districts except Kasaragod with a maximum in Wayanad.	Increases in all districts with maximum in Kasaragod, Malappuram, Kannur, and Thrissur.

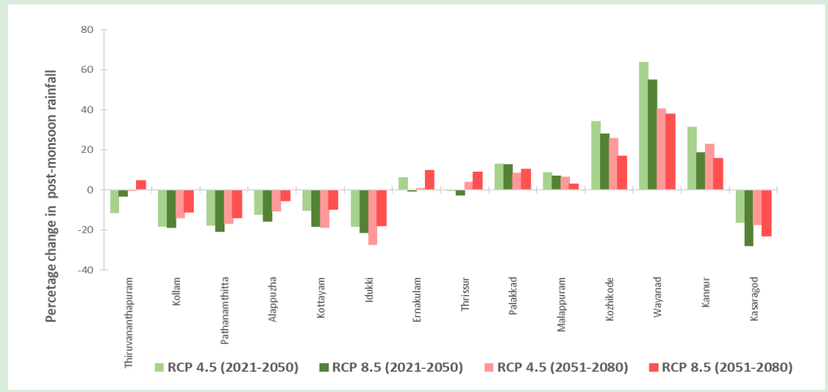


Figure 3.13: Percentage change in post-monsoon rainfall in the near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios compared to the historical period (1991–2020)

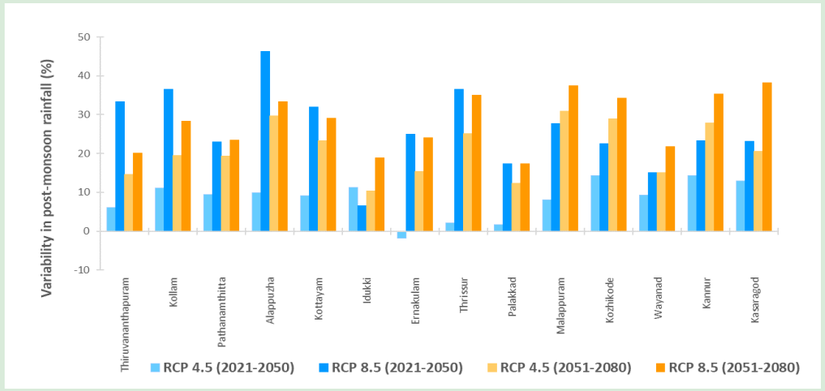


Figure 3.14: Change in variability of post-monsoon rainfall during the near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios compared to the historical period (1991–2020)

3.4.2.6 Number of rainy days

According to IMD, a rainy day is defined as a day with rainfall of 2.5 mm or more. The analysis of rainy days under historical and projected periods shows that there will be an increase in the number of rainy days during the near-term (2021-2050) and the mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios in most of the districts (**Figure 3.15**). The total number of rainy days ranged from 3497 (Wayanad) to 4956 (Kottayam) days during the 30-year historical period. During the near-term period, the number of projected rainy days ranges from 4103 (Thiruvananthapuram) to 4962 (Ernakulam) under RCP 4.5 and 4157 (Kasaragod) to 5166 (Ernakulam) under RCP 8.5 respectively. During the mid-term period, the number of projected rainy days ranges from 3956 (Wayanad) to 4833 (Ernakulam) under RCP 4.5 and 3845 (Wayanad) to 4809 (Ernakulam) under RCP 8.5 respectively. During the near-term period, the Kannur and Kasaragod districts and during the mid-term, the Kottayam, Ernakulam, Kannur, and Kasaragod districts showed a decline in the total number of rainy days under both the RCP scenarios. The district-wise number of rainy days during the historical period and the projected periods under both RCP 4.5 and 8.5 scenarios are presented in **Annexure 3.3**.

3.4.2.7 Extreme rainfall events

Extreme rainfall events were analysed considering the intensity of rainfall under three categories: Heavy Rainfall (64.5 mm/day to 115.5 mm/day), Very Heavy Rainfall (115.6 mm/day to 204.4 mm/day), and Extremely Heavy Rainfall (>204.5 mm/day). The number of occurrence of these events were computed for the historical (1991-2020), projected near-term (2021-2050) and projected mid-term (2051-2080) periods under the two climate scenarios, and the change was computed for all the districts.

A) Heavy rainfall events

The number of heavy rainfall events increases from the historical period to the near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios (**Figure 3.16**). Heavy rainfall events are projected to increase from 21 to 363 days in the historical period to 98 to 547 days under RCP 4.5 and 89 to 608 days under RCP 8.5 in the near-term period. In the mid-term period, the heavy rainfall days range from 87 to 592 days under RCP 4.5 and 79 to 519 days under RCP 8.5 respectively (**Annexure 3.4**).

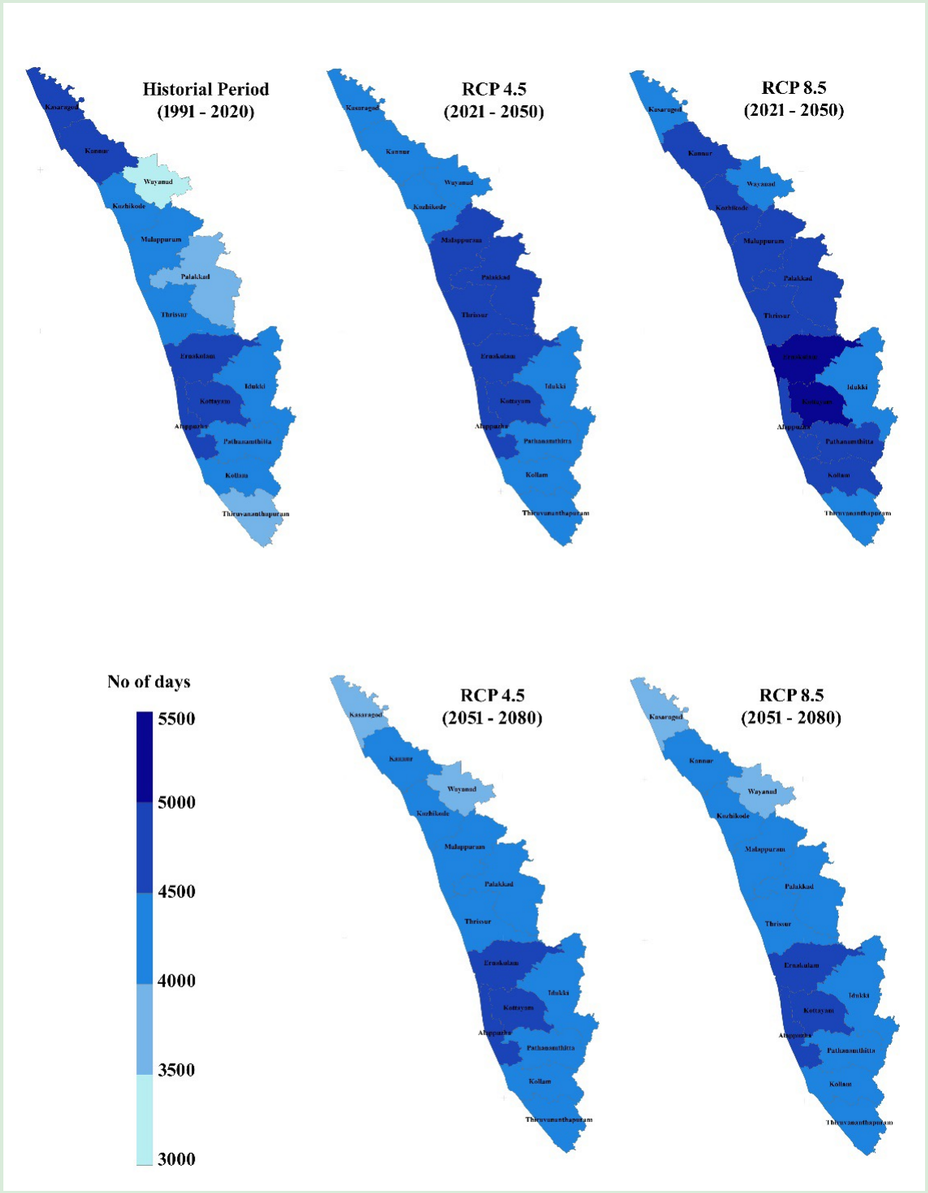


Figure 3.15: Total number of rainy days during the historical (1991–2020) and projected near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios

Major inferences	
Scenario 4.5	In the near-term period (2021-2050), heavy rainfall events are projected to increase in all the districts, and the maximum increase is observed in Ernakulam (547), Kannur (530), and Thrissur (515). In the mid-term period (2051-2080), Thrissur (592), Ernakulam (539), and Kannur (492) show the maximum number of increased heavy rainfall events.
Scenario 8.5	The heavy rainfall events increase during the near-term and mid-term periods. Ernakulam, Thrissur, and Kottayam show maximum number of increased events both in near-term and mid-term periods.

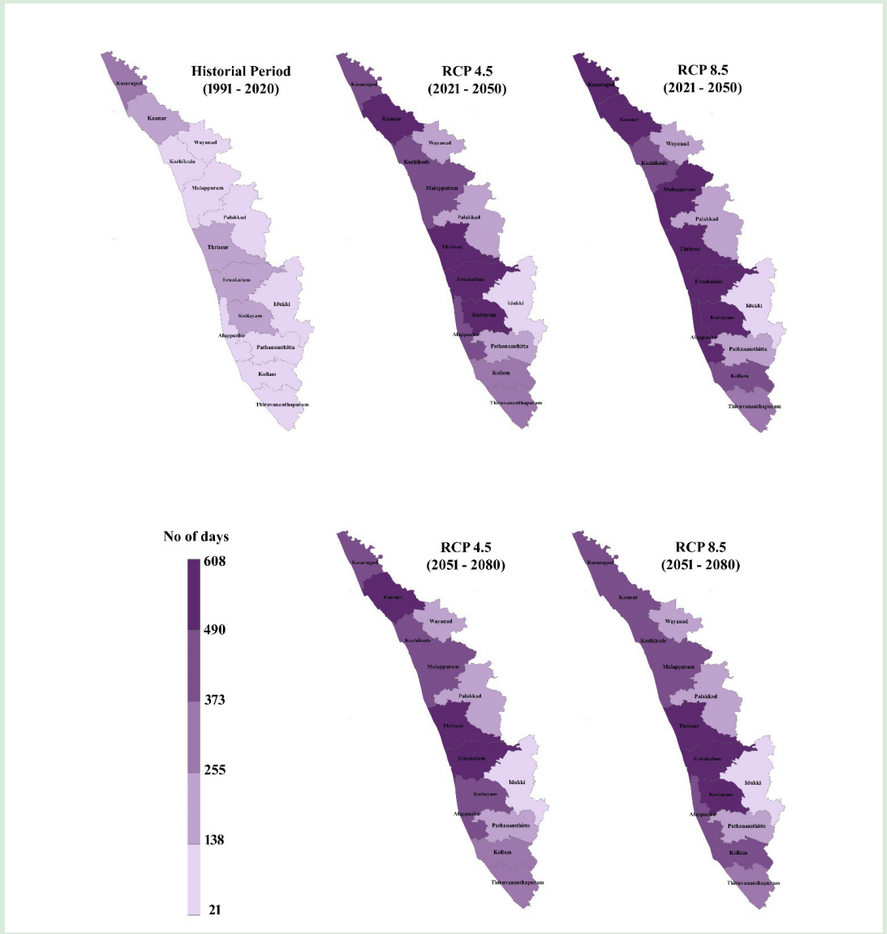


Figure 3.16: Total number of heavy rainfall days during the historical (1991–2020) and projected near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios

B) Very-heavy rainfall events

The number of very-heavy rainfall events increases from the historical period to the near-term (2021-2050) and mid-term (2051-2080) periods (**Figure 3.17**) under RCP 4.5 and RCP 8.5 scenarios. It increases from 2-59 days during the historical period to 13-279 days under the RCP 4.5 scenario and 15-328 days under the RCP 8.5 scenario in the near-term period. In the mid-term period, there are 23-254 events under RCP 4.5 scenario and 25-289 events under RCP 8.5 scenario (**Annexure 3.4**).

Major inferences	
Scenario 4.5	Very-heavy rainfall events are projected to increase in all the districts. The near-term increased events are more in Kannur (279) Thrissur (278), and Kasaragod (258). These districts also show an increased number of events in the mid-term as well (Kannur - 254, Thrissur - 252, and Kasaragod - 241), but less than the number of near-term events.
Scenario 8.5	This scenario also shows a similar trend among the districts with the maximum increased events in Kannur (328) Thrissur (319), and Ernakulam (277) in the near-term, and in Thrissur (289), Kasaragod (288), and Kannur (286) in the mid-term periods.

Figure 3.17: Total number of very heavy rainfall days during the historical (1991–2020) and projected near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios

C) Extremely-heavy rainfall events

Extremely-heavy rainfall events increase from the historical period to the near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios (**Figure 3.18**) (**Annexure 3.4**).

Major inferences	
Scenario 4.5	In the near-term period, Kannur (53), Thrissur (41), and Kasaragod (34) districts show maximum increase in the number of extremely heavy rainfall events. There is an increase in the number of events in the mid-term period with maximum numbers in Kannur (63), Kasaragod (54) and Thrissur (48).
Scenario 8.5	An increase in the number of events is observed in all the districts, with a similar pattern as in the RCP 4.5 scenario. The maximum number of events is noticed in Kannur (76), Kasaragod (52), Thrissur (46), and Malappuram (46) in the near-term. In the mid-term period, Kannur (61), Kasaragod (61), Thrissur (54), and Alappuzha (50) show the maximum number of events.

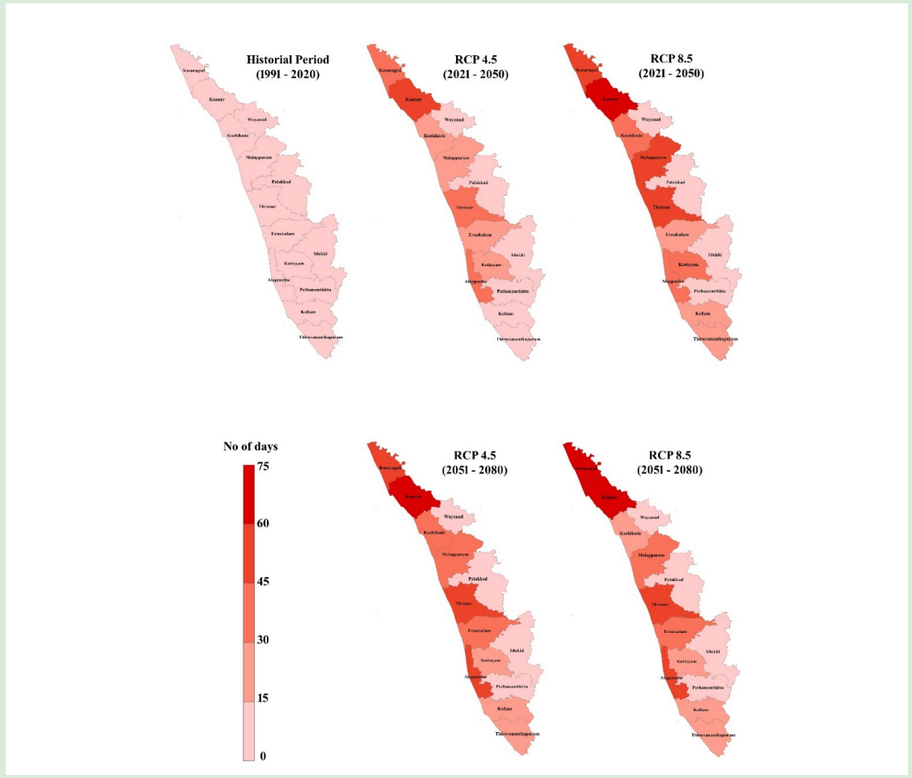


Figure 3.18: **Total number of extremely heavy rainfall days during the historical (1991–2020) and projected near-term (2021-2050) and mid-term (2051-2080) periods under RCP 4.5 and RCP 8.5 scenarios**

3.5 Summary

Temperature is projected to increase in all the districts under both RCP 4.5 and RCP 8.5 scenarios compared to the historical period.

- The summer maximum temperature increases by 1°C to 1.5°C under RCP 4.5 and 1.5°C to 2°C under RCP 8.5 in all the districts, and the winter minimum temperature increases by 1°C to 2°C under both scenarios in most of the districts, except Alappuzha and Thiruvananthapuram.

Mean annual rainfall is projected to increase in all the districts under both RCP 4.5 and RCP 8.5 scenarios compared to the historical period.

- The northern districts are projected to receive more annual rainfall. The trend shows that there is an increase in RCP 4.5 scenario in both the projected periods, and then gradually decreases in RCP 8.5 scenario in most of the districts.
- The seasonal projections, except for post-monsoon, show an increase both in the near-term (2021-2050) and mid-term (2051-2080) periods. The post-monsoon rainfall in the southern districts shows a declining trend compared to the historical period (near-term, RCP 4.5 (10-18%) & RCP 8.5 (1-21%); mid-term, RCP 4.5 (11-27%) & RCP 8.5 (5-18%). Kasaragod district in the north also shows a decline. Monsoon rainfall shows more increase in the southern districts, and all other seasonal rainfall is more in the northern districts.
- Rainfall variability increases in most of the districts during pre-monsoon and post-monsoon seasons in the near-term and mid-term periods under both climate scenarios. More variability is seen in Thiruvananthapuram, Kollam, Alappuzha, Kannur, and Kasaragod. Winter and monsoon rainfall variability shows an increase in the southern districts and a decrease in most of the northern districts in both climate scenarios.

The number of rainy days, in general, shows an increase in most of the districts compared to the historical period, but there is a decline from the near-term to the mid-term period.

- Compared to the historical period, Alappuzha, Kottayam, Idukki, Kannur, and Kasaragod show a decline in the number of rainy days under RCP 4.5 and 8.5 scenarios.
- Thiruvananthapuram, Kollam, Pathanamthitta, Palakkad, and Wayanad show maximum increase in the number of rainy days under RCP 4.5 and 8.5 scenarios.

Heavy rainfall events are projected to increase in all the districts under both RCP 4.5 and RCP 8.5 scenarios compared to the historical period.

- Alappuzha, Ernakulam, Thrissur, and Malappuram districts show an increased number of events. Idukki and Kasaragod show the lowest increase.

Very heavy rainfall events are projected to increase under both RCP 4.5 and 8.5 scenarios compared to the historical period, and a decline is seen from the near-term to the mid-term period as well.

- Alappuzha, Ernakulam, Thrissur, Kannur, and Kasaragod districts show an increased number of events. Idukki shows the lowest increase.

Extremely heavy rainfall events are projected to increase in all the districts under both RCP 4.5 and RCP 8.5 scenarios compared to the historical period.

- Alappuzha, Thrissur, Kannur, and Kasaragod districts show an increased number of extremely heavy rainfall events. Idukki, Palakkad, and Wayanad show the lowest increase.

3.6 Limitations

The climate assessment results presented here are likely to have some uncertainty due to the following reasons:

- Coarse-resolution of the projected climate change data.

- The climate change information is derived from CORDEX data at 0.5° x 0.5° resolution. Further, the sub-grid variability within the 0.5° x 0.5° resolution grid is not captured in the analysis, which is likely to introduce some uncertainty.
- There could be potential uncertainty arising out of the methodology used to estimate the district averages.
- The absence of station-level data for some of the eastern regions for bias correction and therefore some under- or over-estimation of climate parameters are likely.

However, it is noted that the direction of changes in temperature, rainfall, and extreme events are largely in agreement with the literature at global, South Asia, and national levels.

The climate projections for Kerala are consistent with the national level report on climate change from the Ministry of Earth Sciences, which concludes, 'Climate models project an increase in the annual and summer monsoon mean rainfall, as well as the frequency of heavy rain occurrences over most parts of India during the twenty-first century (Krishnan et al., 2020). It is clear from this assessment that the climate in the districts of Kerala – both temperature and rainfall – has changed over the historical period, and in the future, both temperature and summer monsoon rainfall is projected to increase.

The extreme rainfall events are projected to increase, indicating changes in the magnitude, frequency, and timing of occurrence of these events – all with implications for natural resource sectors such as coastal fisheries, forests, water, etc., and socio-economic systems such as agriculture and health, and communities in different districts. As per IPCC AR5, the risk of climate-related impacts results from the interaction between climate-related hazards (including hazardous events and trends) and the vulnerability and exposure of human and natural systems. Alternative development paths influence risk by changing the likelihood of climatic events and trends, through their effects on GHGs and land use, and by altering vulnerability and exposure.

4. Vulnerability Assessment

4.1. Overview

There are several uncertainties associated with future projections of climatic and non-climatic factors; however, such information helps to build awareness about the need for initiating affirmative anticipatory action to deal with expected future risks. Given an uncertain future, the immediate adoption of resilience-building measures is a 'no-regret' strategy that has the benefit of the availability of multiple options at affordable costs. Care must be taken, however, to select only those strategies that remain neutral or result in favourable outcomes in case the projected scenario realises, and do not cause any adverse outcomes in case any scenario other than that projected realises.

The 'first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability' (IPCC, 2014). "Risk – and thus, the impacts – of climate change is determined by the interaction between hazard, exposure, and vulnerability". Among the three factors of climate risk, governments and development agencies can address climate change impacts by first reducing vulnerability. Thus, there is a need to assess the inherent vulnerability of natural and socio-economic systems, using local expert knowledge for the selection of context and sector-specific indicators, as any effective vulnerability assessment is context-specific and is a vital preceding step to developing no-regret adaptation practices, strategies, and policies.

The ongoing changes in temperature and rainfall, their variability, and the observable increase in the frequency of occurrence of disastrous extreme events have been impacting both natural ecosystems and socio-economic systems across the country, and in Kerala, in particular, since it is a coastal State. Such impacts are projected to exacerbate under future climate change, placing these systems at high risk.

4.2. Assessment of Impacts of Climate Change

Climate change and variability have an impact on the environment that provides us with safe food, clean drinking water, pure air, healthcare,

and recreational opportunities. Food services are reliant on agricultural and livestock farming, both of which are vulnerable to climate change. Climate change has an impact on a variety of parameters related to livestock productivity, reproduction, health, and adaptability, and also affects the parameters that govern agricultural productivity. Kerala, being a coastal state, is at risk of sea level rise and its coastline is susceptible to large-scale sea erosion, losing over 40% of its coastline to the sea over the past 26 years (Kankara et al., 2018) due to sea level rise, leading to more frequent and severe coastal flooding in low-lying areas and coastal erosion. Also, continued global warming is projected to substantially intensify the global water cycle, including its variability, global monsoon precipitation, and the intensity of wet and dry episodes, which can have implications for the water sector, according to the IPCC's Sixth Assessment Report (Portner et al., 2022). These, in combination with anthropogenic influences, are already wreaking havoc on people's lives, livelihoods, and food security. Another sector greatly affected by changing climate is health. Climate change can affect human health directly (e.g., impacts of heat stress, death/injury in floods and storms) and indirectly through changes in the ranges of disease vectors (e.g., mosquitoes), water-borne pathogens, water quality, air quality, and food availability and quality. Global climate change is, therefore, a newer challenge to ongoing efforts to protect human health (McMichael et al., 2003). Kerala was the first Indian State to establish tourism as a separate business, and climate change is already having an impact on the tourism industry in Kerala. It is expected to have far-reaching consequences in the coming years, affecting the consumer's vacation choices with respect to geographical locations, the destination's competitiveness and sustainability, and tourism's contribution to development (Scott et al., 2012).

Against this background, it is important to understand the risks and impacts of climate change on various sectors in Kerala. This is imperative to develop sustainable, economic and local-level nature-based adaptation solutions and to protect the State from further loss and damages due to extreme events and other climate change impacts. The impacts of climate change on various sectors in Kerala, such as agriculture and allied sectors, forest and biodiversity, coastal fisheries, water resources, health, and tourism will be discussed in detail in the next section.

4.2.1. Agriculture

Climate change impacts are said to be locally differentiated, and some crops may already be at risk, according to research by Zhao et al. (2017). Due to temperature rises and changes in water availability, Kerala's agriculture sector is vulnerable to climate change, which can have severe effects on crop yields across agro-ecological zones.

Rice is one of Kerala's most significant crops, and the effects of climate change on rice have been extensively investigated. Aswathi et al. (2021) observed that increasing the maximum and minimum temperatures considerably affected the grain output of the rice variety 'Jyothi'. Varghese et al. (2020) used the Cropping System Model (CSM) Crop Estimation through Resource and Environment Synthesis (CERES) Rice model embedded within the Decision Support System for Agro-technology Transfer (DSSAT) package to predict rice yield in Kerala under Representative Concentration Pathway 8.5 (RCP 8.5) with the help of climate change scenario input from the MRI-GCM model developed at Meteorological Research Institute (MRI). Their analysis indicated that future rice yields will reduce due to increase in temperature and reduction in rainfall.

Black pepper, cardamom, nutmeg, clove, ginger, and turmeric are a few of the spices grown in Kerala. Climate change, according to Joy (2020), will have an impact on these spice crops as spices are cultivated in varied agro-climatic regions from tropical to temperate, and climate is the primary determinant for spice production. S Nair et al. (2021) investigated the impact of climate change on black pepper output in six main black pepper-producing areas in Kerala and reported a significant decrease in black pepper production with each unit increase in both maximum and minimum temperatures. Similarly, unit increase in relative humidity and rainfall were found to have a negative impact on black pepper production.

Cardamom is another significant spice grown in Kerala. According to Murugan et al. (2012), sustained exposure to daytime temperatures, as high as 32°C, can cause the leaves and young tillers of cardamom to completely wither. Reduced pollination and abortion of cardamom flowers may result from a relatively high air temperature during flowering (April–May), especially when combined with an extended dry season. As cardamom is particularly sensitive to both excess rainfall and drought, rainfall, an essential climatic variable related to climate change, has a huge impact on cardamom yield.

Temperature is a crucial predictor of nut yield in coconut, which is one of Kerala's most important tropical crops (Peiris et al., 1995). At the seedling and reproductive stages, coconut is vulnerable to high temperatures (Hebbar et al., 2020). The temperature at the time of the fruit (nut) setting has a significant impact on the number of nuts produced per inflorescence (Samarasinghe et al., 2018). Changes in rainfall patterns have had a negative impact on coconut production, according to researchers. Using secondary data on rainfall gathered from 1991 to 2015, Abhinav et al. (2018) investigated the effects of rainfall fluctuation on coconut productivity. Extreme rains at the end of the year (October–November) can cause severe button shedding and pest infestations in the plantations, resulting in a decline in coconut production.

The State Climate Change Cell of the Directorate of Environment and Climate Change (DoECC) compiled hazards and exposure data at the district level. According to this data, the percentage of drought-prone areas in the State varies from 22.41% in Kasaragod to 92.83% in Kollam, and the percentage of area prone to multiple hazards (flood, landslide, coastal hazards) varies from 20.96% in Kannur to 66.94% in Alappuzha. In addition, the percentage departure of rainfall from the normal ranged from 3.67% in Kottayam to 50.53% in Wayanad.

Considering all the above factors, and the high percentage of area exposed to hazards, which is likely to increase with climate change, the risk to agriculture and its productivity in the State of Kerala is high.

4.2.2. Livestock

Climate change has a stronger impact on biological output, whether it is global, regional, or local. Climate change has an impact on a variety of parameters related to livestock productivity, reproduction, health, and adaptability. The percentage of livestock population residing in multi-hazard-prone areas ranges from 26.18 % in Kasaragod to 89.88 % in Palakkad.

Higher temperatures cause changes in the animal's body physiology, such as increased respiration rates (> 70–80/minute), blood flow, and body temperature (> 39 °C) (Pereira et al., 2008). Higher-milk-producing breeds are more susceptible to heat stress as it leads to increased metabolic heat generation, whereas low-milk-producing animals are more resistant (Dash et al., 2016). The dry matter intake and milk yield are reduced as the temperature and temperature humidity index value rise above the crucial threshold level. Heat stress adversely affects poultry farming also. Heat stress reduces chicken feed intake, resulting in poorer body weight, egg production, and meat quality, as well as reduced eggshell thickness and increased egg breakage (Deng et al., 2012; Lin et al., 2004).

Livestock is vulnerable to most of the extreme events, but the most calamitous is flood (Zollinger, 2004). When animals stand in contaminated water for an extended amount of time, diseases of the hooves and skin may develop. They are vulnerable to tetanus and other poisons in the flood water due to deep incisions in their skin. Furthermore, animals become susceptible to hepatitis, diarrhoea, food poisoning, and other diseases. The 2018 Kerala floods resulted in the death of 5163 cows, 541 buffaloes, 5166 calves, 1228 heifers, 6380 sheep/goats, 1053 pigs, 20000 quails, 1143734 poultry and 464772 ducks, leading to the loss of 167.8 crore INR (KPDNA, 2018).

4.2.3. Fisheries and Coastal ecosystems

Climate change has already led to a notable sea level rise globally and is projected to continue in the future. The NASA Sea Level Projection Tool that uses data from IPCC 2021 shows that Kochi might possibly experience a sea level rise of 0.22m by 2050, and a 0.58m by 2100 under SSP2-4.5 scenario[1].

The coastal districts of Kerala are spread over 59% of the State's area (23026 km^2), and are very densely populated. The National Shoreline Change Assessment carried out by the National Centre for Coastal Research (NCCR) for a period of 26 years (1990–2016) shows that 45 % of the Kerala coast is eroding, 34% is stable and 21 % is accreting. "The districts of Kasaragod, Kannur, Malappuram, Ernakulum, and Kollam are dominated by both erosion and stable condition with few pockets of accretion" (Kankara et al., 2018). Coastal flooding and loss of coastline due to erosion is making the government relocate many of the coastal population to other places.

Marine ecosystems have traditionally been the primary source of livelihood for coastal fishing communities in Kerala. In recent years, rising sea level and sea surface temperatures have adversely affected such ecosystems and the income fishing communities derive from them. Changes in temperature, dissolved oxygen, and acidity associated with climate change, impact plankton productivity, with cascading effects up the food chain. In addition, the loss of coral reefs and their diminishing role in the marine ecosystem, and threats to fishery productivity and marine biodiversity are major challenges.

Decline and changes to marine productivity threaten both livelihoods and subsistence on Kerala's extensive coastline. More recent modelling by the FAO suggests declines in marine productivity between 10% and 17% by 2050, depending on the emissions scenario (Savo et al., 2017). Notably, the coastal and marine sector is a source of valuable fish protein not only for the growing Indian population but also for the global food basket and is a key export commodity for India. It is estimated that the fisheries sector supports around 10,44,000 fisher folk population in Kerala, of which 1,94,910 are active coastal fishers (Kerala Fisheries Handbook, 2020).

Some marine ecosystems, such as mangroves, salt marshes, and seaweed ecosystems, beyond having high biodiversity values and providing breeding grounds and nurseries for fisheries, can also play a key role in mitigating global climate change through their ability to store carbon. These blue carbon ecosystems are being degraded at a very high rate in the State of Kerala (Biju Kumar et al., 2017). Research by Vivekanandan et al. (2009) has identified the seas around India, notably the western coast, as a global hotspot for climate change impacts on marine heat waves. According to this study, marine heat waves are projected to extend their spatial footprint and to grow in duration and intensity, even under lower emissions pathways (RCP4.5), impacting marine ecology unlike anything in recent history.

4.2.4. Water Resources

There are 44 rivers in Kerala, four of which are medium in size (Bharatapuzha, Pampa, Periyar, and Chaliyar) while the rest are minor. The 44 rivers have a combined yearly production of 70323Mm^3, of which only 60% is estimated to be usable for drinking (Joseph et al., 2011). The brackish water area of Kerala cover about 65213 hectares (Kerala Fisheries Handbook, 2020). Apart, Kerala has tanks, ponds, and springs. Kerala's net groundwater availability is estimated at 5.12 billion cubic metres (BCM). The net availability varies by district, from 188.77 MCM in Idukki to 584.10 MCM in Palakkad. The Stage of Groundwater Extraction for the State is 51.68%; the highest in Kasaragod district (76.40%) and the lowest in Wayanad district (24.17%). The water availability in the State has been decreasing over the decades. The annual extractable groundwater recharge for Kerala during 2020 has decreased by 1.76% when compared with 2017. The Stage of Groundwater Extraction in the State shows a decrease from 51.24% in 2017 to 51.68% in 2020 (GWD Kerala & CGWB, 2022).

A warming climate leading to significant changes in atmospheric circulations has made the tropical regions of the globe exposed to extreme climatic events. From the Great Indian Ocean Tsunami of 2004 to a series of cyclones (Ockhi in 2017, and Gajja in 2018) and droughts (2004, 2009, 2013, 2016, 2017), to the great floods of 2018, Kerala has faced climatic extremes in varying intensity (Eldho & Sreedevi, 2019). Some of the observable and expected impacts on Kerala's water resources due to climate change are described in the sections below.

4.2.4.1. Sea Level Rise

Sea level rise will lead to seawater incursion into rivers and other coastal freshwater resources of the State. With rising sea level, the freshwater-saltwater interface (transition zone between freshwater and seawater) moves inland, leading to an increase in salinity in wells and also in the rivers near the coast. Research studies conducted along the coastal areas in Kerala showcase increased salinity in freshwater sources (Remya et al., 2018). Changes in river salinity can affect the ecological system in rivers, leading to disastrous effects on the dependant flora and fauna and agricultural practices. Seawater incursions can also deem groundwater extraction and pumping structures located along the river unproductive. An increase in sea level will also lead to a lower sub-surface flow of groundwater towards the sea, leading to a higher residence time of water in the aquifer, in turn affecting water quality due to rock–water interactions (Rao, 2011).

Low-lying areas like Kuttanad, which is spread across about 500 sq. km, with an elevation between 0.6 and 2.2 m below the sea level, are already seeing the population being displaced due to sea level rise (Rao, 2011). Famously called the 'Rice bowl of Kerala', it is the only place in the country where farming activities take place below sea level. However, sea level rise and frequent floods are leading to an exodus of people. Already reeling under the pressure of drinking water scarcity, saline water intrusion in wells and the drastic reduction in the groundwater quality is making matters worse in Kuttanad.

4.2.4.2. Erratic Rainfall Patterns

Kerala receives an average annual rainfall of 3000mm spread mainly across two monsoon seasons, with the maximum being received in June and July (Guhathakurta et al., 2020). However, recent years have seen a shift in the rainfall pattern in the State. The State average seasonal rainfall in both seasons during the past 121 years (1901 – 2021) has shown a decreasing trend of about 10% of LPA/100 years (ICCS, 2022). The increase in temperature over the Arabian Sea in the past two decades has increased the frequency of cyclonic events along the Indian West Coast. This has greatly affected the rainfall pattern in Kerala. Though July and June were the months receiving the highest rains, frequent and heavy spells have been seen in August, September and October in the last four years.

4.2.4.3. Floods

Kerala experienced an abnormally high rainfall from 1 June 2018 to 30 August 2018, leading to severe flooding in 13 districts in the State. The State received an excess of 96% during the period from 1st to 30th August 2018, and 33% during the entire monsoon period till the end of August (KSDMA, 2018). The 2018 floods affected around 5.4 million people, and nearly 450 lives were lost. The economic losses were estimated at 3.8 million USD (Hunt & Menon, 2020). The pattern of heavy-intensity rainfall repeated in August 2019, August 2020, and October 2021, causing floods and landslides leading to the loss of life and property in various parts of the State.

These floods, especiallyin 2018 ironically caused a drinking water crisis, mainly in coastal and low-lying areas. Floods led to the pollution of wells and damage to water pumps and treatment plants. Heavy precipitation events can also lead to an increase in the amount of run-off into surface water bodies, washing sediments, pollutants, solid waste, etc., greatly affecting the water quality and surface water storage capacity. Sedimentation and soil erosion are also leading to a reduction in the

1 *https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool*

capacity of hydel reservoirs in the State (Joseph et al., 2011).

4.2.4.4. Droughts

Kerala, even with its 44 rivers and lush greenery, has been impacted by droughts of varying intensities in the past. Severe dry spells and droughts were experienced by the State in recent decades. Eight of the 10 warmest years on record were of the recent decade (2012 – 2021). The warmest years on record in ascending order were: 2021 (+0.40°C), 2014 (+0.42°C), 1987 (+0.45C), 2015 (+0.66°C), 2017 (+0.71°C), 2020 (+0.81°C), 2019 (+0.88°C), 2016 (+0.97°C). As a result, the annual mean temperature of Kerala during the past decade (2011 – 2020 / 2012 – 2021) was also the warmest decade on record with the decadal average annual mean temperature anomaly of 0.51C / 0.55°C. A significant increasing trend of 1.05°C / 100 years is observed in the State averaged annual mean temperature during 1901 – 2021 (ICCS, 2022).

The most distressing drought in 2016 severely impacted both agriculture and hydrology in the State. Since more than 70% of the agriculture in Kerala is rainfed, extended meteorological drought leads to extreme agriculture and hydrological droughts. Climate change, along with changes in land-use patterns, is leading to extended periods of drought in the State, leading to increased frequency of water shortages for drinking, agriculture, and power generation. Studies also indicate that once perennial river basins in the State, like that of Bharathapuzha, which is the largest basin in the State (based on drainage area), are experiencing persistent drought conditions owing to an increase in temperature conditions and a decrease in precipitation. The basin is also projected to be severely drought-prone between 2026 and 2040 (Jincy Rose & Chithra, 2020).

The days after the 2018 floods witnessed dry spells throughout Kerala, which resulted in a drastic reduction in river flows, drying up of streams and wells and increased drought. The water availability in Kerala post the rainy season is determined by the water that is held in the soil, which is discharged slowly into rivers, streams, and groundwater flows after meeting evapotranspiration requirements. However, the heavy rains during August 2018 led to a massive loss of stored soil water due to landslides and a reduction in riparian vegetation led to the depletion of this soil water storage that normally is made available during the post-monsoon season (Madhusoodhanan & Sreeja, 2019).

The decrease in rainfall, increase in temperature, and degradation of the hydrological systems have resulted in the reduction of discharge in the four major river basins of the state (Chaliyar, Bharathapuzha, Periyar, and Pamba). An increase in temperature along with alterations in cropping patterns in the river basins has triggered an increase in water loss through evapotranspiration. An increase in the number of low and no-flow events is observed in the rivers of Kerala. This led to increased groundwater extraction and a subsequent decline in the groundwater table in the State (Mathew et al., 2021).

4.2.5. Forests and Biodiversity

Globally, forests are prone to various stresses, including changes in the hydrological cycle, loss of biodiversity, warming climate, forest conversion, etc. Forests support the livelihoods of millions of individuals, and this dependence on forests becomes extremely acute and visible in the event of a drought, flood, crop failure, or other such calamities.

Climate change is now determined as being inevitable and is projected to increase the physiological stress on forests due to higher temperatures, longer drought duration, and modified frequency of occurrence of extreme events (IPCC, 2012). This has severe repercussions for the conservation of biodiversity and ecosystems, especially in tropical forests.

The Fifth Assessment Report of the IPCC (2014) concluded that climate change has already impacted significantly not just the lives of humans, but also the environmental and ecological systems in all countries in the last few years. Projections show that extinction risks

will increase under all RCP scenarios, and the greater the climate change, the higher will be the associated risk. Further, medium (RCP 4.5)-to-high emission (RCP 8.5) scenarios pose a high risk of sudden and irreversible regional-scale changes in the structure, composition, and functions of ecosystems.

In India too, forest ecosystems are susceptible to stress due to the high dependence of local communities on forest resources as also due to increasing incidents of climate extremes and climate variability—such as frequent droughts, high levels of warming, water stress, El Nino phenomenon, etc. The projected changes in mean climate and climate extremes could also contribute to further forest vulnerabilities.

According to the Indian State of Forest Report (2019) of the Forest Survey of India, the recorded forest area in the State of Kerala is 11,309 sq. km, which is 29.11% of Kerala's geographical area. The forest cover in the State is 21144 sq. km, which is 54.42% of the state's geographical area. According to forest canopy density classes, the State has 1,934.83 sq. km under the Very Dense Forest class, 9,508.24 sq. km under the Moderately Dense Forest class, and 9,701.22 sq. km under the Open Forest class (**Figure 4.1**).

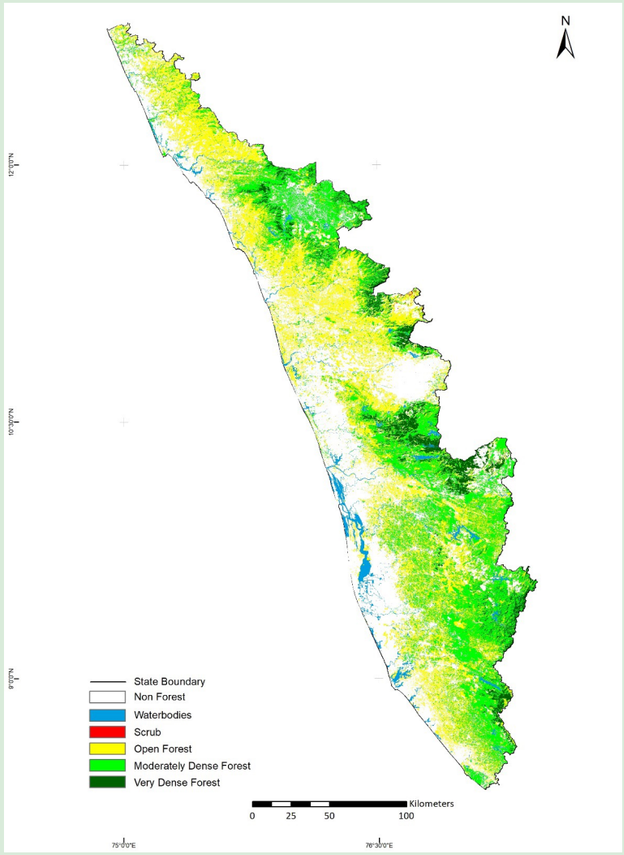


Figure 4.1: **Forest cover map of Kerala (Source: ISFR (FSI, 2019)))**

The Kerala SAPCC 1.0, based on the available literature, discusses the impacts of climate change on forest ecosystems. It summarises that temperature changes would lead to changes in the growth and regeneration capacity of many species of flora, and also result in significant loss of biodiversity, leading to a shift in boundaries of tropical evergreen forests, sholas, and mangroves. It also concludes that forest fires may increase due to the gradual rise in temperature, leading to the loss of fragile ecosystems, adversely impacting wildlife. The SAPCC 1.0 also states that flora and fauna would become increasingly vulnerable – and maybe, even extinct – under a climate change scenario.

In this report, the impact of climate change on the forests in Kerala – especially, the forested grids – is assessed using a dynamic vegetation model, LPJ (Lund-Postdam-Jena Model). For this purpose, a multi-model ensemble of high-resolution downscaled (CORDEX/IITM) climate projection was adopted. The assessment is for two climate scenarios – RCP 4.5 and RCP 8.5 – for two time periods – short-term (2030s) and long-term (2080s).

4.2.5.1. The Model

LPJ, the dynamic global vegetation model used for the assessment, was developed by the Department of Plant Ecology, Lund University, Sweden; Potsdam Institute for Climate Impact Research, Germany and Max Planck Institute for Biogeochemistry, Jena, Germany. The version used for this assessment is LPJ 3.1. With a modular framework, LPJ combines process-based, large-scale representations of terrestrial vegetation dynamics and land-atmosphere carbon and water exchanges (Sitch et al., 2003, Smith et al., 2001). LPJ is a widely used vegetation model across the world, and Upgupta et al (2015) have validated LPJ for studying the Indian scenario. The model is run at a resolution of at 0.5° latitude and longitude, with specified atmospheric CO_2 concentration, soil type and monthly fields of temperature (°C), precipitation (mm/month), and cloudiness (%). The model evokes a response to changes in factors like water availability, atmospheric CO_2 concentration and climate, and estimates the structural changes in major vegetation types. Net Primary Productivity (NPP) under projected climate change scenarios is also simulated by the LPJ model.

4.2.5.2. Input data for LPJ model

The climate data required for the model – temperature, precipitation, and cloud cover – was available from CORDEX (Coordinated Regional Climate Downscaling Experiment) and was used. Temperature and precipitation data from six CORDEX models from the IITM RCM ensemble have been used for the historical period (1980 –2010) and two future periods – mid-term (2021–2050) and long-term (2070 –2099) for two climate scenarios, RCP 4.5 and RCP 8.5. The cloud cover data has been obtained from the SMHI RCM ensemble.

Input data to the LPJ model

Domain	Driving Model	Ensemble	RCM Model	Frequency	Variable
WAS-44	CNRM-CERFACS-CNRM-CM5	R1i1p1	RegCM4-4	monthly	Hurs
	CSIRO-QCCCE-CSIRO-Mk3-6-0				Tas
	MPI-M-MPI-ESM-MR				Pr
	NOAA-GFDL-GFDL-ESM2M				sfcWind
	IPSL-IPSL-CM5A-LR				Cld
	CCCma-CanESM2				

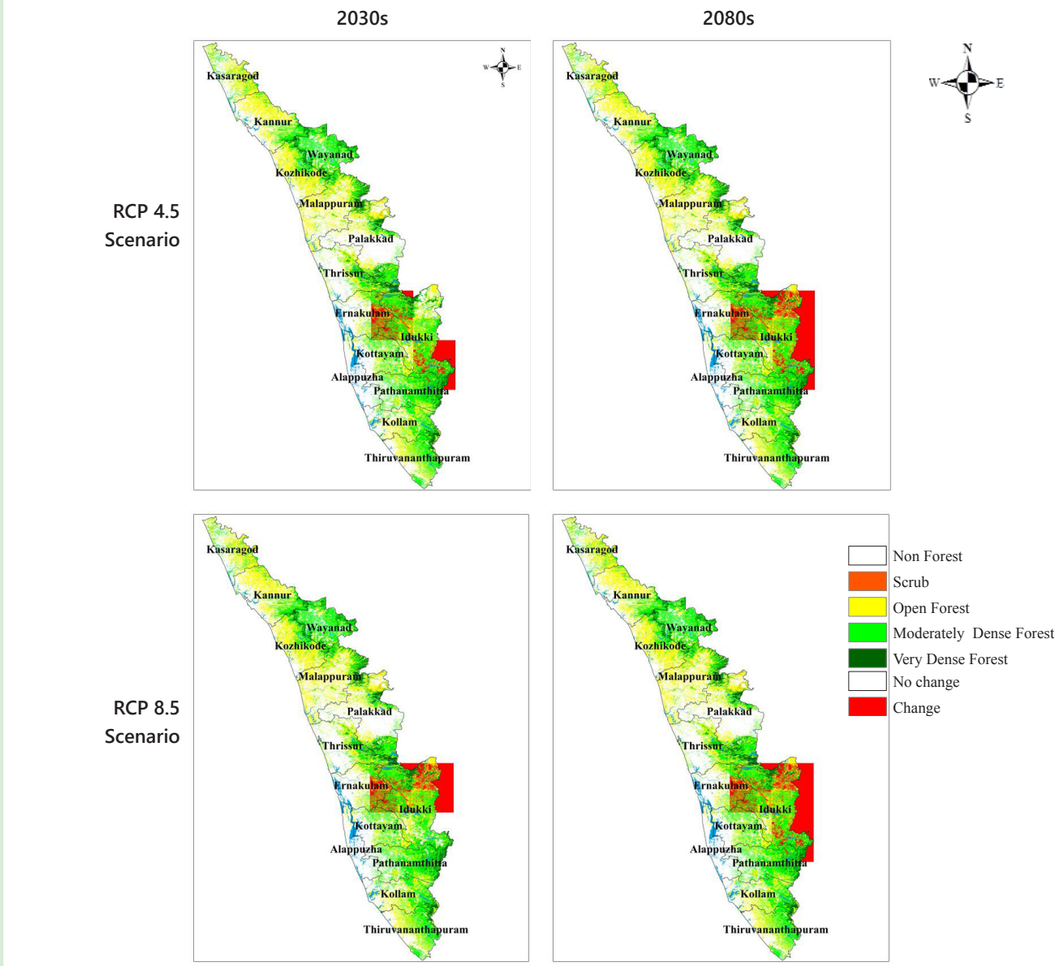


Figure 4.2: **Forest vegetation change during the 2030s (2021–2050) and the 2080s (2071–2100) compared to the baseline (1980–2010) under climate scenarios**

4.2.5.3. Impacts of climate change on forest types

The LPJ model is run across India, and the grids falling across the State of Kerala have been accessed to analyse the climate change impact on forest types. Forest grids impacted by the change in climate are shown in **Figure 4.2** which includes short-term 2030s and long-term 2080s for the two future scenarios; RCP 4.5 and RCP 8.5 when compared to the historical baseline for the years ranging from 1980 to 2010. It is seen that for certain forested grids, vegetation change has been projected, implying a changing climate in future in these areas. This changed climate

would be adverse for existing vegetation, forest type, and biodiversity. These adverse climatic conditions may also lead to forest dieback and mortality.

- RCP 4.5 scenario: Forested grids in the districts of Ernakulam, Idukki, Kottayam, and Pathanamthitta are projected to change in the short and long term.
- RCP 8.5 scenario: In the short term, the forested grids in the districts of Ernakulam and Idukki are projected to be impacted. Forested grids in the districts of Ernakulam, Idukki, Kottayam, and Pathanamthitta are projected to be impacted in the long term.

Changes in vegetation in parts of Ernakulam, Idukki, Kottayam, and Pathanamthitta forest areas have been mainly projected in the short as well as long-term periods under both climate scenarios. The projections included forest areas that were very dense, moderately dense and open forest areas in the above-mentioned regions of Kerala. Wayanad and Palakkad districts are likely to be minimally impacted or with no impact, according to LPJ model projections under the climate scenarios considered. Over a period of time, there could be a change with refined and improved knowledge and a greater understanding of climate scenario conditions.

4.2.5.4. Impacts of climate change on Net Primary Productivity (NPP)

LPJ model simulations for RCP 4.5 scenario suggest that the mean forest NPP in Kerala will show a marginal increase of up to 25% by the 2030s (short-term) and a higher increase of up to 35% in the 2080s (long-term). Under RCP 8.5 scenario, the model projects an increase of up to 35% in NPP for the 2030s, and in the long term (2080s), the increase could even be up to 55%, as per projections. **Figure 4.3** presents the impact of climate change on the NPP of Kerala forests.

RCP 4.5 scenario

Short-Term (2030s): Under this scenario, the increase in NPP is up to 15% in the districts of Kasaragod, Kozhikode, Thrissur, Ernakulam, and

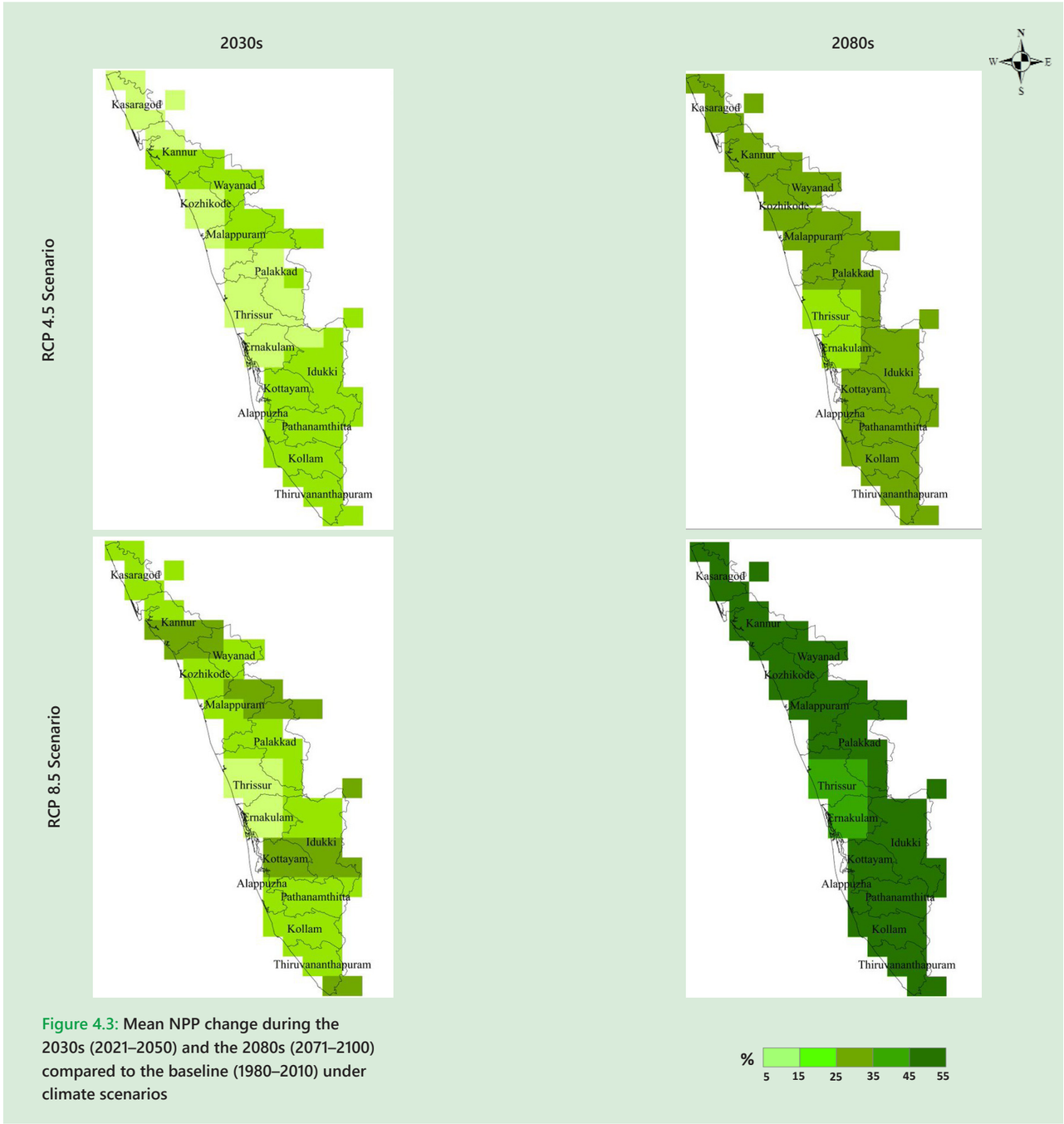


Figure 4.3: Mean NPP change during the 2030s (2021–2050) and the 2080s (2071–2100) compared to the baseline (1980–2010) under climate scenarios

parts of Palakkad. A higher increase in the range of 15%–25% is projected for the southern districts of Idukki, Kottayam, Alappuzha, Pathanamthitta, Kollam, and Thiruvananthapuram.

Long-Term (2080s): Under this scenario, the projected increase in NPP is in the range of 15%–35% across most Kerala districts. The increase in NPP is lower (15%–25%) in Ernakulum and Thrissur. An increase in NPP in the range of 25% - 35% is projected for all other districts in Kerala.

RCP 8.5 scenario

Short-Term (2030s): The NPP trends are similar to that projected for the short-term RCP 4.5 scenario. Under the RCP 8.5 scenario, an increase in NPP of up to 35% is projected. The increase is up to 15% in Ernakulum and Thrissur and 15%–25% in Kasaragod, Kozhikode, Palakkad, and Kollam. Maximum increase in NPP of 25%–35% is projected for parts of Kannur, Wayanad, Kozhikode, Malappuram, Idukki, and Kottayam districts.

Long-Term (2080s): Under this scenario, the projected increase in NPP is in the range of 35%–55 % across Kerala districts. The increase in NPP is high, in the range of 35%–45% in Ernakulum and Thrissur, and 45%–55% in all other districts.

Overall, NPP is projected to increase in Kerala under both RCP 4.5 and RCP 8.5 scenarios. The projected increase is mainly due to high CO_2 concentration in the atmosphere and CO_2 fertilisation. However, the LPJ model has its limitations and does not consider soil nitrogen limitations and the potential impacts of forest pests and fire under a changing climate.

4.2.6. Health

Climate change affects human health in through a number of ways – heat waves, flood, landslide, drought, communicable diseases, etc. Changes and variability in atmospheric moisture content lead to a complex set of weather outcomes – erratic rainfall, drought, and an increase in heavy spells of rain during shorter durations (Abhilash, 2019). As a result of unusually high rainfall in a short period during the monsoon season in

August 2018, over 450 people lost their lives and over 1.4 million were displaced from their homes (KPDNA, 2018).

In many tropical developing countries, where food security is already a challenge, rising temperatures and more unpredictable rainfall, and the loss of agricultural area owing to droughts and flash floods, are predicted to lower crop production. This is likely to put the country's food security in jeopardy, as malnutrition is already a major public health issue. Malnutrition kills millions of people each year due to a lack of essential nutrients and consequent vulnerability to infectious diseases like malaria, diarrhoea, and respiratory disorders (Patil & Deepa, 2007). According to the NFHS-5 data for Kerala State, the percentage of children under the age of five who are stunted has increased from 19.7% in NFHS-4 to 23.4%, and the percentage of children who are wasted has increased from 15.7 to 15.8%. Children under the age of five who are underweight have increased from 16.1% to 19.7%. Anaemia has increased in people of all ages (International Institute for Population Sciences (IIPS) and ICF, 2021).

The analysis done by State Climate Change Celll (DoECC) based on the flood susceptibility map of Kerala (KSDMA & NCESS, 2010) shows that the percentage of flood-prone areas in Kerala varies from 0.8% to 53.89%, with Idukki being the least prone and Alappuzha being highly prone to flooding. Flooding increases the rate and spread of waterborne diseases such as diarrhoea, cholera, hepatitis E, leptospirosis, and other gastrointestinal infections, posing serious public health implications (Alderman et al., 2012). It also increases the risk of vector-borne diseases, such as malaria and dengue fever (Semenza & Suk, 2018); and respiratory and allergic diseases, such as asthma and skin rashes (Mendell et al., 2011). Stagnant water and increased precipitation produce breeding grounds for mosquitoes, bacteria, viruses, and other microorganisms like mould (Gage et al., 2008), which increase susceptibility to infectious diseases or pandemic outbreaks and lead to higher levels of morbidity and mortality. These health concerns are linked to mental health issues, including sadness, stress, and anxiety, all of which aggravate physical problems (Akpinar-Elci et al., 2018). The subsequent health effects, when combined with their economic consequences, large-scale relocation, and infrastructure disruption, can result in a significant deterioration in the impacted population's overall quality of life (Sekulova & Van den Bergh, 2016)

Saltwater intrusion in coastal areas due to sea level rise, contaminate groundwater and makes it unfit for domestic and agricultural use (Sreekesh et al., 2018). The percentage area of surface water with salinity >5ppt varies from 22.7 % in Malappuram to 66.72 % in Kollam, according to a salinity intrusion analysis conducted by the State Climate Change Cell (DoECC) based on CZMP published in 2019. Rising sea levels can lead to changes in the distribution of disease-spreading insects, as well as have implications on nutrition owing to the loss of agricultural land and changes in fish capture and consumption. Rising sea levels may also have health implications associated with population displacement (Patil & Deepa, 2007).

Kerala is witnessing an increasing burden of communicable and non-communicable diseases. Although the State has been successful in controlling a number of communicable diseases earlier, the emergence of chikungunya, leptospirosis, hepatitis and H1N1 in recent years has led to considerable morbidity and mortality. Instances of vector borne diseases like dengue, malaria, Japanese encephalitis, scrub typhus etc. have seen a marked increase in many districts. Water borne infections like different kinds of diarrhoeal diseases, typhoid and hepatitis are showing persistence in many Districts. Cholera has surfaced in many Districts after few years of relative low incidence. Incidence of Malaria is strongly affected by climate change. 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, vector of dengue, Chikungunya and Zika are highly sensitive to climate conditions.

Any disease caused, transmitted or harboured 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. The **Table 4.1** presents the communicable diseases reported in the State between 2017 and 2020.

Although, Kerala might not have as high a temperature as compared to the meteorological subdivisions from the North-West and Central India, the occurrence of heat related illness is increasing in some pockets. For the first time, heat wave was officially declared in the State in 2016. Temperature of Palakkad district was 6°C above normal touching a record high of 41.9°C. Even maritime districts such as Alappuzha and Kozhikode experienced increase of more than 4°C above long period average on 27th April. Temperature in 2016 was 2 to 3 degree Celsius

Table 4.1. **Prevalence of communicable diseases in the State during the period 2017 - 2020**

Name of Diseases	2017		2018		2019		2020	
	Case	Death	Case	Death	Case	Death	Case	Death
Dengue Fever	21993	165	4090	32	4651	14	2722	22
Malaria	1194	2	908	0	656	1	268	1
Chikungunya	54	0	76	0	109	0	558	0
AES (Sus. JE)	5	4	28	15	59	5	15	4
Japanese Encephalitis (JE)	1	0	5	2	11	2	0	0
Leptospirosis	1408	80	2079	99	1211	57	1039	48
Hepatitis A	988	24	1369	5	1620	7	464	2
Hepatitis B	817	7	759	7	828	6	475	3
Cholera	8	1	9	0	9	0	2	0
Diphtheria	79	5	23	1	32	2	--	--
Typhoid	314	1	109	0	27	0	16	0
ADD (Diarrhoea)	463368	8	540814	12	544027	6	250788	1
Scrub Typhus	340	5	400	6	579	14	423	8
Kala Azar	--	--	--	--	--	--	1	0
West Nile Fever	--	--	1	0	11	2	--	--
Kysanur Forest Disease	--	--	--	--	8	2	29	3
H1N1	1411	76	823	50	853	45	58	2

Table 4.2. District wise heat related illness in the State

District	2016				2019			
	Heat Rash	Sun Burn	Sun Stroke	Death	Heat Rash	Sun Burn	Sun Stroke	Death
Thiruvananthapuram	0	6	0	0	18	20	3	0
Kollam	0	58	0	0	144	59	3	0
Pathanamthitta	0	15	0	0	113	94	2	0
Alappuzha	0	15	0	0	57	1	0	0
Kottayam	0	4	0	0	6	48	3	0
Idukki	0	52	0	0	87	146	1	0
Ernakulam	0	29	0	0	56	56	6	1
Thrissur	0	24	0	0	26	56	1	0
Palakkad	0	80	0	0	72	101	6	0
Malappuram	0	30	0	0	25	45	1	0
Kozhikode	0	22	0	0	80	172	4	0
Wayanad	0	10	0	0	7	34	0	0
Kannur	0	12	0	0	61	30	2	0
Kasaragod	0	19	0	0	12	13	0	0
Total	0	376	0	0	764	875	32	1

higher than normal in all districts in the State. Several sunburn incidents were reported from various parts of the State in 2016. The KSDMA declared heat wave, sun stroke, and sun burns as 'State Specific Disasters' in 2019. According to IDSP, 1671 heat related issues had been reported in the State from 25.02.2019 to 01.06.2019 (**Table 4.2**) (SAPCCHH, 2022).

4.2.7. Tourism

Climate change can cause several impacts on the tourism industry, depending upon the geographical location and type of activity. Extreme weather events (sea level rise, flood, drought, wildfire, infectious disease, etc.) as fallout can influence tourist activity as well as their safety. Beaches are some of the most popular tourist locations in Kerala, considering it is a coastal state. Lagoons, mangrove swamps, sandy and rocky coasts, and open seafront make up Kerala's tropical marine ecosystem. As a result, coastal areas are tourist attractions and significant economic contributors. Coastal areas are under threat from climate change as sea level rise is altering shorelines and coastal boundaries, resulting in seawater intrusion. This results in local population migration to other areas, which will have an impact on economic growth. Furthermore, the loss of coastal areas and shorelines has the potential to damage the habitats of many ecologically sensitive species, resulting in biodiversity extinction (Siddiqui & Imran, 2019).

Forest and biodiversity tourism, particularly in relation to national parks, has proven to be a popular tourist attraction. The appeal of forests as recreational destinations (hiking and trekking) has grown in recent years (Dudek, 2017). The

majority of the time, people from metropolitan regions choose these locations based on their requirements and interests in nature. Kerala, which is part of the Western Ghats, has a total forest area of 11524.15 square kilometres, divided among six National Parks, 18 Wildlife Sanctuaries, one Community Reserve and 32 Reserve Forests (Kerala Forest Department, 2022). Western Ghats in Kerala with its tropical forest ecology, offers a natural advantage for ecotourism growth. The increasing risk of species extinction, decreasing freshwater, expanding health and life insecurity, increasing accidents due to wildfires, increasing heat waves, and rising disease risks are all potential hazards to Kerala's forest tourism. These dangers may limit tourists' options for trekking and hiking areas (Siddiqui & Imran, 2019).

4.3. Need for Vulnerability Assessment

In anticipation of the threat to these systems from climate change, a system's robustness in terms of its health and resilience needs to be quantified. A vulnerability assessment is a process that allows for such quantification. It can help to identify and prioritise systems, based on their inherent sensitivity and lack of coping or adaptive capacity.

To update the SAPCC, sectoral vulnerability assessments have been conducted for the agriculture, livestock, forests, water, coastal fisheries, tourism, and health sectors (**Annexure 4.1**). This section presents the results of a comprehensive Composite Vulnerability Index computed at the district level for the State of Kerala. A Composite Vulnerability Index in the State Action Plan on Climate Change would help prioritise areas of intervention and also the key drivers of vulnerability that need to be prioritised for investment. The sectoral Vulnerability Index would be useful at the time of implementation of adaptation programmes and projects.

4.4. Vulnerability Assessment: Definition and Conceptual Framework

The vulnerability assessment was carried out based on the risk management framework adopted by the 5th Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC, 2014). This framework (**Figure 4.4**) focuses

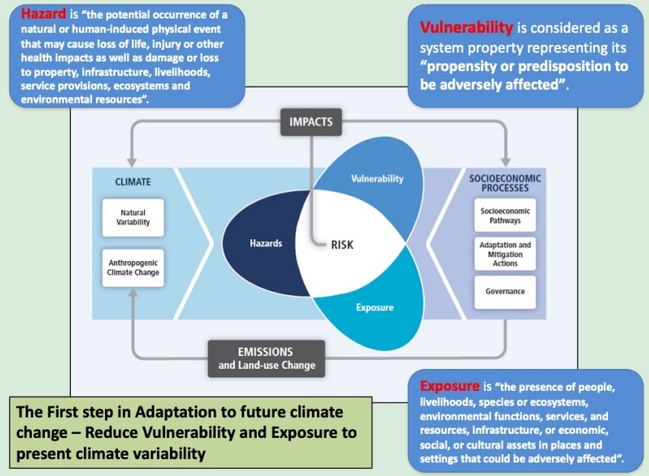


Figure 4.4: IPCC AR5 Risk Assessment and Management Framework, (IPCC, 2014, Sharma et al., 2018)

on the concept of 'risk', which arises 'from the interaction of vulnerability, exposure and hazard'. Here, vulnerability is a 'system property' comprising sensitivity and adaptive capacity and represents the propensity of a system to be adversely affected, independent of exposure.

IPCC Working Group II for AR-5, defines the following terms:

- Vulnerability is 'the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.
- Adaptive Capacity is 'the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences, and
- Sensitivity is 'the degree to which a system or species is affected, either adversely or beneficially by climate variability or change. The effect may be direct (e.g., change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise).

Vulnerability is a non-observable and non-measurable state of a system and is a theoretical concept (Hinkel, 2011). It indicates the predisposition of a natural ecosystem or a socio-economic system to be adversely affected. Here, predisposition indicates a certain lack of (adaptive) capacity of the system to deal with or overcome the adverse impacts (its sensitivity) of a hazard. These two functions help to conceptualise the internal state or property of a system.

4.5. Methodology and Framework

An indicator-based approach following the IPCC's AR5 Risk Assessment and Management Framework was employed for the computation of current sectoral and comprehensive vulnerability (Sharma et al., 2018). **Figure 4.5** presents the broad approach and steps to vulnerability assessments.

Step 1	Scoping and objective of vulnerability assessments
Step 2	Selection of type of vulnerability assessments - sectoral and composite
Step 3	Selection of tier method - Tier 1
Step 4	Selection of sector, spatial scale, community or system, and period for assessment
Step 5	Identification, definition, and selection of indicators for vulnerability assessments
Step 6	Quantification of indicators
Step 7	Construction of a correlation matrix and finalisation of indicators
Step 8	Normalisation of indicators
Step 9	Weights allocation to indicators
Step 10	Aggregation of indicators and development of sectoral and composite vulnerability indices
Step 11	Representation of vulnerability profiles and ranking of districts: spatial maps
Step 12	Identification of drivers of vulnerability for no-regret adaptation planning

Figure 4.5: Broad approach to sectoral and comprehensive vulnerability assessments

Tier 1 methodology was adopted to assess both current sectoral and composite vulnerability. This entailed use of secondary sources of information to quantify indicators and equal weights were assigned to all finalised indicators. The details are presented below:

Step 1: Scoping of vulnerability assessment – to identify and rank vulnerable districts of Kerala.

Step 2: Selection of type of vulnerability assessment – There are known linkages, interactions, and interdependencies that exist between biophysical and socio-economic systems, and as such, integrated vulnerability assessments were conducted. Indicators representing sensitivity and adaptive capacity and that reflect the socio-economic, biophysical, and institutional capacities, or lack thereof, was used to assess the vulnerability of the agriculture, livestock, forests, water, coastal fisheries, tourism, and health sectors. A comprehensive combination of indicators from all these sectors was also used to assess the composite or overall vulnerability of districts in the State.

Step 3: Selection of tier methods – Tier 1 assessment was conducted using secondary sources of information.

Step 4: Selection of spatial scale and period for vulnerability assessment.

- **Spatial scale**: district-level assessment for the State of Kerala.
- **Period**: 2011–2020, considering the availability of data.

Step 5: Identification, definition, and selection of indicators for vulnerability assessment – selection of indicators is one of the most critical steps of the vulnerability assessment. Indicators were selected based on sectoral expert consultation. For each sector, 23 to 33 indicators were suggested by experts. Since, there could be autocorrelation among the indicators, which weakens vulnerability assessment results, the indicators were finalised after checking for correlation.

Step 6: Quantification of indicators – all indicators were quantified using secondary data sources. Sources used to quantify the selected indicators for Vulnerability Assessment are provided in the respective tables.

Step 7: Construction of a correlation matrix – once the indicators were quantified, a correlation matrix was constructed to exclude those indicators that have a significant correlation ($r^2 \geq \pm 0.70$) with other indicators. Many of the indicators suggested for inclusion by sectoral experts were highly correlated. Section 4.4.1.2 highlights the indicators that were excluded from the assessment, and Section 4.4.1.3 presents the final list of indicators considered for the construction of a Composite Vulnerability Index.

Step 8: Indicators were normalised based on their functional relationship with vulnerability. Two types of functional relationships are possible:

Positive relationship – vulnerability increases with an increase in the value of the indicator. The following formula is used if the indicator has a positive relationship:

$$x_{ij}^{P} = \frac{Xij - Min\ i\ \{Xij\}}{(Max\ i\ \{Xij\} - Min\ i\ \{Xij\}}$$

Negative relationship – vulnerability increases with decrease in the value of the indicator. The following formula is used if the indicator has a negative relationship:

$$x_{ij}^{N} = \frac{Max\ i\ \{Xij\} - Xij}{Max\ i\ \{Xij\} - Min\ \{Xij\}}$$

Where, X_{ij} is the variable that is being normalised and has the value of the j^{th} indicator for the i^{th} region, and x^{P}_{ij} (for positive relationship) and x^{N}_{ij} (for negative relationship) are the normalised values, which will lie between 0 and 1.

Step 9: Assigning weights to 20 - 30 indicators are not only difficult, but is inconsequential. So, equal weights were assigned to all the finalized indicators.

Step 10: Aggregation of indicators and development of Vulnerability Index – as equal weights were assigned; the Vulnerability Index was constructed by simply taking an average of the normalised scores.

Step 11: Representation of vulnerability and vulnerability ranking – districts were ranked on a three-point scale of high, medium, and low vulnerability for the assessments.

Step 12: Identification of drivers of vulnerability for no-regret adaptation planning – Drivers of vulnerability were identified for each of the three

vulnerability classes. Most significant drivers have also been provided for each district in the highly vulnerable class, as vulnerability is highly contextual and location-specific.

Vulnerability Index values lie between 0 and 1, where 0 is not vulnerable and 1 is the most vulnerable. Arrangement of the assessed Vulnerability Index values in decreasing or increasing order allows for comparison and ranking of districts.

4.6. Assessment of Vulnerability

The vulnerability was assessed for the agriculture, Livestock, forests, water, coastal fisheries, tourism, and health sectors (**Annexure 4.1**), along with the computation of a Composite Vulnerability Index representing all major sectors. The framework and methodology specified in Section 4.3 was followed to for the assessment of vulnerability, and results of the Composite Vulnerability Assessment are presented in the following sections.

4.6.1 Composite Vulnerability Assessment

For the construction of composite vulnerability, 19 indicators were initially selected (10 sensitivity and 9 adaptive capacity indicators). Post correlation assessment, 17 indicators were finalised and selected for the assessment. Details of indicator selection, the rationale for their selection and exclusion, and the finalised list of indicators are provided below.

4.6.1.1 Indicator selection

The selection of indicators is the most critical step in the assessment of vulnerability. Indicators were selected to represent the adaptive capacity and sensitivity of each sector, based on sectoral expert consultation and data availability. For Composite Vulnerability Assessment, a total of 19 indicators were selected to holistically represent all sectors as well as significant factors perceived by experts to influence the vulnerability of districts in Kerala. The list of all indicators selected, the rationale for their selection, the function of vulnerability that they represent (sensitivity or adaptive capacity), and the source of data used to quantify them is presented in **Table 4.3**.

Table 4.3: **Initial list of indicators recommended by sectoral experts to represent the current composite vulnerability of Kerala**

SN	Indicators	Rationale for selection	Function of vulnerability	Source
1.	Population density	Kerala is a very densely populated State. High population density implies higher competition for the finite resource as well as employment opportunities. It also has significant implications for human health and well-being.	Sensitivity	Census of India (2011)
2.	Percentage of the total population below the poverty line (BPL)	The degree to which poorer sections of a community are adversely affected by any hazard is disproportionately higher. Districts with a higher percentage of the population below the poverty line are thus inherently more sensitive to the impacts of climate hazards.	Sensitivity	WFP (2014)
3.	Percentage share of natural resources-based income	The productivity of natural resource-based incomes is highly dependent on the climate. With climate change, communities dependent on these income sources are thus very sensitive and may be adversely impacted.	Sensitivity	Department of Economics and Statistics (2018–19)
4.	Percentage of the total population that are inherently sensitive (below 6 and over 65 years of age and people living with disabilities)	The very young, the elderly, and those living with disabilities are known to be at the greatest risk of serious illness and mortality due to climate hazards such as heat stress, floods, etc.	Sensitivity	Census of India (2011); Disability Census Report (2015)
5.	Air Quality Index	Climate change could increase exposure to risk factors such as pollen, mould, ozone, and particulate matter at the ground level, reducing air quality and aggravating respiratory diseases. People living in districts with already poor air quality are thus more sensitive.	Sensitivity	KSPCB (2010–19)
6.	Groundwater Quality Index	Groundwater quality determines the potability of water from groundwater sources. Communities with poor groundwater quality are inherently more sensitive to water shortages during climate hazards.	Sensitivity	CGWB (2019)
7.	Surface Water Quality Index	The surface Water Quality Index measures the pollution load and demand on surface water sources. Communities with already poor surface quality are thus more sensitive to water contamination during climate hazards, particularly floods and droughts.	Sensitivity	CWRDM (2016)
8.	Variation in productivity of principal agricultural crops	Crops are highly sensitive to variations in climate parameters, particularly rainfall and temperature. This indicator measures the historical variation in crop yields of some of the principal crops cultivated in Kerala. It directly reflects the sensitivity of crops to climate variability. Districts with historically higher variation in crop productivity are thus more sensitive, as climate change is projected to increase the variability of rainfall and temperature.	Sensitivity	Department of Economics and Statistics (2018–19)
9.	Average Infant Mortality Rate (IMR over 5 years)	High infant mortality rates are generally indicative of unmet human health needs in sanitation, medical care, nutrition, and education. Communities in districts with higher IMR lack access to basic amenities, and are thus more sensitive.	Sensitivity	DHS (2019)

SN	Indicators	Rationale for selection	Function of vulnerability	Source
10.	Communicable diseases per 1,000 population	Changes in temperature and rainfall variations due to climate change are projected to increase vector-borne diseases. Similarly, extreme rainfall and flooding have the potential to increase water-borne disease incidence. With high population density as observed in Kerala and future climate change, communities in districts with an already high incidence of communicable diseases are thus more sensitive.	Sensitivity	DHS (2019)
11.	Percentage of district area covered by forests (forest cover)	Forests provide important ecosystem services that are essential for the sustainable productivity of rural economies. They are also an important source of alternative livelihoods and food during crop failure. Districts with a higher percentage area under forests thus have a higher capacity to adjust to climate hazards.	Adaptive capacity	FSI (2019)
12.	Net groundwater availability per 1,000 population	Communities in districts with higher water availability indicate a higher capacity of the population to respond to water stress during climate hazards.	Adaptive capacity	GWB (2019)
13.	Number of healthcare facilities per 1,000 population	As climate hazards can have severe implications on human health, access to functional healthcare facilities would be fundamental in enhancing adaptive capacity and lowering vulnerability.	Adaptive capacity	DHS, DME (2020)
14.	Number of healthcare professionals per 1,000 population			
15.	Percentage of net irrigated area to total cultivable area	Irrigation provides an essential buffer to crops against climate hazards such as droughts. This indicator reflects the existing infrastructural provisions for irrigation water supply, and thus the adaptive capacity of agriculture in the districts of Kerala.	Adaptive capacity	Agriculture Dept. (2019)
16.	Road density	Access to roads and transportation broadly indicates integration with the economy and the associated spread effects of development. Under a changing climate, access to roads is pivotal for disaster management.	Adaptive capacity	LSG, PWD, NHAI (2019)

SN	Indicators	Rationale for selection	Function of vulnerability	Source
17.	Meteorological monitoring station density	Measured as the number of meteorological stations per 1,000 km^2 of district area. Continuous monitoring of local weather and thus long-term climate is essential to gauge and quantify the potential impacts, loss, and damages of climate hazards. Early warning and development of location-specific no-regret adaptation strategies based on information gathered at these stations provide invaluable adaptive capacity to local communities.	Adaptive capacity	IMD, KSDMA, IDRB (2020)
18.	Percentage of households with treated water supply	Access to potable water is a basic human right. Safe and readily available water has serious implications for human health and gender inequalities. Improved water supply and sanitation, and better management of water resources can boost economic growth and can contribute greatly to poverty reduction.	Adaptive capacity	KWA & Jalanidhi (2019)
19.	Capacity of shelter camps per 1,000 population	The capacity of disaster relief camps is paramount in provisioning adequate and essential aid and shelter to communities during climate hazards.	Adaptive capacity	KSDMA (2020)

4.6.1.2 Correlation Assessment

Post-quantification of indicators, a correlation matrix was constructed to identify those indicators that may have a significant correlation with other indicators and to exclude them. According to the assessment:

- The indicator - average infant mortality rate has a very significant negative correlation (r2 = -0.735) with the indicator - number of healthcare professionals per 1,000 population. This is logical, as districts that have more healthcare professionals will have more functional healthcare facilities, which in turn, increase the access to better emergency healthcare for communities, lowering the IMR. As such, the IMR was excluded.
- Similarly, the indicator - road density has a very significant positive correlation (r2 = 0.799) with the indicator - population density. This is also logical, as districts with more people have invested in the development of road infrastructure to increase connectivity. Hence, road density was excluded.

4.6.1.3 Final Indicators for Vulnerability Assessment

With the exclusion of two indicators, a total of 17 indicators were finalised and selected for the quantification of composite vulnerability (the first 9 indicators represent sensitivity and the remaining 8 represent adaptive capacity).

1. Population density
2. Percentage of the total population below the poverty line (BPL)
3. Percentage of the total population that are inherently sensitive (below 6 and over 65 years of age and people living with disabilities)
4. Percentage share of natural resources-based income

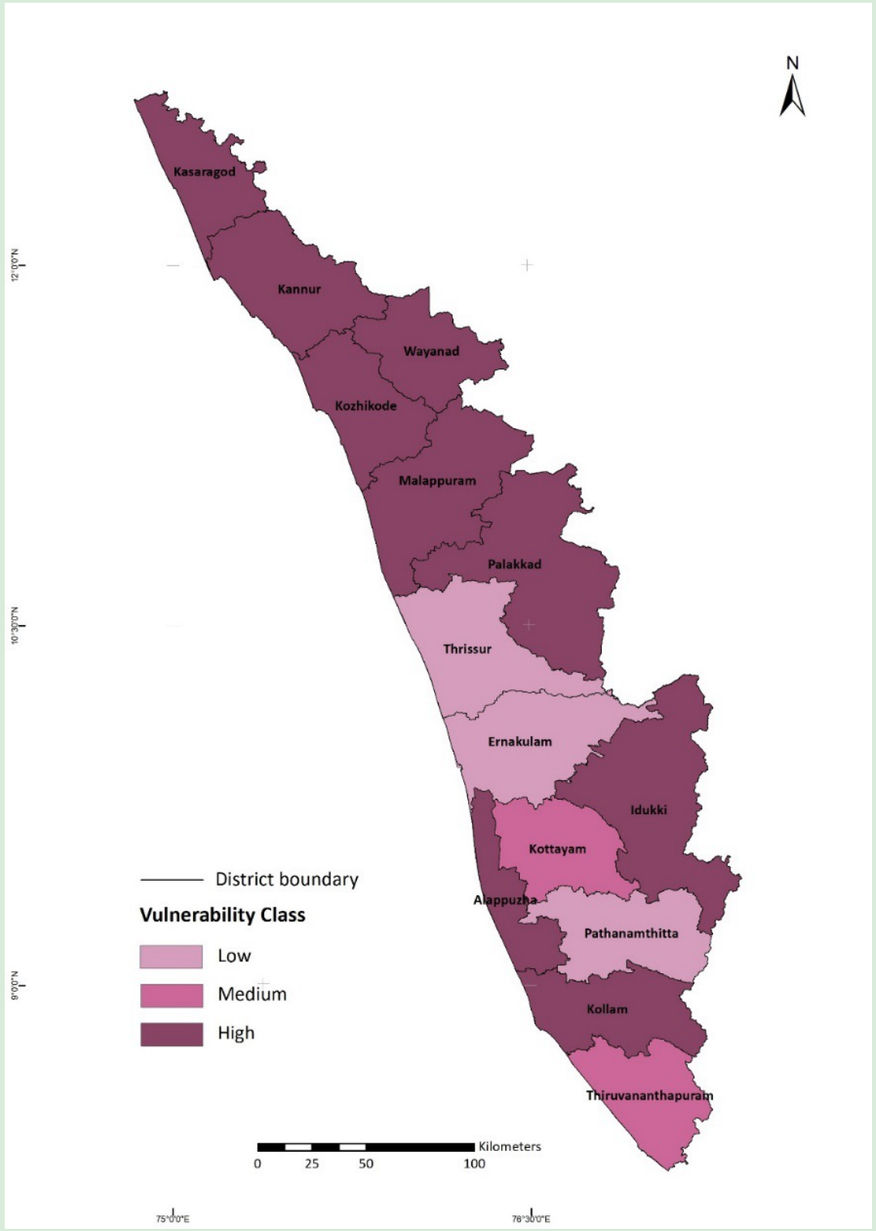


Figure 4.6: **District wise Composite Vulnerability Index**

5. Air Quality Index
6. Groundwater Quality Index
7. Surface Water Quality Index
8. Variation in productivity of principal agricultural crops
9. Communicable diseases per 1,000 population
10. Number of healthcare facilities per 1,000 population
11. Number of healthcare professionals per 1,000 population
12. Net groundwater availability per 1,000 population
13. Percentage of households with treated water supply
14. Percentage net irrigated area to total cultivable area
15. Percentage of district area covered by forests (forest cover)
16. Meteorological monitoring station density
17. Capacity of shelter camps per 1,000 population

As equal weights were assigned to all indicators, normalised scores of indicators were aggregated into a Composite Vulnerability Index by simply averaging the normalised values of all indicators for each district.

4.6.2 Composite Vulnerability Index

The fourteen districts of Kerala were classified on a three-point scale of high, medium, and low vulnerability. Of the fourteen districts, nine were ranked as highly vulnerable, two as moderately vulnerable, and the remaining three were ranked as having low vulnerability. Wayanad, Kozhikode, Kasaragod, Palakkad, Alappuzha, Idukki, Kannur, Malappuram, and Kollam are the highly vulnerable districts according to the Composite Vulnerability Index, with Wayanad ranked as the most vulnerable in the State (**Figure 4.6**).

According to the Composite Vulnerability Assessment, Kottayam and Thiruvananthapuram are the medium vulnerable districts. Pathanamthitta, Ernakulam, and Thrissur districts are classified as having a low vulnerability, with Pathanamthitta having the least vulnerability.

This means that communities in these three districts have relatively low sensitivity and very high adaptive capacity, lowering their overall vulnerability. This, however, does not mean that communities in these districts are not vulnerable. They are relatively less vulnerable when compared to the other districts in Kerala when considering these indicators to represent the functions of vulnerability.

It is very important to note that vulnerability assessments are context-specific. They are a relative comparison and are highly dependent on the indicators selected for the assessment. They are also dependent on the scale at which the assessment is conducted. Several vulnerability studies have been conducted for the State of Kerala; however, they are either sector-specific (coastal fisheries) or conducted at a micro-scale (Thiruvananthapuram City). Similarly, several other vulnerability assessments conducted at the district level compare the districts of Kerala to all the other districts across the country. The scale in the present study is limited to comparing the fourteen districts of Kerala to each other. Furthermore, the indicators selected and the methodology used is different from these other studies, and as such, results are not comparable.

4.6.3 Drivers of Vulnerability

Averages of the normalised values of indicators were considered to represent the drivers of vulnerability for different vulnerability classes. Indicators that have averaged normalised scores over 0.5 were considered significant drivers of vulnerability and those with values over 0.70 were considered priority drivers (in bold) and are presented in **Table 4.4**.

Vulnerability is highly context-specific, and as such, the significant drivers of vulnerability are presented here for each district based on the percentage contribution of each normalised indicator value to a district's Composite Vulnerability Index score.

1. **Wayanad**: Poor surface water quality; high percentage of the population living below the poverty line; high population burden on

Table 4.4: **Drivers of composite vulnerability at the district level, Kerala**

Vulnerability Class	Drivers of Vulnerability	Districts
High	1. **High percentage of the inherently sensitive population (below 6 and over 60 years of age; people living with disabilities)** 2. **Fewer healthcare professionals** 3. **Fewer relief shelters available relative to the district's population** 4. **Fewer households with treated water supply** 5. High incidence of communicable diseases 6. Poor irrigation coverage 7. High population burden on healthcare facilities 8. Poor spread and coverage of local meteorological monitoring stations 9. Limited groundwater availability 10. High percentage of the population living below the poverty line	Wayanad, Kozhikode, Kasaragod, Palakkad, Alappuzha, Idukki, Kannur, Malappuram, and Kollam
Medium	1. **Poor irrigation coverage** 2. **High percentage of inherently sensitive population** 3. **Fewer relief shelters available relative to the district's population** 4. **High population density** 5. **Limited groundwater availability** 6. Poor air quality 7. Poor surface water quality	Thiruvananthapuram and Kottayam
Low	1. **Fewer relief shelters available relative to the district's population** 2. **High percentage of inherently sensitive population** 3. **Poor irrigation coverage** 4. **Poor spread and coverage of local meteorological monitoring stations**	Thrissur, Ernakulam, and Pathanamthitta

public healthcare facilities; poor spread and coverage of local meteorological monitoring stations and high incidence of communicable diseases.

2. **Kozhikode**: Poor irrigation coverage; limited groundwater availability; fewer relief shelters available relative to the district's population; high population density and high percentage of inherently sensitive population.
3. **Kasaragod**: Fewer households with treated water supply; fewer healthcare professionals; high incidence of communicable diseases; high variability in principal crop yields and fewer relief shelters available relative to the district's population.
4. **Palakkad**: High variability in principal crop yields; poor groundwater quality; fewer relief shelters available relative to the district's population; fewer healthcare professionals and poor spread and coverage of local meteorological monitoring stations.
5. **Alappuzha**: Low forest coverage; high population density; a high percentage of inherently sensitive population and fewer healthcare professionals.

6. **Idukki**: High dependence on natural resource-based income sources; poor spread and coverage of local meteorological monitoring stations; high population burden on public healthcare facilities and fewer households with treated water supply.
7. **Kannur**: Fewer relief shelters available relative to the district's population; high percentage of inherently sensitive population; poor irrigation coverage; fewer households with treated water supply and fewer healthcare professionals.
8. **Malappuram**: High incidence of communicable diseases; high percentage of inherently sensitive population; fewer healthcare professionals; limited groundwater availability and fewer relief shelters available relative to the district's population.
9. **Kollam**: Poor irrigation coverage; fewer relief shelters available relative to the district's population; high percentage of inherently sensitive population and fewer healthcare professionals.
10. **Thiruvananthapuram**: High population density; limited groundwater availability; fewer relief shelters available relative to the district's population and poor irrigation coverage.
11. **Kottayam**: High percentage of inherently sensitive population and poor irrigation coverage.
12. **Thrissur**: Fewer relief shelters available relative to the district's population and high percentage of inherently sensitive population.
13. **Ernakulam**: Poor air quality; Poor surface water quality and high percentage of inherently sensitive population
14. **Pathanamthitta**: Poor spread and coverage of local meteorological monitoring stations and poor irrigation coverage.

The recurring themes in the highly vulnerable districts appear to be **human health, disaster management, and natural resource management.**

- In terms of human health, the vulnerable districts have a large population of very young, very old and people living with disabilities, disease prevalence, and reduced availability of functional healthcare.
- The sensitivity of disaster management is reflected by the poor capacity of relief shelters in these districts and the poor spread and coverage of local meteorological monitoring stations.
- With regards to natural resources, it is varied and district-specific, but the majority of these districts have poor groundwater/surface water quality and availability, poor irrigation coverage, and high variability of crop yields. Alappuzha has poor forest coverage.

To lower the overall vulnerability of communities within highly vulnerable nine districts, these drivers will have to be prioritised. Sector-specific drivers of vulnerability are provided in **Annexure 4.1**. In Section 6 on Adaptation, specific adaptation strategies for addressing the drivers of vulnerability are discussed.

4.7. Summary

The composite vulnerability assessment identifies Wayanad, Kozhikode, Kasaragod, Palakkad, Alappuzha, Idukki, Kannur, Malappuram, and Kollam as the most vulnerable districts in terms of overall inherent vulnerability. Along with the sectoral vulnerabilities identified (**Annexure 4.1**), this information may be used to:

1. prioritise hotspot districts for investment in interventions to lower inherent sectoral or composite vulnerability;
2. develop a more nuanced understanding of other possible drivers of vulnerability in terms of sector-specific hotspot districts;
3. develop targeted interventions to lower sensitivity and build the adaptive capacity of communities by addressing the identified drivers of vulnerability.

More meaningful assessments would involve assigning stakeholder weights to indicators to

identify the true drivers of vulnerability and a multi-scale approach to prioritise villages and households for implementation of interventions where they are most needed, given resource constraints.

Furthermore, with climate change, there is a need to integrate the probability of occurrence of present and future climate hazards, and exposure of community and critical infrastructure to these hazards, along with vulnerability assessments to assess the climate hazard risk to all sectors and communities as a whole. The Climate Change Cell, DoECC, Kerala has initiated this process by compiling data on the exposure of different productive land classes (croplands, forests, coastal areas, etc.) to historical hazards such as droughts, floods, landslides, and sea level rise.

The most effective vulnerability reduction measures in the near-term are programmes that improve basic public needs, such as the provision of clean water and sanitation, increasing capacity for disaster preparedness and response, and poverty alleviation. Sector-specific strategies to lower vulnerability are provided in Section 6.

Further, heavy rainfall events are projected to increase in magnitude and frequency with implications for coastal fisheries, forests, water, etc., and socio-economic systems such as agriculture and health, and communities in different districts.

It is clear from literature that the impacts of climate change on water, agriculture, Livestock, fisheries, tourism, and health sectors are likely to be adverse. Further, modelling studies on the impact of climate change on the forest sector shows impacts that may be adverse with moisture paucity and nitrogen limitations. The impacts of climate change and its implications for the various sectors and socio-economic systems will be exacerbated by existing vulnerabilities. The ranking and identification of drivers of vulnerability provides an opportunity to formulate strategies to address this vulnerability, and thereby help adapt in the short term, while building resilience in the long term, in biophysical and socio-economic systems.

5. Mitigation

5.1. Overview

Kerala is the fifth least greenhouse gas (GHG) emitting State in India. The State accounted for only 0.04% of the national emissions in 2015 (0.89 $MtCO_2e$ (Million tonnes of CO_2 equivalent)) (GHGPI, 2018). This low share of emissions was mainly due to its large forest cover, activities in energy conservation, relatively lesser industrial processes, and energy efficiency improvements. The forest cover, which acts as a carbon sink, accounts for 54.70% of the total geographical area of the State (FSI, 2021). Kerala is also one of the top-performing States in activities to improve energy efficiency (AEEE & BEE, 2019). However, emissions from energy sectors (or emissions due to energy use), which account for 80% of the emissions, had seen a growing trend—increasing at a compounded annual growth rate (CAGR) of 5.5% between 2005 and 2015 (**Figure 5.1**). Within the energy sector, transport (54%) was the highest contributor to GHG emissions, followed by buildings (21%).

The transport sector in Kerala depends largely on conventional fuels. Apart from the pandemic-hit (post-2019) and recession period (2011–2017), the State experienced an average vehicle growth of 10% annually, with the growth rate of personal two-wheelers and cars reaching 15% during 2005–2017. This increasing trend of personal vehicles is the reason behind burgeoning energy consumption in the transport sector in Kerala.

This section covers the emission-mitigation analysis of major energy sectors, such as industry, public electricity generation (or power), transport, buildings, and the agriculture sector. Section 5.3 discusses the key policies and programmes implemented in Kerala between 2015 and 2019 (5 years), to reduce GHG emissions or those that led to emission reductions as a co-benefit. The efficacy of these policies and programmes in terms of emissions mitigated is discussed in Section 5.4. The emissions mitigated were calculated using the Intergovernmental Panel on Climate Change (IPCC), 2006 methodology for GHG emissions calculation (IPCC, 2006). In the present analysis, only carbon dioxide (CO_2) gas which constitutes 99% of energy-based emissions is considered (GHGPI, 2018).

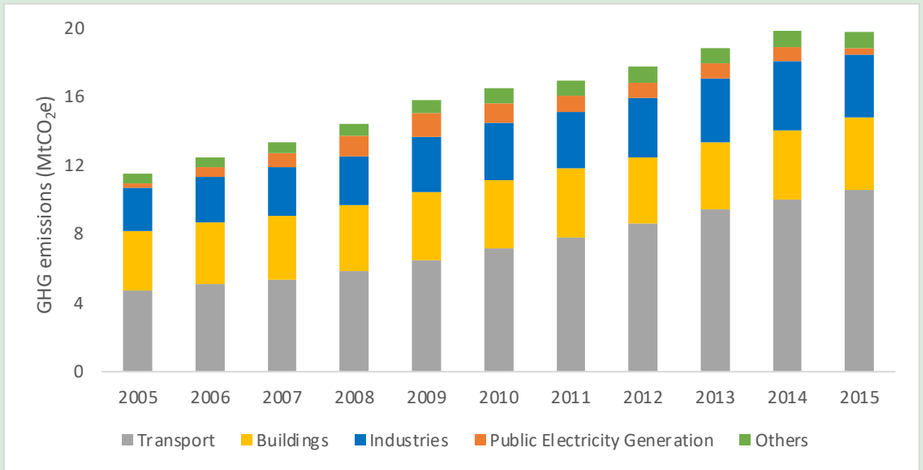


Figure 5.1: **Emissions due to energy use in Kerala between 2005 and 2015**[1]
Source: GHGPI, 2018

The input data for the GHG mitigation assessment of each policy was received from relevant line departments or taken from State government reports available in the public domain. The detailed methodology, inputs, and assumptions for sectoral-emission-mitigation calculations are provided in **Annexure 5.1**. Suitable national averages or inputs from various India-specific research studies were considered in places where there was any data gap.

Section 5.5 presents potential mitigation strategies for the energy sector for the period 2023–30. Details of potential projects, including their emission-mitigation potential, scale, investment requirements, and barriers to implementation are also presented.

5.2. GHG Profile of Kerala

There are independent assessments made to identify the GHG emission profile of the State. For instance, the GHG Platform India (GHGPI) has made GHG emission assessments for the sectors- AFOLU, IPPU, Waste and Energy, and Transport Sectors in the State (GHGPI, 2018). There are possibilities that the State may have a near-neutral status considering its emission profile from various sectors. To understand and examine the methodological and technical viability of the existing assessments, the Department of Environment convened a GHG inventory consultative workshop as part of the SAPCC Revision Process. The consultative workshop brought together experts from across the nation and sectoral refinements required upon the existing assessments were identified and recorded. The major recommendations of the workshop were,

1. A comprehensive State level GHG inventory may be carried out by addressing the limitations of the present assessments incorporating possible methodological refinements and updated data for the sectors – Energy &; Transport, IPPU, AFOLU and Waste.
2. Support from the sectoral line departments/ agencies is required to address the data gaps enabling assessments in the higher tiers.
3. Steps to be taken to generate state-specific activity data and emission factors in relevant sectors.
4. A common framework shall be formulated to bring standardization in future regional/local/ LSG level GHG assessments in the State.

The Environment department has initiated the GHG emission assessment following the recommendations of the expert groups in the consultative workshop to arrive at more precise estimates.

5.3. Assessment of Existing Mitigation Strategies

This section lists the major mitigation strategies undertaken in Kerala's energy sector post-submission of the SAPCC 1.0 and estimates the achievements of these strategies in terms of GHG mitigated during 2015–2019[2]. Further, Nationally Determined Contributions (NDCs) and Sustainable Development Goals (SDGs) linked to each policy are also mapped (**Table 5.1**).

NDCs are climate actions that each country had communicated to the United Nations Framework Convention on Climate Change (UNFCCC); NDCs are aligned to achieve the long-term goals of the Paris Agreement—i.e., limiting global average temperature well below 2^0C compared to the pre-industrial period. India also announced the following NDC targets: i) increasing the fossil-free electric power installed-capacity share to 40%, ii) reducing the emissions intensity of GDP by 33%–35% (from 2005 levels), and iii) adding 2.5 to 3 billion tonnes of carbon sink by the year 2030[3]. Against this backdrop and commitments, the State climate change action plans are being revised and fortified to align them with the NDCs. In addition, India is also committed to achieving the SDGs to address a range of social needs—end poverty, improve health and education, and reduce equality—while tackling climate change.

In subsections 5.3.1 to 5.3.5, sector-wise activities, policies, and programmes implemented during 2015–2019 for emission mitigation are discussed.

5.3.1. Power

Kerala is the first State in the country to attain 100 per cent household electrification. Kerala stands at the 20th position in terms of installed capacity in the country, with 3,102 MW (including off-grid and excluding captive power capacity) as of March 2021 (CEA, 2021). The installed capacity mainly consists of large hydroelectric projects, accounting for around 60% (2,058.76 MW) of the total installed capacity. Kerala also has 694 MW of fossil-based power plants operating with diesel, naphtha, and natural gas as fuel (MoP, 2021b) (**Figure 5.2**) which generate fewer concentrations of GHGs. However, the State imports ~70-80% of its electricity from other States (KSEBL, 2021). The actual electricity generation and consumption in the State were 7,638 GWh and 25,146 GWh, respectively, in 2020–21.

In terms of renewable energy (RE) installed capacity, Kerala stands at the 15th position as of March 2021, accounting for 18% of the total installed capacity (CEA, 2021). The highest capacity addition has been in solar-based power, with a cumulative installed capacity of 257 MW as of March 2021 (MNRE, 2021a). Other RE sources include 230 MW of small hydro, 2.3 MW of biomass, 13 MW of solar RTPV, and 62.5 MW of wind-based power plants (MNRE, 2021b, 2021c, 2021d)). Some of the unique achievements of the State in the recent past are the addition of around 1 MW of floating solar power in reservoirs and artificial lakes, the commissioning of a fully solar-based airport at Cochin which is the first of its kind in the world and '24 x 7 power for all' status in all areas, including agriculture consumers (CEA, 2012; CIAL, 2021; Kerala State Planning Board, 2021a; NTPC, 2017).

Under the Ministry of New and Renewable Energy (MNRE), the target set forth for 2022 in Kerala is

1 *Other sectors include fisheries and agriculture.*

2 *Time period for emission mitigation evaluation is from 2015, post the submission of SAPCC 1.0 in 2014*

3 *This study does not consider India's enhanced NDC targets, announced in November 2021.*

Table 5.1: **Policies in Kerala between 2015 and 2019**

Sector	Sub-Sector	Major Policies/Programmes and Schemes	NDC Linkages	SDG Linkages
Power	RE-based electricity generation	Kerala Solar Energy Policy 2013 Development of Wind Farms in Private Land in Kerala Subsidy schemes for RTPV and government producers Urja Kerala Mission Kerala Power Policy 2019 KERC (Renewable Energy and Net Metering) Regulations, 2020 Renewable Purchase Obligations (RPO) National Solar Mission	NDC 1 NDC 2 NDC 3 NDC 4 NDC 8	SDG 7 SDG 11 SDG 12 SDG 13
	Transmission and distribution	UDAY R-APDRP IPDS PAT Scheme DDUGJY TransGrid 2.0 Urja Kerala Mission National Mission for Enhanced Energy Efficiency National Tariff Policy	NDC 3	SDG 7 SDG 12 SDG 13
	Plant efficiency of thermal power plants	PAT Scheme Renovation and modernization activities Kerala Industrial and Commercial Policy 2018 National Mission for Enhanced Energy Efficiency	NDC 2 NDC 3	SDG 7 SDG 12 SDG 13
Transport	Public transport improvement	City mobility plan Kochi Integrated transport system - Kochi Metro Rail	NDC 2 NDC 3 NDC 5	SDG 9 SDG 11 SDG 13
	Electric/Clean Mobility	Kerala Electric Vehicle Policy Non-Motorized Transport (NMT) FAME	NDC 2 NDC 3 NDC 5	SDG 7 SDG 11 SDG 12 SDG 13
	Infrastructure Development	Urban Infrastructure Development Scheme for Small and Medium Towns Kerala Sustainable Urban Development Project Atal Mission for Urban Transformation	NDC 2 NDC 3 NDC 5	SDG 9 SDG 11 SDG 13
Industries	Energy Efficiency	Kerala Industrial and Commercial Policy 2018 PAT Scheme	NDC 2 NDC 3	SDG 7 SDG 9 SDG 13
Buildings	Energy Efficiency	Pradhan Mantri Ujjwala Yojana UJALA Scheme Energy Conservation Building Code (ECBC)	NDC 1 NDC 8	SDG 7 SDG 12 SDG 13
Agriculture	Energy Efficiency	Demand-side management	NDC 2 NDC 3	SDG 7 SDG 12 SDG 13
	Renewable-based irrigation	Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Yojana (PM-KUSUM)		

1,870 MW of solar and 100 MW of small hydro (NITI Aayog, 2015). In its efforts to decarbonize the sector, the State has introduced policies and programmes to promote RE-based electricity generation.

During 2015–2019, the major policies, guidelines, and programmes to promote RE-based electricity generation in the State included Kerala Solar Energy Policy 2013, Development of Wind Farms in Private Land in Kerala, Kerala Power Policy 2019, National Solar Mission, and central subsidy schemes for solar ground-mounted and rooftop photovoltaics (RTPV). The State had also introduced some single-window services and online portals, such as KSEBL Ekiran—a solar RTPV portal. The service centres for RE devices, Urja Mithra, and state-specific business models for RTPV adoption by domestic consumers are some of the unique measures adopted in Kerala (ANERT, 2004, 2013, 2021; KSEBL 2020a; MNRE, 2015b, 2019a).

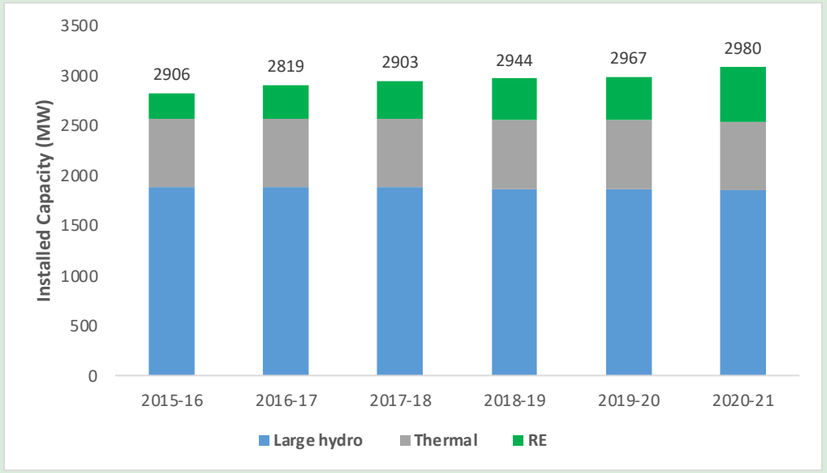


Figure 5.2: **Source-wise grid-connected installed capacity**
Source: (CEA, 2007, 2012, 2017a, 2020, 2021; MNRE, 2019b)

The Kerala Government had also launched a programme called 'Urja Kerala Mission', aimed at the integrated development of the electricity sector by 2021 (ANERT, 2018). The projects announced under this programme include:

- Soura – installation of 1000 MW of solar (500 MW of RTPV) by 2021
- Dyuthi 2021 – modernization of the distribution grid to reduce power interruptions.
  Kerala State Electricity Board Ltd (KSEBL), the major DISCOM in the State, had issued approvals for allocating INR 4,036 Crore between 2018–19 and 2021–22 (KSEBL, 2022).
- TransGrid 2.0[4] - reduction of Transmission and Distribution (T&D) losses and constraints in the transmission network
  It is proposed to arrange finance mainly from Kerala Infrastructure Investment Fund Board (KIIFB), Power System Development Fund (PSDF) under the Central Electricity Authority (CEA), and the Green Energy Corridor (GEC) under MNRE (KSEBL, 2020a).
- Filament-free Kerala – supply of good-quality LED lamps to replace filament bulbs in houses and street lights
- eSafe – massive publicity programme to sensitize electricity users on safety aspects.

In 2019, the MNRE approved the Central Public Sector Undertaking (CPSU) Scheme Phase-II—a viability gap funding scheme to set up 12,000 MW of cumulative grid-connected solar projects in 4 years from 2019–20 to 2022–23 for India. The scheme mandates the use of solar photovoltaic (SPV) cells and modules manufactured domestically, thereby giving a thrust to the 'Make in India' programme (PIB, 2019).

All these policies and programmes were designed to attract RE investments to the State by reserving land for RE projects, removing transmission and wheeling charges, reducing procedural delays (online portals), developing the grid infrastructure for power evacuation, carrying out resource potential assessments, providing subsidies, facilitating central finance schemes from MNRE, etc. In addition, to increase the share of RE-based generation in the electricity mix, the Ministry of Power (MoP) mandated Renewable Power Obligations (RPO) and Renewable Energy Certificates (REC) (KSERC, 2015, 2020).

Despite these policies and programmes, the installation of RE-based sources was sluggish and the State could achieve only 14% of the MNRE targets for solar as on March 2021 (MNRE, 2021a). The reasons for lower installations of solar-based power in the State are land procurement issues, low technology maturity levels, the inadequacy of institutional arrangements, non-compatibility of T&D infrastructure, etc (Kerala Power Policy 2019, 2018).

Regarding the T&D infrastructure, T&D losses and Aggregated Technical and Commercial (AT&C) losses in the State are one of the least in the country. Kerala stands at the 3rd position in Ujjwal DISCOM Assurance Yojana (UDAY) scheme achievements as on September 2021 (MoP, 2021a). The State aimed at reducing its AT&C losses from 11.91% in 2015–16 to 11% in 2018–19 as per the UDAY scheme and has managed to bring them down to 10.66% as of September 2021 (MoP et al., 2017; Ujwal DISCOM Assurance Yojana, 2021). Key activities carried out under this scheme include LED supply, feeder metering, rural feeder audits, and rural/urban distribution transformer (DT) metering. The UDAY dashboard indicates that the feeder segregation and smart metering progress are low in the State and need to be paced up. The KSEBL was also one of the designated consumers in the Bureau of Energy Efficiency's (BEE) flagship programme under the National Mission for Enhanced Energy Efficiency (NMEEE) – Perform, Achieve, and Trade-2 (PAT-2) cycle. The T & D loss in the financial year 2008-09 was 18.83% which has been reduced to 10.32 % by the end of FY 2020-21. The Losses are the lowest among the utilities in the country (KSEBL, 2022).

In addition to UDAY and PAT schemes, Kerala had been part of central financial assistance schemes such as Restructured Accelerated Power Development and Reforms Programme (R-APDRP) and the newer scheme of R-APDRP – Integrated Power Development Scheme (IPDS) to reduce AT&C and T&D losses (Kerala State Planning Board, 2021a). Under the IPDS scheme, the State has undertaken activities to strengthen sub-transmission and distribution networks, metering of distribution transformers, feeders, and consumers in urban areas, and information technology implementation in the sector. The State had received INR 121.58 Crore under this scheme as of March 2020 (KSEBL, 2022). Extensive work has been done under the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) scheme for improving the T&D infrastructure in the State (Government of India, 2022). In addition, TransGrid 2.0 had also aided in improving T&D infrastructure in the State (KSEBL, 2014). Apart from KSEBL, Kerala has two DISCOMs—Kannan Devan Hills Plantations Company Private Limited and Thrissur Corporation. Though these DISCOMs are not part of PAT schemes or energy efficiency targets, these DISCOMs need to follow the energy efficiency guidelines set forth by BEE.[5]

The State had also undertaken activities to improve the energy efficiency of thermal power plants (TPPs). All the existing TPPs with a capacity of 671 MW were under the PAT-1 scheme (2012–15), and three plants of capacity 611 MW were part of PAT-2 (2015–2019) (BEE, 2012, 2016). In the PAT-1 cycle, only the NTPC Kayamkulam plant was able to meet the targeted energy consumption reduction. For the remaining thermal plants, the Energy Savings Certificates (ESCerts [6]) of 2317 were approved by BEE in the power sector for the PAT-1 cycle to compensate for the non-compliance[7]. In the PAT-2 cycle, the assessment is complete for the targeted period. However, ESCerts have not yet been approved by BEE.

With all these policies and programmes in the power sector, Kerala has been able to make progress in improving its scores in the Sustainable Development Goals (SDGs). As per the SDG India Index 2020–21 of NITI Aayog, Kerala scored 100 (out of 100) in SDG 7 – Affordable and Clean Energy. However, the State still has a great deal to do in achieving the SDG 13 goal on Climate Action, in which it scored only 69 for the 2020–21 period (NITI Aayog, 2021).

5.3.2. Transport

Kerala has all major modes of transport, such as road, rail, water, and air. Roadways dominate Kerala's transport sector. The State has 2,38,773.02 km of road network with 548 km/100 km^2 density, which is roughly three times the national average. The length of road per lakh population is 993.54 km and almost 90 per cent of the road network is single-lane (Kerala State Planning Board, 2021b). Kerala occupies a significant position on the Indian Railways map with 1045 route km and 1745 km of running track and 2087 km of total track length. Palakkad and Thiruvananthapuram divisions under Southern Railways in the State are operating the rails. Inland waterways are also significant in Kerala with a total length of 1895 km (Kerala State Planning Board, 2021b). This is the most efficient, economic, and environment-friendly mode of transport.

Kerala had a good and efficient bus network, but in the last few years, private vehicles are being preferred. To bring back commuters to public transport, and to shift to environment friendly transport options, the Kerala Government has drafted a few plans, policies, and projects. With its Integrated Transport System, the government aims to implement a seamless commuting network in cities across the State. This started with Kochi Metro as a pilot project (Urban Transport Initiatives of Government of Kerala, Kochi as a Pilot City, 2018). The Kochi Metro Rail Limited (KMRL) also prepared a city mobility plan. This plan aimed at integrating all modes of transport,

4 *Transgrid 2.0 is a State-led programme for a long-term transmission plan (2016–2032) with a mission to enhance system reliability, and security, and reduce system losses with minimum disturbance to the environment. This project aims at strengthening of transmission network to meet the future energy requirement of the State.*

5 *EMC - Tier II Consultations*

6 *Purchase of ESCerts is mandatory for not meeting targets set in PAT cycles.*

7 *Data from Energy Management Centre.*

including non-motorized transport, light rail, metro, bus, water metro and intermediate public transport (autos and cabs/taxis). It also plans for public bike sharing, route rationalization for buses, and intelligent transport systems for increasing the efficiency of the transport network and providing last-mile connectivity. Presently, KMRL is operating on a stretch of 27.4 km with 24 stations between Aluva and SN Junction, and a further extension to Thirppunithura is in the progress, upon completion of which the total length would become 28.12. With the daily maximum ridership crossing 100000, the government has plans to extend the service. The metro is one of the most environmentally friendly and economical modes of transport and providing feeder service to this network will ensure an efficient and sustainable transport system. KMRL has installed a solar PV capacity of 3.54 MW. The total reduction in emissions due to Kochi Metro operation for the year 2018 was estimated to be 31.72 ktCO_2e[8]. The daily ridership of Kochi Metro is forecasted to reach 229177 by 2030 (KMRL, 2018).

By 2017 Under Kerala Sustainable Urban Development Project (KSUDP), INR 142 Crore was spent on developing urban transport infrastructure. Atal Mission for Rejuvenation and Urban Transformation (AMRUT) was launched in Kerala in 2015, and many infrastructure development projects, such as non-motorized transport, public transport, and parking facilities, were undertaken (Kerala State Planning Board, 2021b).

Like many states in India, Kerala has also taken initiatives to boost electric mobility. The State has announced its Electric Vehicle (EV) Policy in 2019 and aimed to introduce one million EVs by 2022. The strategic initiatives planned in this regard are –(1) Addressing the viability Gap, (2) Creating adequate charging infrastructure, (3) Promotion of local manufacturing, (4) Awareness creation and promotion, (5) Human capacity building and re-skilling. However, the target was missed given that there are only 43989 EVs on road in October 2022[9]. KSEB supports electric mobility by creating adequate charging infrastructure in the State. ANERT has prepared guidelines and support for charging infrastructure and plans to set up solar-powered charging stations.

Apart from these plans and projects at the State level, Kerala also benefits from national-level policies, such as FAME for EV purchase and manufacturing subsidy (Scheme for Faster Adoption and Manufacturing of Electric Vehicles in India Phase II (FAME India Phase II), 2019) and Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSM) for transport infrastructure development. The Kerala State Road Transport Corporation (KSRTC) has already initiated to run e-buses as city circular services.

The Kerala State Water Transport Department transports about 150 lakh passengers per annum[10]. Water transport is thus a significant mode of transport in Kerala. Kerala has also launched a successful solar-powered passenger ferry operated between Vaikom and Thavanakadavu. This is the first commercially viable solar-powered passenger ferry in India.

With these plans, policies, and projects to improvise the transportation sector, Kerala State is a front-runner in SDG 11 on Sustainable Cities and Communities, with 79 points (NITI Aayog, 2021).

5.3.3. Industry

The industry sector in Kerala contributed 28% to the state's Gross State Domestic Product in 2019-20 (Kerala State Planning Board, 2021b). Petroleum refinery, cement, chemicals, ammonia, and fertilizer industries are some of the largest and most energy- and emissions-intensive industries in the State. These industries together contribute to about 75% of the emissions from all industries in Kerala (GHGPI, 2018). The world-famous Chavara shoreline rare earth deposits support three major mineral industries in Kerala, viz., The Indian Rare Earths Limited, Kerala Minerals and Metals Limited, and The Travancore Titanium Products.

The energy efficiency and emission mitigation measures in the State are mainly guided by national-level policies (like in the transport sector). The Kerala Industrial and Commercial Policy 2018 falls short of mentioning any measures to improve energy efficiency or emissions intensity of industries at the State level. The major energy-intensive industries in Kerala, such as the Fertilizers and Chemicals Travancore Limited (FACT Ltd), Travancore Cochin Chemicals Limited (TCC Ltd), Malabar Cements, Hindustan Newsprint Limited, Bharat Petroleum Corporation Limited – Kochi Refinery, etc., were part of PAT cycles (BEE, 2012, 2016). The industry sector could not meet the PAT-1 cycle target, and minus (-) 3151 ESCerts [11](net) were issued. The major barrier to implementing energy efficiency measures in industries is the lack of finance. Financial institutions are neither providing soft loan schemes nor special loans. The lack of Energy Service Companies (ESCO)[12] in the State also affected the implementation of EE schemes/ programmes[13]. One of the major decarbonization options for the industrial sector is electrification (i.e., shifting from fossil-based sources to electricity). However, the lack of reliable grid electricity is one of the major deterrents to shifting to electricity.

FACT Ltd, a public sector company located at Udyogamandal and Cochin, is one of the largest fertilizer manufacturers in the country. The major products of FACT Ltd. are fertilizers, ammonium sulphate, caprolactam, and anhydrous ammonia. The fuels used for production are Regasified Liquid Natural Gas (RLNG), furnace oil, and electricity. RLNG is used as the major raw material as well as fuel to produce ammonia[14] FACT Ltd was part of PAT-1 and PAT-2 cycles and had achieved PAT-1 targets[15].

BPCL Kochi refinery is one of the frontline refineries in the country, with a crude oil refining capacity of 15.5 million metric tonnes per annum (MMTPA). It has a diverse product portfolio, which as of now includes petrochemical feedstock and speciality products such as benzene and toluene, in addition to fuels (LPG, naphtha, motor spirit, etc.). It has achieved its PAT target in cycle II and has been successfully reducing its specific energy consumption over the years by consistently investing in energy conservation equipment and technology (BPCL, 2019).

The State-owned TCC Ltd. – a chlor-alkali company is engaged in the manufacturing of caustic soda lye (32%, 48% solutions), caustic soda flakes, chlorine, hydrochloric acid, and sodium hypochlorite. The company was part of PAT-1 and PAT-2 cycles and had achieved the PAT-1 target. The plant received the 'National Energy Conservation Award in the Chlor-Alkali sector' in 2005 (The TCC, Ltd, 2019). Very recently, the plant commissioned a waste heat recovery unit, which can generate 40 tonnes of steam/day and saves nearly INR 3 Crore annually. This is also helping TCC Ltd. to reduce its furnace oil consumption. The company has also been identified as one of the cheapest suppliers of hydrogen in the State for transport.

Malabar Cements Ltd., a State public sector enterprise, is the largest cement manufacturing plant in Kerala with an annual capacity of 0.82 million tonnes. The company was part of PAT-1 and PAT-2 cycles and had secured the first State award for energy conservation. The plant has plans for capacity expansion to reach an annual production of 1 million MT. The long-term plans for the plant include diversification projects such as setting up a wind power plant and a micro hydel power plant for captive power (EMC, 2017).

8 *Estimations as per the final EIA Report for Kochi Metro*

9 *As per VAHAN Dashboard -https://vahan.parivahan.gov.in/vahan4dashboard/*

10 *https://www.swtd.kerala.gov.in/pages-en-IN/aboutdept.php*

11 *The Energy Saving Certificates (ESCerts) are created under the Perform Achieve Trade (PAT) scheme of the Ministry of Power. ESCerts are market-based instruments designed for designated consumers (DCs) of energy intensive industries and sectors, who are assigned targets in every compliance period to `bring down their specific energy consumption.*

12 *ESCOs are companies that conduct energy audits of existing facilities, retrofit and implement energy efficient projects by identifying energy saving opportunities*

13 *Information from Energy Management Centre.*

14 *Information from FACT Ltd.*

15 *Purchase of ESCerts is mandatory for not meeting targets set in PAT cycles*

The company also has proposals for fuel switch to pet coke from coal and overall improvement of energy efficiency of the manufacturing plants.

The Micro, Small, and Medium Enterprises (MSME) sector in Kerala accounts for 5.21% (23.79 lakhs) of India's MSME sector, employing 44.64 lakh individuals as of March 2016 (MSME, 2021a). The MSME sector has consistently been registering higher growth rates compared to other sub-sectors in the industrial sector (Envis Centre, 2022). The major MSME sectors in Kerala are the coir, handloom, handicrafts, and seafood industries (SLBC, 2018). The energy efficiency improvement activities in MSME sectors in Kerala are notable compared to other States. However, the data on baseline energy consumption is not documented for many MSME units and does not have any specific targets for energy savings (AEEE & BEE, 2019). The EMC is currently providing support (including finance) for energy audits, energy efficiency capacity-building programmes, and awareness programmes in the MSME sector to some extent (EMC, 2021; MSME, 2021b).

5.3.4. Buildings

The Construction industry is the second largest employment sector in Kerala, after agriculture (Department of Economics and Statistics, 2019). Around 4 lakh new buildings were constructed in Kerala in the year 2016–17, of which 77.5% were residential. Of these, 77% were constructed in rural areas and 23% in urban areas. A similar trend was seen in commercial buildings as well. 72.5% of commercial buildings were constructed in rural Kerala and only 27.5% were in urban areas.

Kerala's building sector is the largest electricity consumer in the State, about 70% (Kerala Power Policy, 2019), and therefore, a significant contributor to emissions, right from the material and construction to the operation and occupation phase. Most urban buildings in Kerala are now concrete roof buildings that retain heat, thus increasing the demand for artificial cooling. Understanding this issue, the Kerala government has issued the Kerala Energy Conservation (Building Code) Rules 2017 for building construction. The code applies to new buildings which have a connected load of 100 kW or greater, a contract demand of 120 kVA or greater, or having conditioned area of 500 m^2 or greater, and is intended to be used for commercial purposes such as commercial complexes, shopping malls, hotels, hospitals, motion picture theatres, office buildings, banks, educational buildings, cyber parks etc., and others that are not primarily used for the manufacturing process, except building for residential purpose.

The Energy Management Centre (EMC) in Kerala provide support to building sector stakeholders for constructing ECBC-compliant buildings and has also undertaken various awareness programmes. So far, the EMC has supported the design of 16 such buildings. Commercial buildings in Kerala consume 18% of the total electricity—an increase from 2000 MU in 2007–08 to 2700 MU in 2010–11. There is a potential of 15–25% savings from commercial buildings with ECBC (EMC, 2009). The Pradhan Mantri Ujjwala Yojana (PMUY)[16], beneficiaries reached 2.56 lakh in 2019 and the number has remained the same till 2021 (PPAC, 2021).

Given the increasing number of buildings, the need for electrical appliances is also increasing. The Ministry of Power, with implementation support from Energy Efficiency Service Limited, launched the Unnat Jyoti by Affordable LEDs for All (UJALA) scheme in 2016. The scheme aims at providing LED bulbs to reduce power consumption per household. Kerala has distributed 1.54 Crore LED bulbs, 19,650 tube lights and 9,100 energy efficient fans across the State[17].

5.3.5. Agriculture

Agriculture pumping accounts for 3.73% of electricity consumers, and 1.43% of the state's total electricity consumption. Kerala is perceived as a water-surplus State and the rainfall received in the Kharif season is sufficient to meet the irrigation water requirements (Lathika, 2010). The annual electricity consumption of the irrigation pump sets in the State is therefore much lower than the national average. The EMC-Kerala had recommended the Department of Agriculture to make amendments to its regulations to statute all new pumps to be BEE star-rated. The replacement of inefficient pumps in use by BEE star-rated pumps was also in the recommendations (EMC, 2018). Kerala has undertaken Demand Side Management (DSM) programmes in the agriculture sector, which include the use of energy-efficient pumps, solarisation of off-grid and grid-connected agricultural pumps, agriculture feeder separation, and awareness campaigns on Energy Efficient agricultural practices among farmers. Kerala also has a dedicated DSM cell despite not having DSM regulations (BEE, 2021).

The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) Scheme launched in 2019 is expected to increase the solarisation of the state's agriculture. The scheme has three nationwide components: Component A is for setting up 10,000 MW of decentralized ground-mounted grid-connected renewable power plants on barren land. Component B is for the installation of 17.5 lakh standalone solar-powered agriculture pumps, and Component C is for the solarisation of 10 lakh grid-connected agriculture pumps[18].The specific targets and budget for the KUSUM scheme for the State of Kerala are yet to be announced. Thus far in the State under component A, 40 MW have been sanctioned of which installation is pending. Under Component B, total of 100 solar pumps have been sanctioned and installations are pending. Under Component C, 45100 individual solar pumps and 3200 feeder level pumps have been sanctioned of which the installation status is 30 and 0 respectively[19].

5.4. GHG Implications of Existing Policies and Programmes

GHG implications of some of the major policies and programmes currently operating in the State were estimated in terms of emissions mitigated concerning the base scenario. The start year for this analysis is 2015. The broad definitions for the 'base' and the 'actual' or 'policy' scenarios are provided below.

- Base scenario: In this scenario, existing inefficient and carbon-intensive technologies continue to dominate the energy sector. The historic trend before the implementation of decarbonization measures in 2015 continued.
- Actual/Policy scenario: This scenario is termed the 'actual' scenario while conducting emissions mitigation analysis for the period 2015–2019. For this analysis, data on the actual achievement of policies/programmes, collated through literature review and line departments are utilized. In the case of projections, from 2023 to 2030, this scenario is termed a 'policy scenario', wherein the State targets and aggressive decarbonization measures (more ambitious than the current programmes) were considered.

There were some data gaps while carrying out the assessment. Wherever possible, suitable proxies from national-level reports and interpolations/ extrapolations, based on the available data have been used. Details of these assumptions made in each sector are provided in **Annexure 5.1**. **Figure 5.3** depicts the two scenarios considered for estimating emissions savings with decarbonization measures to the base case. **Table 5.2** presents the GHG implications of the current policies and programmes in the power, transport, industry, buildings, and agriculture sectors.

5.4.1. Power

The three major activities undertaken in Kerala to decarbonize the power sector are increasing RE-based electricity generation, reducing T&D losses, and improving the plant efficiency of thermal power plants. The emissions mitigated with these activities and programmes are estimated for the

16 *launched in May 2016 to provide clean cooking fuel to deprived women in rural areas and those below the poverty line*
17 *Refer http://ujala.gov.in/*
18 *Refer https://www.india.gov.in/spotlight/pm-kusum-pradhan-mantri-kisan-urja-suraksha-evam-utthaan-mahabhiyan-scheme*
19 *Refer https://www.pmkusum.mnre.gov.in/landing.html*

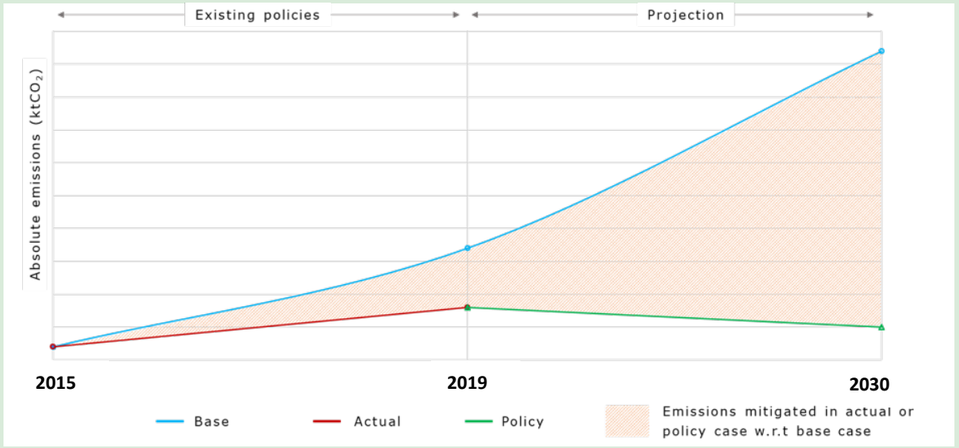


Figure 5.3: Scenario definition and approach graph

2015–2019 period. The data required for this analysis were collated from literature reviews and the Tier-consultations with line departments.

To estimate the emissions mitigation potential and achievement of the policies and programmes, a base scenario is defined; it represents the use of existing and high-carbon footprint technologies. The installed capacity of RE technologies was considered to grow at pre-2015 period rates.

For the lever-increased electricity generation from RE, marginal electricity generation from RE-based sources was considered for the base case. The RE-installed capacity addition trend between 2010 and 2014 (5 years) was considered and the same is considered to continue till 2019. The remaining demand is assumed to be met with power purchases from other states (base case). For the 'actual' scenario, actual source-wise generation is considered.

In the improved T&D infrastructure lever, T&D losses are evaluated as they attribute the increased emissions to the energy losses than AT&C loss[20] (CEA, 2015). The base scenario for improved T&D infrastructure considered a marginal reduction in T&D loss at a CAGR of 0.5% (lower than PAT scheme targets for DISCOMs) with nominal maintenance activities (BEE, 2016). The actual scenario considered the real T&D loss trajectories between 2015 and 2019 (Kerala State Planning Board, 2021b).

For the lever – energy efficiency improvement of thermal power plants, a marginal annual reduction in Net Heat Rate (NHR) of 0.1% is considered for the base scenario for diesel and natural gas plants. This assumption is based on various plant-level studies on nominal improvement and degradation of heat rate with regular annual maintenance. A nominal annual increase in NHR of 0.2% due to ageing and a nominal annual decrease in NHR (0.3%) with maintenance activities are observed (CEA, 2019b; CERC, 2013; Korellis, 2014). For the actual scenario, real plant-wise NHR data is used. Based on the data shared by the Energy Management Centre on ESCerts approved as part of PAT cycle 1, the NHR values were back calculated. The detailed methodology to estimate the actual heat

20 T&D losses are due to energy dissipated during transmission and distribution of power. These losses also include losses due to pilferage by hooking, bypassing meters, defective meters, errors in meter reading, and un-metered supply of energy. T&D loss excludes the billing efficiency, which is included in AT&C losses.

Table 5.2: GHG implications of current policies and programmes

Sector	Sub-Sector	Major Policies/ Programmes and Schemes	GHG Mitigation Potential wrt Base-Case	Achievement wrt Base Case	Barriers to Achieve the Potential
Power	RE-based electricity generation	MNRE 2022 RE target Solar installed capacity by 2019: 1,074 MW [21] Wind: 75 MW	978 $ktCO_2$	208 $ktCO_2$	Land availability and procurement issues, Inadequacy of grid infrastructure.
	T&D infrastructure	PAT-2 cycle[22] T&D loss target for 2018–19: 12.55%	792 $ktCO_2$	1,133 $ktCO_2$	The target was over-achieved. High investment requirements, Land constraints in densely populated areas for cable overhaul.
	Thermal power plants	PAT scheme	1 $ktCO_2$	0.29 $ktCO_2$	Lack of finance.
Transport	Public transport improvement	Kochi Metro	31.719 $ktCO_2$ (in 2018)		
	Electric mobility	Kerala electric vehicle policy Faster Adoption and Manufacturing of Electric vehicles (FAME)	1.71 $ktCO_2$	0.72 $ktCO_2$	The 2022 target of 1 million EVs is likely to be skipped Lack of interventions for EVs in intermediate public transport EV penetration likely to increase in near future in private vehicles
Industry	PAT Scheme	Energy-efficiency improvements in large energy-intensive industries		480 $ktCO_2$	Absence of state-level policy encouraging energy efficiency in Industries Lack of finance

21 Estimated from cumulative capacity target by 2022. The target is equally divided for the years between 2016 and 2022.
22 UDAY scheme was the major flagship programme to improve T&D infrastructure. Since the target was for AT&C loss %, this scheme was not directly mapped for mitigation potential versus achievement calculation.

Sector	Sub-Sector	Major Policies/ Programmes and Schemes	GHG Mitigation Potential wrt Base-Case	Achievement wrt Base Case	Barriers to Achieve the Potential
Buildings	Lighting - Residential	UJALA		1623.71 $ktCO_2$	Push from the centre helped replace conventional lights with LED
	Streetlight	SLNP		138 $ktCO_2$	-
	Efficient appliances			410 $ktCO_2$	No set target at the state level
	Building efficiency	ECBC	NIL	NIL	
Agriculture	Irrigation pump sets	Demand side management		33 $ktCO_2$	Lack of data and incentives for adopting EE pumps High capital expenditure for solar pumps – may not be financially attractive for farmers with access to free/ subsidized electricity

rate in the targeted year using EScerts and base year NHR is provided in **Annexure 5.1** (BEE, 2020).

In the power sector, the increased RE-based electricity generation mitigated 208 $ktCO_2$ (solar, wind, small hydro, biomass/cogeneration) of cumulative emissions to the base case during the 2015–19 period. Reduction in the T&D loss percentage and improvement in energy efficiency in thermal power plants decreased emissions by 1,113 $ktCO_2$ and 0.29 $ktCO_2$ of GHG emissions, respectively, to the base scenario during this period.

5.4.2. Transport

To reduce emissions from the transport sector, Kerala has put forth many projects and plans in the form of EV policy, NMT policy, Vehicle Scrappage Policy, Kochi metro rail project, etc. But the major push is seen in electric mobility. The total number of electric vehicles in Kerala has crossed 12,000 according to the VAHAN dashboard. But this is far less than the target of 1 million EVs by 2022. Data from comprehensive mobility plans, the VAHAN dashboard, and emission factors from the existing technical literature were used to estimate the current carbon savings due to EV policy over the base case scenario. The base case scenario assumes no EV increase after 2019. With the penetration of EVs, a cumulative emission reduction of 0.72 $ktCO_2$ to the base case was achieved from 2015 to 2019.

5.4.3. Industry

For mitigation assessment, the fertilizer (FACT Ltd) and refinery (BPCL, Cochin Refinery) sectors were considered. In the base scenario for improved energy efficiency lever, an annual autonomous energy-efficiency improvement of 0.09% (level 2 of India Energy security scenarios 2047) in the fertilizer industry was considered (IESS, 2015). This reduction is possible with voluntary efficiency improvements undertaken across the industrial sector. For the actual scenario, the fuel consumption data from FACT. Ltd was used for emissions calculation.

In the base scenario for the refinery, a nominal energy index was assumed to remain constant at 2015 levels. For the actual scenario, the fuel consumption and NRGF data provided by the BPCL Kochi refinery were used for emissions calculation.

The estimated emissions savings from the fertilizer and refinery industry are 34 $ktCO_2$ and 446 $ktCO_2$ between 2015 and 2019, respectively.

5.4.4. Buildings

For the buildings sector (residential and commercial), the key actions undertaken toward emission reduction are energy-efficient electrical lighting, fixtures and appliances, and Heating, Ventilation, and Air Conditioning (HVAC). Under the UJALA scheme for energy efficient lighting, Kerala distributed 19,650 LED tube lights with an estimated annual emission saving of 0.71 $ktCO_2$, 1.5 Crore LED bulbs with an estimated annual emission savings of 1623 $ktCO_2$, and 9,100 energy-efficient fans with an estimated annual emission saving of 251.85 $ktCO_2$[23].

5.4.5. Agriculture

The key decarbonization activities in the agriculture sector were efficiency improvement and solarisation of pumps through the PM-KUSUM scheme. For the efficiency lever, the overall motor efficiency of the pump sets starting at 58% is assumed to improve at 0.33% in the base case and 0.9% in the policy case for estimating the emissions mitigated. This would mean that by 2019, out of the total electric pumps, 6% are assumed to be EE pump sets in the base case and 18% in the policy case. The cumulative emissions mitigated with the efficiency lever between 2015 and 2019 is 33 $ktCO_2$ to the base case.

As of 2019, nearly 5,200 solar pumps were allotted in Kerala under the PM-KUSUM scheme. However, there were only a few installations during this period. Therefore, solarisation was not accounted for in evaluating the efficacy of schemes in the agriculture sector.

5.5. Proposed Mitigation Strategies and Activities/Actions

Based on the State's ongoing policies, programmes, their current status, and targets at the national level, mitigation activities for energy sectors such as power, transport, industry, buildings, and agriculture during 2023–30 are proposed and provided in this section. **Table 5.3** presents the sectoral mitigation actions proposed and details including the cumulative mitigation potential, the investment required, and NDC and SDG linkages.

5.5.1. Power

The Fourteenth Five Year Plan of Kerala envisages enhanced power generation through a shift to renewable energy sources and enhancement of energy efficiency following the national commitments under the Paris Agreement on climate change. The power sector in the State has a wide range of possibilities for undertaking mitigation activities, although the sector has accounted for only 2%–5% of the total energy sector emissions[24]. The emissions from the sector would likely increase at current levels of decarbonization, given the rising electricity demand. Based on electricity demand projections for key sectors and electricity demand of miscellaneous sectors from the Central Electricity Authority, the demand would increase by 50 per cent in Kerala by 2030 from 2015 levels (CEA, 2017b). The electricity supply sector in the State is also susceptible to various crises in major power-producing states (such as fuel unavailability, strikes, and natural calamities), thereby affecting its energy security. The power crisis and energy insecurity are likely to increase in the future if the State does not take action to increase its self-reliance for power generation. Therefore, building new power-generating sources in the State has become a necessity. The State also needs to make

23 Refer http://ujala.gov.in/

24 https://www.ghgplatform-india.org/economy-wide/

Table 5.3: Sectoral mitigation activities

Sector	Project/ programme	Scale or capacity addition (size)	Mitigation potential in 2023–2030 (ktCO2)	Total investment required (INR Crore)	NDC linkages	SDG linkages
Power	RE based electricity generation (includes RTPV)	3.46 GW by 2030	17993	21663	NDC 1 NDC 2 NDC 3 NDC 4 NDC 8	SDG 7 SDG 11 SDG 12 SDG 13
	Improve T&D infrastructure	Reduce T&D loss to 8.8% by 2030	9,434	600	NDC 3	SDG 7 SDG 12 SDG 13
	Improve the energy efficiency of thermal power plants	Heat rate within 5% – 7.5% of design heat rate	0.05[25]	529	NDC 2 NDC 3	SDG 7 SDG 12 SDG 13
Transport	Increased adoption of EV and installation of EV chargers	5 lakh EVs by 2030 51k charging stations	2185	23,535	NDC 2 NDC 3	SDG 7 SDG 11 SDG 13
Industry	Improve energy efficiency in the fertilizer industry	Improvement in specific energy consumption at CAGR = -0.29% (RLNG), = -0.82% (electricity), -1.01% (furnace oil)	61	131	NDC 1 NDC 2 NDC 7 NDC 8	SDG 9 SDG 12 SDG 13
	Improved energy efficiency and avoiding indirect emissions from grid electricity with in-house RE	Improvement in specific energy consumption at CAGR = -0.2%; and share of grid electricity in the energy assumed to be 0 in the 2023–30 period	5,500	180	NDC 2 NDC 3 NDC 8	SDG 7 SDG 12 SDG 13
Buildings	Increased adoption of efficient lighting (street lighting and residential)		16071	18	NDC 1 NDC 8	SDG 7 SDG 9 SDG 13
	Increased adoption of efficient appliances (Residential)		4776	785		
	Adoption of Energy Conservation Building Code		351	1828		
Agriculture	Demand-side management (through energy-efficient pumping)	38% of the total pump-sets	145	584	NDC 2 NDC 3	SDG 12 SDG 13
	Stand-alone pumps, solar pumps	9% of the total pump-sets	76	2385	NDC 2 NDC 3	SDG 7 SDG 12 SDG 13
TOTAL			56592	52,238		

25 *The estimate is based on slight improvement in PLF. Information of projected/anticipated PLF for future is not available and the mitigation potential strongly links to plant operations*

substantial investments in renewable energy to align with India's NDC commitments.

The activities are already in place to increase solar installed capacity to 1,000 MW (including 500 MW RTPV, and 100 MW floating solar power projects by 2022 (Kerala State Planning Board, 2021b). Given the pandemic period and floods in recent years, delays in the actual commissioning of these projects are anticipated, to come up by 2024. In addition, the State had planned for adding 100 MW of wind power, and the bidding process for the same is underway, likely to be commissioned in the next two years[26].

By 2030, cumulative solar projects would reach 3 GW (including 1.1 GW of RTPV[27]). The wind cumulative capacity would be 395 MW, anticipating that all the currently approved

26 *Data from KSEBL.*

27 *The solar potential estimated at present is 6,110 MW (utility-scale potential reported by MNRE). Share of RTPV is arrived at using 2022 solar ground mounted and RTPV targets by MNRE.*

projects would start operating by 2030. Capacity addition of small hydro and waste-to-energy plants of 19 MW and 46 MW, respectively, are also considered. These small hydro and waste-to-energy plants have already received approval from the State government and are at various stages of implementation (LSGD, 2018). The installed capacity of RE is projected to increase to 3.46 GW in 2030 under the policy scenario. The highest addition is planned for solar-based projects, accounting for 89% of the RE installed in 2030. Also, these RE installations would be of grid-based or decentralized types. Setting separate targets for grid-based and decentralized would be difficult at this stage of planning. In addition, the installation of storage systems for ensuring the stability of the grid is required with an increase in the share of RE in the electricity supply mix. The electricity storage via pumped hydro storage and batteries needs a detailed assessment of electricity demand and supply till 2030. Those types of analysis and power sector planning are out of the scope of the current Action Plan preparation. Analysis of pumped storage potential and their likely annual built rates, and battery storage requirements needs to be taken up as a high-priority task in the near-term goals. With increased RE-based electricity generation, GHG-emission mitigation of 17,993 $ktCO_2$ to the base case can be achieved cumulatively by 2023–30[28].

For the lever-improved T&D infrastructure, the PAT cycle-7 has a T&D loss target of 9.08% to be met by 2024–25. The activities planned in TransGrid 2.0 (-0.4% point annual reduction), which is anticipated between 2019–20 and 2024–25, should reach 9.7% by 2025 (KSEBL, 2022). Further, there are plans to reduce T&D loss to 8.8% by 2030 (-0.2% point annual reduction)[29]. Therefore, to meet PAT-7 and 2030 proposed targets, current schemes such as TransGrid 2.0, Dyuthi 2021, UDAY, and IPDS need to be continued till 2030. According to KSEBL, the major share of distribution loss is in the LT distribution network and needs targeted actions to be implemented. Smart metering progress is also low in the State, though it received in-principle approval from the Integrated Power Development Scheme (IPDS) monitoring committee through the INR 38.62 Crore grant in 2018 (Power Finance Corporation Ltd, 2018). Data on voltage-wise distribution losses are required to effectively draw up mitigation plans. This activity needs to be prioritized as a near-term goal.

For the estimation of mitigation potential with projected T&D loss reduction, the base case with T&D loss trajectory, (same as the existing policy analysis done in 5.2 is considered (CAGR =-0.5%). The T&D loss would reduce to 13.54% and 8.8% in base and policy scenarios, respectively, in 2030. This reduction in T&D loss in the policy scenario could avoid 9,434 $ktCO_2$ emissions to the base case between 2023 and 2030.

For the energy-efficiency improvement lever, the base scenario definition is kept the same as for the existing policy analysis. For the policy scenario, the gross heat rate of the power plants is reduced and the deviation of the heat rate from the design heat rate is limited to 7.5%. The energy-efficiency improvement[30] as per the policy scenario could reduce emissions by 0.05 $ktCO_2$ to the base case between 2023 and 2030. For the last few years, the thermal power plants in Kerala were operating at a very low Plant Load Factor, mainly due to high fuel costs. For emission-mitigation potential analysis, a slight improvement in power generation based on Compounded Annual Growth Rate (CAGR) estimated from historical generation data is considered. Also, the lack of current plant operating parameters from a few thermal plants impacted the emission mitigation potential.

An investment of around INR 22,792 Crore is required to decarbonize the power sector for the policy scenario between 2023 and 2030 (excluding the O&M cost). Of this amount, INR 21,663 Crore is required for installing RE projects between 2023 and 2030. Even though the capital cost of RE technologies is expected to decrease in the future, the cost decline and the O&M cost during the operational years were not considered in this analysis[31]. To account for the costs of the project development process that includes investment-grade RE resource assessments, access to land (either acquisition or leasing), supporting infrastructure development (roads, water, transmission interconnections, etc.), transmission system strengthening, and so on, 20% of the capital cost is added to the RE investment estimates[32] (NITI Aayog, 2015). Also, because consumers or developers will be making the necessary investment in most cases, the State should focus on attracting investments by making regulatory changes.

The investment required to reduce T&D loss will depend on activities undertaken for the same. Based on the secondary literature review, a ballpark investment of around INR 300 Crore is needed to reduce the T&D loss by 1% per DISCOM. In the policy scenario, meeting 8.8% T&D loss requires a reduction from 2020–21 levels by 2%, and INR 600 Crore is required for the same (estimated from INR 300 crores per 1% of T&D loss improvement per DISCOM). This investment excludes grid expansion activities and is not based on a detailed analysis of Kerala's current T&D infrastructure. Therefore, a detailed state-specific investment estimation is needed. Already, INR 6,375 Crore have been estimated for TransGrid 2.0 projects till 2024 (focussed on expansion and multi-circuit linking), and additional finance needs to be allocated from the post-2024 period. To improve the energy efficiency of TPPs, (529 MW) need to undergo Renovation and Modernisation (R&M) activities at INR 1 Crore/MW (cost for R&M activity as per CERC).

In addition to the above mentioned programmes, some activities in the power sector, such as RTPV potential assessment in all cities and government and public buildings in towns and identifying government-owned land parcels suitable for RE projects, can be further disbursed for RE installations by public/private ownership is also proposed.

5.5.2. Transport

The Fourteenth Five Year Plan envisages the development of a multimodal transport system for enhancing the share of public transportation for passengers and freight movement. More energy-efficient railways (urban and long distance) and inland waterways are the two major modes proposed. Kerala also plans for E-BRT, which will link electric mobility to mass rapid transit, resulting in enhanced emission reductions. Kerala has identified two BRT corridors in Thiruvananthapuram and Kochi for the E-BRT pilot project. Other such initiatives include water metro and light rail.

The Kochi water metro project intends to provide boat feeder services to Kochi Metro. The project comprises 15 water routes that will connect 38 jetties across 10 island communities through two boatyards. The services will be planned for headways varying between 10 and 20 minutes. The project plans for 78 eco-friendly boats that will run on electricity and will have zero outward discharge. There will be 23 such boats with a passenger capacity of 100 and 55 boats with a passenger capacity of 50. The Kochi water metro is estimated to save 10.23 $ktCo_2$ by 2025[33].

Based on our analysis of VAHAN data and vehicle growth trends, Kerala is estimated to have ~2 Crore two-wheelers, 6 lakh rickshaws, ~1 Crore cars, and 1.5 lakh buses by 2030. Cars will be the major contributors to air pollution, followed by two-wheelers, and then, auto rickshaws and buses. Hence, the State needs to target EV

28 Large hydroelectric projects in the State could also mitigate GHG emissions. This was not accounted in this estimation.

29 High loss reduction target for the coming years is not practicable. Further, any significant reduction in T&D loss requires higher capital investments.

30 The electricity generation from thermal power plants is projected based on a CAGR estimated using historic generation.

31 The cost decline of RE technologies are subjected to market conditions, technology improvements, raw material cost, and changes at the global level along with policies. Incorporation of cost decline requires a cost curve modelling and is out of scope of this study. Similarly, O&M cost also varies with aforementioned factors.

32 Ballpark estimate based on various RE tariff guidelines.

33 Estimations as per the final EIA Report for Kochi Water Metro prepared by WAPCOS

implementation through effective EV policies for the private car and cab segment. Also, the Corporate Environment Responsibility (CER) and Corporate Social Responsibility (CSR) funds may be channelled to establish EV charging stations.

After the introduction of EVs, Kerala has managed to bring down road transport emissions by 7 $ktCO_2$ in 2021. By 2030, this is estimated to reach 752 $ktCO_2$ in the policy scenario over the base case scenario, and the cumulative reduction from 2023 to 2030 in the policy scenario is estimated to be 2,185 $ktCO_2$. Kerala has around 1.3 lakh buses and the current growth rate is as low as 1.5%; with this rate, Kerala is estimated to have 1.5 lakh buses by 2030, including private buses. Hence there is scope for the introduction of E-buses that can bring down emissions remarkably.

Considering the potential for transforming Kerala in EV component manufacturing, the Government of Kerala has engaged Kerala Development and Innovation Strategic Council (K-DISC) to spearhead the formulation and implementation of electric vehicle policy for the State and promote EV component manufacturing. The other stakeholders in the initiatives include Travancore Titanium Products Ltd., Vikram Sarabhai Space Centre, Centre for Development of Advanced Computing (CDAC), TrEST Research Park. The proposed EV development and manufacturing consortium shall focus on three areas of EV ecosystem as (i) energy storage, (ii) drive-terrain, and (iii) electronics. The total estimated cost is INR 66.28 Crore.

Given the current growth rate, it is estimated that 3 lakh e-two-wheelers, 1 lakh e-autos, and 75,000 e-cars will be plying on the roads in Kerala by 2030. It is assumed that the target of the State EV policy of 3000 e-buses by 2022 would be achieved by 2030. Under this scenario, a total of 744 $ktCO_2$ emission reduction is estimated. Assuming a 40% subsidy for all vehicle segments as per FAME 2, the investment required from authorities for EV intervention is INR 9,208 Crore.

The other major intervention for Kerala would be to increase the number of public transportations. The public transport system in the State relies mainly on buses with KSRTC and private fleet operators. Kerala has around 6,000 public buses with KSRTC alone. The Fourteenth Five Year Plan envisages improving the efficiency of public transportation by modernising the fleet with energy-efficient buses including e-buses. The share of public transport in Kochi is 50%, according to a Kochi Metro DPR report. Implementing the water metro project estimates increasing the shift to public transport by around 10% by 2035. With an increase in the number of buses, the Kochi mobility plan can aim at increasing the share of public transport including bus, metro, and feeder services to 70% by 2030. Kerala has plans to include more solar boats.

5.5.3. Industry

To mitigate emissions from the industries sector in Kerala, the ongoing PAT scheme is assumed to continue over the horizon period compared to the base scenario with energy-efficiency improvements of 0.09% (based on IESS[34] level 2 trajectory)[35] and 0.5%[36] in the fertilizer industry and refineries, respectively.

For the policy scenario, improvements prescribed under the notified PAT cycles are continued till 2030, as there are no prescribed state-level policies or energy-efficiency improvement targets. The efficiency improvements in the policy scenario are based on the improvement targets set by the PAT scheme and the historical energy efficiency improvements.

For the fertilizer industry, fuel-wise specific energy consumption (SEC) improvements in FACT which is the major fertilizer manufacturer in the State were considered. For the major fuel—Regasified Liquified Natural Gas (RLNG) — used for Ammonia production—an annual reduction of 0.29% is considered between 2023 and 2030. The fuels used for FACTAMFOS production, such as electricity and furnace oil consumption, are projected to decline at a rate of 0.82% and 1.01%, respectively, between 2023 and 2030.

BPCL Kochi has been included in the PAT scheme from Cycle II onwards. Refineries generally achieve energy efficiency by minimizing losses, reducing routine flaring, and improving crude composition (TERI, 2016). In the Policy scenario, a slightly more aggressive (compared with BAU) energy-efficiency improvement is to be considered, and no requirement for grid electricity (assuming an adequate supply of in-campus solar power). The implementation of sub-sector-wise SEC reduction targets would be feasible when implemented in a phased manner.

The energy efficiency improvement activities in the fertilizer industry and refineries will lead to an estimated emissions savings of about 5,561 $ktCO_2$ between 2023 and 2030, with an overall investment requirement of about INR 311 Crore by 2030. Due to a lack of data, the emission mitigation potential and related investments were not quantified for other major industries in Kerala. In addition, access to reliable grid electricity would play a major role in decarbonizing this sector, which was not quantified comprehensively in this analysis. Provision of reliable power to major industries by KSEBL and other DISCOMs is required. This would also improve DISCOM's financial health by expanding its consumer base in the industrial sector. Also, many large industries are not part of the PAT scheme. An energy efficiency target like the PAT scheme needs to be announced at the State level for these industries.

Along with the above mentioned mitigation actions for major industries, certain activities to improve energy efficiency in the MSME sectors are proposed. At present, data on energy consumption and conservation activities in MSME sectors are not collated in detail. The current baseline energy consumption and conservation activities are needed for proposing energy efficiency measures in sub-sectors of MSMEs. Energy audits of MSME units as a short-term goal would aid in monitoring these parameters and placing them on record. The installation of RE-based electricity generating sources to power MSME clusters in Kerala would play a major role in decarbonizing the sector as most of these processes can be easily electrified (Pal & Hall, 2021).

5.5.4. Buildings

In the buildings sector, the key levers considered for emission reduction are energy-efficient lighting, energy-efficient appliances, and the adoption of ECBC-compliant buildings. This analysis considers LED lights, energy-efficient fans, televisions, refrigerators, and air conditioners. For LED penetration, IESS level 1 and level 3 are considered, understanding the push from both the Centre and the State. Looking at Kerala's GDP growth rate, a high growth scenario was considered while estimating the number of appliances, and level 1 and level 2 of IESS were assumed for appliance efficiency for estimating emission savings.

The base case assumes a mix of LED, CFL, and incandescent lights. In 2015, the penetration of LED bulbs was only 38%. This is expected to increase to 53% by 2030 with the support of the UJALA scheme and the cumulative emission savings between 2023 and 2030 is estimated to reach 16071 $ktCO_2$.

For the television segment, the number of televisions per household increases from 0.56 in 2015 to 0.96 in 2030. With 10% high-efficiency televisions, the emission savings between 2023 and 2030 is estimated to be 476 $ktCO_2$. With energy-efficient fans, the savings are estimated to be 2105 $ktCO_2$, 986 $ktCO_2$ for refrigerators, and 1208 $ktCO_2$ for efficient air conditioning between 2023 and 2030.

In addition to this, the implementation of ECBC for 10% of commercial floor space can reduce 91 $ktCO_2$ of emissions in 2030 and cumulative emission savings from 2023 to 2030 is estimated to be 351 $ktCO_2$.

34 *The India Energy Security Scenarios, 2047 is a tool developed by and housed in the Energy division of NITI Aayog (IESS, 2047)*

35 *CAGR between 2017 and 2032 of specific energy consumption was taken.*

36 *This is based on the trajectory 2 assumed for Mangalore Petroleum and Chemicals limited in Karnataka State Energy Calculator (GoK & NITI Aayog, 2018). Both refineries are comparable in terms of specific energy consumption and energy index.*

5.5.5. Agriculture

The mitigation measures in the agriculture sector comprise three key levers: replacement of old pumps with EE pumps, installation of solar pumps, and dedicated solar-based agriculture feeders during 2023–30.

The number of electric pumps is assumed to grow at a CAGR of 0.05% between 2023 and 2030. This is based on the growth rate calculated with 2014–19 data (Ministry of Power, 2014–2019) and stakeholder consultation. Currently, Kerala has only 21% of its gross cropped area under irrigation. The vision of the State Agricultural Department is to develop irrigation resources to boost productivity. For the energy efficiency lever, the base case efficiency improvement trajectory was taken from the IESS 2047 Level 1 projection, wherein the overall efficiency of pumps improves from 58% in 2018 to 62% in 2030 (IESS, 2015). For the policy scenario, the overall efficiency of the pumps in the State increased from 58% in 2018 to 69% in 2030 (based on IESS Level 2 trajectory).

For the solarisation lever with stand-alone solar pumps, a target of 45,000 pumps by 2027 and 49,000 pumps by 2030 is considered. Even though 5,200 pumps were allotted as part of the PM KUSUM scheme, the actual installation is marginal and the installation of only 100 solar pumps is anticipated by 2023. However, the ANERT and Department of Agriculture had taken notable steps for deploying solar pumps in the State and will be able to achieve the target of 45,000 pumps by 2027[37].

In addition to individual solar pumps, the possibility of dedicated solar-based feeders to solarise pumps is also considered, this is in existence in Karnataka and Maharashtra where pilot-scale RE-based feeders for irrigation energy have been installed (PSU Connect, 2020; Rural Marketing Bureau, 2018). However, this was not quantified at this stage of planning. KSEBL and the Department of Agriculture together need to explore the viability of a dedicated solar feeder for Kerala.

37 *Based on the consultations with ANERT during Tier-III consultations.*

The installation of EE pumps in the policy scenario needs INR 584 Crore between 2023 and 2030. For the solarisation lever, INR 2,385 Crore is required in 2023-30. The total cumulative emission savings from the EE lever is estimated to be 145 $ktCO_2$, and from the solarisation lever, savings are around 76 $ktCO_2$ during 2023–30. The cost parameters used for this calculation are provided in **Annexure 5.1**. The key hurdles in decarbonizing the agriculture sector are the high capital cost of solar pumps, receding groundwater levels, infrastructure cost, and time involved in achieving feeder separation for agricultural purposes.

Activities that would have notable emission mitigation potential but were not quantified due to a lack of adequate data have also been examined (**Table 5.4**). Before implementing these activities, a detailed assessment of their relevant details such as monitoring the current energy consumption, evaluating the current GHG emissions, and estimating the mitigation potential and investments is required.

5.6. Summary

The GHG emission from Kerala is one of the lowest among Indian states. However, the State has a huge potential to reduce anticipated GHG emissions. This would also reduce emissions from other States as it is importing a large share of energy resources from other States. This would, in effect, contribute to meeting national climate change commitments. The State had met most of its decarbonization targets in the energy sector over the years. However, the progress on the installation of RE-based power-generating sources, and smart metering was very low. The agriculture sector, despite its small share in energy consumption, shows a potential emissions reduction of 221 $ktCO_2e$ cumulatively in the 2023-30 period. In the transport sector, the State needs comprehensive mobility plans for growing cities and must aim to build seamless multimodal integration. From the electric mobility perspective, the growth of electric two-wheelers is remarkable, but interventions in public and intermediate public transport are needed. There are other activities, which are not included in

Table 5.4: Other mitigation actions

Sector	Project/ Programme	Short-term goal (2–4 years)	Long-term goal (5–8 years)	Co-benefits/Remarks
Power	RE and RTPV potential assessment	Resource potential assessment in all cities and government and public buildings. Identify land parcels suitable for solar and wind-based RE installation (government-owned land)	Improve infrastructure in identified land parcels	Shifting to RTPV and emerging RE technologies would reduce land availability constraints for RE installations
	Promote emerging RE technologies	Installation of pilot projects	Installation of pilot projects	
	Installation of batteries and pumped hydro storage	Analysis of storage requirements till 2030 and potential assessment for pumped hydro storage	Installation of batteries and pumped hydro storage	
Industry	Improving the energy efficiency of non-PAT industries and MSMEs	Energy audits in all registered MSMEs. Capacity-building programmes for energy conservation measures in MSME sectors. Notify energy targets for non-PAT industries under large, and medium categories.	Guidelines for energy conservation activities in major MSME sub-sectors Launch schemes like the PAT scheme for major non-PAT industries	Improving energy efficiency in industries would reduce the fuel cost
	Activities to improve RE-based electricity	Install RE-based electricity sources in major MSME clusters	Activities at DISCOM to supply reliable grid-based power to major industries	Reliability of power would attract industries to shift to grid-based power. This would increase the financial health of DISCOMs

Sector	Project/ Programme	Short-term goal (2–4 years)	Long-term goal (5–8 years)	Co-benefits/Remarks
Transport	Improving public transport and non-motorized transport	5% increase in public transport share by 2025 and 10% by 2030. 5% increase in the share of NMT by 2025. Mini-bus service for women on high-demand routes to make public transport safer and approachable to women (pilot 2 routes in Kochi or Thiruvananthapuram)	Integrated transport hubs. Comprehensive mobility plans for all major cities.	Making public transport safer and more comfortable for women can prompt them to shift further, thus increasing the public transport mode share. KSRTC started the Samudra service for women from the fishing community, the impact of this initiative on GHG could be estimated if the previous mode of travel and past and current travel characteristics would be known. Seamless connectivity is essential to reduce congestion and transport-related emission
	Conversion of existing personalized vehicles into clean fuel/vehicle technology	5% privately owned vehicles.	Extended to 20 % of personalized vehicles	A significant number of vehicular emissions will be reduced.
	Transit Oriented Development (TOD) corridors	Introduction of Mass Rapid Transit System especially Bus Rapid Transit System (BRTS)	Bus augmentation, modal integration, last-mile connectivity	Integration of land use and transport along major mobility corridors yields a reduction in traffic congestion and increases the efficiency of the public transport system
	Road Network Development Plan	Widening roads, increasing public places, and providing adequate parking facilities	Outer Ring Road, Inner Ring Road, Elevated Road, Flyovers	Park-and-ride facilities along transit corridors will reduce the use of personalized vehicles. To relieve congestion at intersections and reduce the travel time
	Improvement of the Inland Water Transport System and adoption of Solar powered vessels.	Transporting 30% of the non-perishable goods through National Waterways.	at least 70% of goods transported through waterways shall be achieved	The carbon footprint generated by land transport such as roads and rails will be reduced

Sector	Project/ Programme	Short-term goal (2–4 years)	Long-term goal (5–8 years)	Co-benefits/Remarks
Buildings	Implementing natural light and ventilation techniques to reduce energy dependency (based on traditional design practices)	Guidelines to measure the energy efficiency of vernacular architectural buildings. Survey to understand the number of such buildings, their condition, age, energy efficiency, etc.	Building guidelines to achieve a balance of modern and traditional building practices to build more efficient and comfortable buildings	Using local materials will reduce emissions during material production and transportation
Agriculture	Assessing the viability of solar dedicated feeders in agriculture and installing solar plants	Assess the financial and technical viability of solar-based dedicated feeder	Identify land parcels suitable for solar plants close to the distribution substation and estimate the potential. Install solar power plants in the identified land parcels	

the Plan due to the dearth of comprehensive assessment mechanisms. For instance, the e-Governance mechanism increasingly adopted by various governments have significant emission reduction potential. Kerala has already initiated the e-Governance administration two decades ago. Such activities need to be scaled up at all levels. It is also important to assess the emission reduction potential of such initiatives.

Aggressive targets must be in place to avoid higher GHG emissions in the future due to an increase in energy demand. The proposed mitigation strategies for the 2023-30 period could reduce around 57000 $ktCO_2$ in 2030, with an investment of around INR 52,238 Crore. Out of this, the State's share is estimated at 5%, and the Central Government's share is at 23%. The remaining investment will be the consumer's share. CSR and CER must be channelized to mitigation investments through suitable policies and regulations. The estimated investment requirement (2023-30) and emission mitigation potential (2023-2030) for various decarbonization measures have been normalized on a 1 to 10 scale, as shown in **Figure 5.4**. Shifting to energy-efficient lighting and appliances has the highest potential to avoid GHG emissions. 37% of the emission mitigated could be achieved with only 5% of the investment needed. Among the quantified proposed strategies, the major proposed decarbonization measures are the installation of RE-based electricity projects, energy efficiency improvement in major industries, and T&D infrastructure improvement.

Among the qualitatively assessed measures, improving the energy efficiency of non-PAT industries and MSMEs, increasing the share of public transportation and adopting natural ventilation techniques would reap high emission reduction in the 2023-2030 period. The efforts

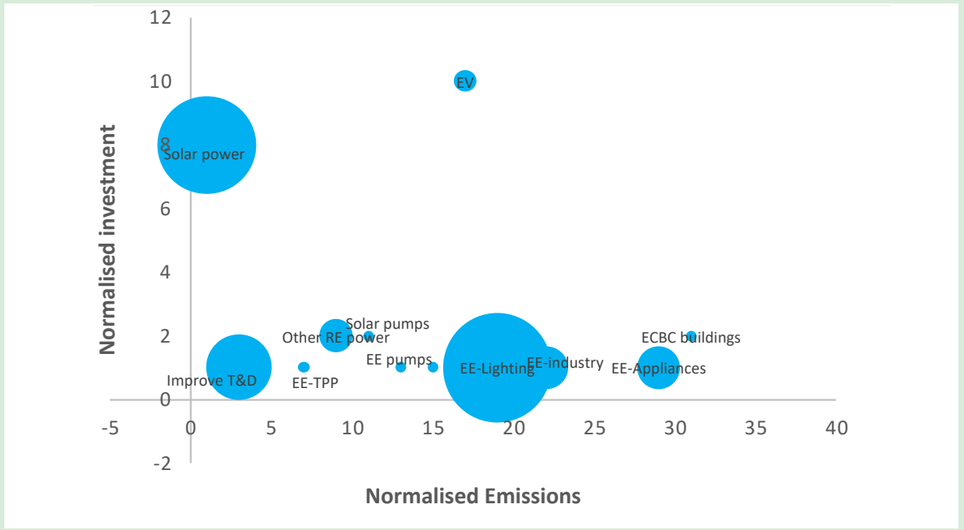


Figure 5.4 **Normalised investments and emission potential of decarbonisation measures**

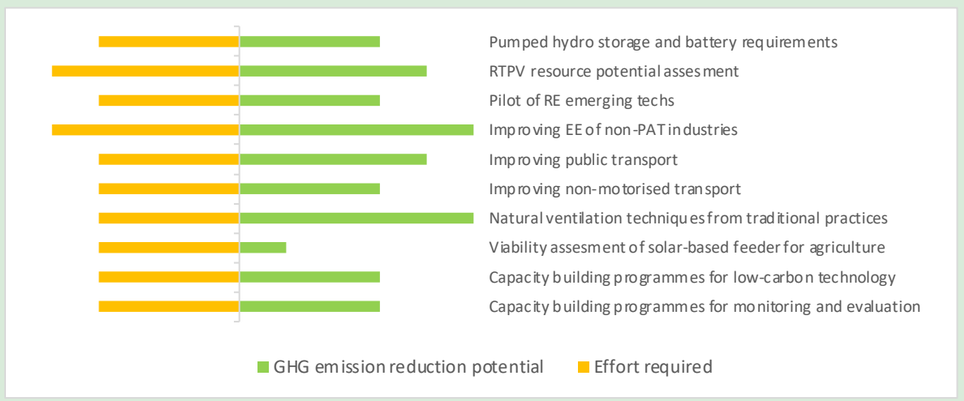


Figure 5.5: **Qualitative representation of GHG mitigation potential Vs efforts required, for activities not quantified**

were assessed qualitatively based on current sectoral infrastructure, manpower and technical requirements for adopting these measures in other counterparts. The qualitative representation were vetted during the stakeholder consultations and by sectoral experts and reviewers. Due to lack of data, it is not able to assess these measures in detail. The efforts to adopt these measures are highest for RTPV potential assessment and improving the efficiency of non-PAT industries (**Figure 5.5**).

6. Adaptation

6.1. Overview

The climate change projections for the State presented in Section 3 of this plan forecast an increase in temperature, rainfall, and extreme rainfall events in the near term (2021–2050) under both moderate (RCP 4.5) and high emission (RCP 8.5) scenarios. Climate impact assessments highlight the observed and projected impacts of climate change on agriculture, livestock, coastal fisheries, forest, human health, tourism, and water sectors. Besides, most of the districts of Kerala are highly vulnerable, as identified in the vulnerability assessments (see 4.4.3). Kerala has been exposed to multiple natural hazards, including droughts, floods, earthquakes, landslides, and sea level rise with coastal erosion and saltwater intrusion. There is a need to develop targeted strategies for enhancing adaptive capacity, strengthening resilience, and reducing the vulnerability of the systems- both natural and socio-economic through the formulation of adaptation actions that are Inclusive, participatory, and gender responsive. Some of the adaptation interventions proposed in this section may also have mitigation relevance.

This part of the plan broadly presents the adaptation strategies and interventions specific to sectors, based on the drivers of composite vulnerability presented in Section 4.4.3. The adaptation strategies and actions are formulated for the sectors of agriculture, livestock, coastal fisheries, forests and biodiversity, health, and water resources. Besides, the priority interventions required for the State also are presented distinctively. Existing policies and programmes implemented in the State that have the potential to provide adaptation benefits are discussed in Section 6.4. The list may not be exhaustive but attempts to project the major interventions in the State that have potentially underpinned the adaptive capacity of the State even in the absence of a coordinated action plan. The rationale for choosing the above-mentioned sectors for developing adaptation strategies is discussed in Section 6.5. Based on the drivers of the vulnerability identified for each sector (**Annexure 4.1**), adaptation strategies and

interventions for the period 2023–2030 have been planned and presented in Section 6.6. Details of the potential interventions with actions, priority districts of implementation, the implementing agencies, expected duration and the financial requirements, are also presented in detail in an Action-Outcome-Objective framework. Further, the barriers to the implementation of any of the strategies and actions planned are also discussed.

6.2. Gender Responsiveness and Inclusivity in the Action Plan

Exclusion may be fed by several factors including gender, age, socio-economic status, disability, race or ethnicity. This may specifically be due to limited access to resources, economic marginalization, restricted rights, sociocultural barriers, stigmas, issues of mobility, deprived access to information and compromised health. Climate change amplifies the existing inequalities in the livelihoods, health, and safety of marginalized communities. This plan in its formulation process has duly addressed these concerns, wherever necessary. The key aspects include:

- Programmes to improve access to health services and climate change induced emergency services, particularly for women, children, differently abled, elderly and marginalised communities.
- Ensuring the priorities and needs of marginalized sections of society in the development planning and funding.
- Creating resilient women communities in livelihood sectors.
- Ensuring the consultation and participation of women in decision-making at local levels regarding the allocation of resources for climate change initiatives.
- Strengthening the women self-help groups and neighbourhood groups network.
- Ensuring inclusive investments in programmes for adaptation, mitigation, technology transfer and capacity building.

Additionally, the plan envisages incorporating gender-sensitive benchmarks and indicators for adaptation projects/programmes in its monitoring and evaluation part.

6.3. The Approach

As discussed in Section 1.3, the adaption planning has been completed through tier-level consultations. Founded on the vulnerability assessment outcomes, sector strategies have been formulated and for each strategy, multiple objectives and outcome-based projects and actions have been designed. The adaptation strategies have been designed on a Climate Change Response Framework which can be monitored and evaluated at different cycles. The Framework is designed to accommodate indicators for specific sectors which is to be finalised by sector specialists under the State Climate Change Cell detailed in Section 8 of the plan.

6.4. Existing Adaptation Relevant Policies and Programmes

There are several Central and State sponsored schemes that are being implemented across sectors which have adaptation relevance. A review of the existing policies and programmes, and how they are contributing to adaptation intentionally or incidentally are presented below along with the key activities involved.

6.4.1. Agriculture

Central Sponsored Schemes (CSS)

The schemes and the adaptation components of the schemes are listed below:

1. **Umbrella Scheme on Krishi Unnathi Yojana**: In 2016, the Umbrella Scheme on Krishi Unnathi Yojana was introduced to combine all key CSS under one umbrella, including the National Mission on Sustainable Agriculture (NMSA), Paramparagath Krishi Vikas Yojana (PKVY), Rashtriya Krishi Vikas Yojana (RKVY), and others. It has a Central share of 60% and a State portion of 40%. The total outlay for 2020–21 was INR 23,750 Lakh and for 2021–22 is INR 25,828 Lakh.
2. **National Mission for Sustainable Agriculture (NMSA)** – NMSA is one of the eight Missions outlined under the National Action Plan on Climate Change (NAPCC). NMSA has been conceptualized by subsuming Rainfed Area Development Programme (RADP), the National Mission on Micro Irrigation (NMMI), the National Project on Organic Farming (NPOF), the National Project on Management of Soil Health & Fertility (NPMSH&F), and Soil and Land Use Survey of India under its domain. The different components of NMSA and their adaptation activities are described below:

- Rainfed Area Development (NMSA-RAD): Aims to promote an integrated farming system with a focus on multi-cropping, rotational cropping, inter-cropping, and mixed-cropping practices, as well as allied activities such as horticulture, livestock, fishery, agro-forestry, and apiculture, to help farmers not only maximize farm returns for sustaining livelihood, but also mitigate the effects of drought, flood, and other extreme weather events.
  - The Watershed plus framework component explores the potential utilization of natural resources base/asset available/created through watershed development and soil conservation activities/interventions under MGNREGS, NWDPRA, RVP&FPR, RKVY, IWMP, etc.
- Soil Health Card (NMSA-SHC):
  - Encourages Integrated Nutrient Management (INM), using soil test/soil health cards to improve soil health and productivity.
  - Promotes farmland development, resource conservation, and crop selection conducive to local agroclimatic conditions for ensuring good productivity and yield.

3. **Paramparagath Krishi Vikas Yojana (PKVY):** PKVY is a soil health management sub-component of Soil Health Management under NMSA. It has the following adaptation activities:

- Supports long-term soil fertility, resource conservation, and the production of safe and healthy food without pesticides.
- Empowerment of farmers through institutional development through cluster approach in farm practices input production, quality assurance, and in value addition and direct marketing through innovative means

4. **Rashtriya Krishi Vikas Yojana (RKVY):** Rashtriya Krishi Vikas Yojana was initiated for ensuring the holistic development of agriculture and allied services. The scheme incentivizes States to increase public investment in agriculture and allied services. The following are the adaptation-based components of this scheme:

- Provides incentives for a high-yielding variety of crops and provides certified seeds to farmers.
- Supports agriculture mechanization, and enhancement of soil health.
- Promotes watershed activities, strengthening of market infrastructure, and infrastructure to promote extension service.
- Gives support to organic and bio fertilizers, research activities by State Agricultural Universities, agro-processing, and strengthening of laboratories for quality control activities.
- Promotes production of quality planting material for horticulture crops, comprehensive piggery, and poultry development.
- The projects under this scheme target risk-prone, underdeveloped, agriculturally distressed, remote, hilly, and tribal areas.
- Women and disadvantaged groups are being given preference for the betterment and promotion of allied activities and non-farm opportunities (such as dairy, animal husbandry, fishing, etc.) for income security.

5. **Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)**: This scheme was launched with the motto "Har Khet Ko Paani" to expand the cultivated area with assured irrigation, reduce wastage of water, and improve water use efficiency. It also concentrates on rainwater harnessing at the micro level through "Jal Sanchay" and "Jal Sinchan" and incentivizes micro irrigation through "Per drop-More crop". The following activities under this scheme provide for long-term irrigation solutions, and hence, contribute to adaptation.

- Constructive activities for drought proofing and flood protection; promotion of water use efficient techniques and micro-irrigation; promotion of horticulture/plantations.
- Promotion of production systems and micro enterprises (example: beekeeping, sericulture, poultry, etc.); community participation in designing and implementing works; livelihood activities for asset-less groups; capacity building.
- Creation of irrigation and water harvesting and conservation structures; improving soil and moisture conservation and land development activities.

6. **Sub-Mission on Agro-forestry (SMAF):** The SMAF (Har Medh Par Ped) scheme was launched to encourage tree plantation on farmland, along with crops/cropping systems to help the farmers to get additional income and make their farming systems more climate resilient and adaptive. It provides various agroforestry practices/models suitable to different agroecological regions and land use conditions. It is a part of the larger mission of NMSA.

7. **National Food Security Mission (NFSM) – Rice & Pulses:** This mission aims to increase the production of rice, wheat, pulses, and coarse grains, through area expansion and productivity in a sustainable manner in selected districts. The scheme's relevant adaptation activities are:

- It creates employment opportunities and enhances the farm-level economy. Disseminates improved technologies and farm management practices.
- Develops security in rice, wheat, and pulse crops through increasing crop productivity.
- It helps in the development of local irrigation methods; promotion of economic water use and usage of improved water application tools.

8. **Mission on Integrated Development of Horticulture – State Horticulture Mission (MIDH – SHM)** – Aim at promoting holistic growth of the horticulture sector, including bamboo and coconut through area-based regionally differentiated strategies. This mission helps in increasing the adaptive capacity of farmers through the ways of following activities:

- It helps in improving productivity by providing quality germplasm and planting material.
- Aids in water use efficiency through micro-irrigation, and sprinkler irrigation.
- It helps in capacity-building for farmers; horticulture mechanization; post-harvest linkage; and beekeeping.
- Promotes agroforestry by creating adequate irrigation systems for horticulture crops; and encouraging organic farming.
- Promotion of FPOs and their tie-up with Market Aggregators (MAs) and Financial Institutions (FIs) to support and ensure adequate returns to farmers.

9. **Sub Mission on Agricultural Mechanisation** - This mission was launched to expand farm mechanization reach to small and marginal farmers, as well as to regions and difficult areas where farm power is scarce. Improved agricultural implements and machinery are critical inputs for modern agriculture, as they increase crop productivity while lowering human drudgery and cultivation costs. Mechanization also aids in boosting the efficiency of other inputs, making it one of the most significant parts of the agricultural sector for increasing farmer's incomes and the contribution of agriculture to GSDP. Objectives of this mission include:

- To offset the adverse economies of scale resulting from small and fragmented landholdings and high individual ownership costs, 'Custom Hiring Centres' and 'Hi-tech Hubs of High-Value Machines' were encouraged.
- To raise awareness among stakeholders, a variety of demonstration and capacity-building initiatives were undertaken.
- Agricultural machines were tested and certified at authorized testing centres across the country to ensure their performance.

State Sponsored Schemes

There are various State sponsored schemes, which are described below, and their adaptation components are enlisted in **Table 6.1**.

1. **Rice Development**: The scheme on rice development thrusts upon the promotion of paddy cultivation in the State through group farming and area expansion programmes like fallow land cultivation, single crop to double crop, and upland rice cultivation, concentrating on the rice-growing agroecological units with natural endowments for augmenting rice productivity.

2. **Development and Promotion of Location Specific Crops:** Assistance is provided for the procurement of quality seeds, land preparation, irrigation, and other cultivation requirements to promote the production of minor millets, oil seed crops such as groundnut and sesame, and sugarcane in specified agroecological units. Crop production operations in tribal areas are promoted to provide food and nutritional security for tribal people, with a focus on activities such as the conservation of indigenous varieties and traditional techniques with scientific backing.

3. **Promotion of Pulses and Tubers**: In the garden lands as well as in 3rd crop rice *padasekharams*, it was recommended to increase the acreage and production of various pulses crops such as cowpea, green gram, black gram, red gram, soya bean, and others. Similarly, it was proposed that the tubers be promoted in collaboration with the Central Tuber Crops Research Institute.

4. **Coconut Development:** With the use of superior agro management practices, multi-species cropping, and farming systems, this programme intends to maximize income from coconut farming. Replanting new, high-yielding dwarf and semi-dwarf cultivars, as well as improved management approaches, will boost production and productivity.

5. **State Crop Insurance Scheme:** The State crop insurance schemes currently cover over 25 important crops and were restructured in 2016–17, resulting in a significant increase in crop loss compensation. The Crop Insurance Fund is funded through registration fees and premiums paid by participating farmers, as well as a government contribution. Minor fruits, apiculture, and floriculture will all be included in the strategy, in addition to the present crops.

6. **Crop Health Management:** Crop health is an important aspect of sustainable agriculture; hence pest management measures must be determined scientifically. Farmers will be provided with systematic surveillance and advisories. The number of surveillance plots will be determined by the cropping patterns of the panchayats that have been chosen.

7. **Crop Pest Surveillance System:** Crop Pest Surveillance System (CPSS) is a Web and Mobile-based, ICT-enabled pest surveillance Information System initiated by the Department of Agriculture, Govt. of Kerala. This is an information system to effortlessly identify the symptoms and diagnose insect pest attacks, diseases, and nutritional

Table 6.1: State sponsored schemes in agriculture sector with adaptation components (2021-22)

Programme	Key Activities Relevant to Adaptation	Amount	Total Outlay
			Lakh INR
Rice Development	Area expansion and double farming	155	7064
	Assistance for growing traditional rice varieties such as Pokkali Kari and Kaippad	136	
	Group farming	6,473	
	Subhiksha Keralam	300	
Development and Promotion of Location-Specific Crops	Promotion of crop production activities in tribal lands to ensure food and nutritional security for the tribal population.	50	131
	Athirappally Tribal Valley Agriculture Project - To support the cultivation of vegetables, tubers, etc.	25	
	Subhiksha Keralam- area expansion of millets through fallow land cultivation.	50	
	Assistance for the cultivation of traditional millets in Idukki	6	
Promotion of Pulses and Tubers	Promotion of tubers/pulses	243	243
Coconut Development	The coconut development programme was implemented in continuous areas called "keragramam" covering a minimum area of 250 ha, to increase production and productivity	4,856	4956
	Integrated pest and disease management, and integrated nutrient management	50	
	Development of high-yielding dwarf and semi-dwarf varieties	50	
Restructured State Crop Insurance Scheme	Helps farmers buffer the crop losses due to extreme climate events	2,000	2,000

Programme	Key Activities Relevant to Adaptation	Amount	Total Outlay
			Lakh INR
Crop Health Management	Pest forecasting and advisory services	150	165
	ICT-based pest surveillance system through IIITMK	15	
Crop Pest Surveillance System	Establishment of ICT based field level pest/ disease observation mechanism		
	Building integrated crop advisory services for farmers		
Climate Resilient Farming	Resilience enhancement of Farming to climate change through strategic research, technological demonstrations, and development of adaptive cropping practices	75	75
Soil and Root Health Management & Productivity Improvement	Soil ameliorants in selected districts	3,000	3,050
	Support for secondary and micronutrients and green manure	25	
	Root health management	25	
Agro Service Centres and Service Delivery	Establishment of new Krishisree Centres	250	900
	Strengthening of existing Karshika Karma Sena	60	
	Strengthening existing Agro-Service Centres/ Krishisree Centres based on business plan	50	
	Group insurance scheme to members of Karshika Karma Sena and Agro service centres and newly formed Krishisree centres	20	
	Operational expenses including wages to mobile clinics	110	
	Functional expenses of KSAMM	200	
	Honorarium to data entry operators of NeGP	210	
Contingency Programme to meet Natural Calamities and Pests and Disease Endemic	Managing buffer stock of paddy seeds and seeds of other important crops.	750	750
	Aiding for bund strengthening and debris removal during flood events		

Programme	Key Activities Relevant to Adaptation	Amount	Total Outlay
			Lakh INR
Strengthening Agriculture Marketing	The operational expense of wholesale markets and district procurement centres	150	3,030
	Agmarknet & Market Intelligence	40	
	Additional support to Weekly Markets	50	
	Market development activities of VFPCK	500	
	Prices Board	80	
	Engaging Karshaka Mitras and training and portal-based service	75	
	Participation in Agri fair	20	
	WTO Cell - Operational expenses	5	
	Online market platform (NEW)	50	
	Share capital to Horti Corp	20	
	Market intervention support for price stabilization	2,000	
	Assistance to Kerala State Ware Housing Corporation for Computerization	10	
	Assistance to Kerala State Ware Housing Corporation for construction of Warehouse cum Agriculture Complex	30	
Punarjani - Restoration of Agricultural Sector in Post-Flood Scenario	Rejuvenation and area expansion of major crops	185	185
	Rejuvenation of infrastructure		
	Development of *padasekharams* and garden lands		
	Mechanization of agriculture		
	Development of markets, nurseries, office buildings, and farms		
	Rejuvenation of agricultural land damaged completely by landslide/landslip		
	Drought mitigation activities like water harvesting and soil and water conservation		

Programme	Key Activities Relevant to Adaptation	Amount	Total Outlay
			Lakh INR
Biodiversity and local germplasm conservation and promotion	Purchasing and distribution of seeds of indigenous varieties	25	25
	Maintaining a registry of indigenous crop varieties		
Post-harvest management & Value addition	Support to value addition through SFAC		1,210
	a) Assistance to small and medium agro-processing units	400	
	b) Assistance to the individual or SHG-based value addition units at the micro level	300	
	Support for value-addition units and marketing in Government Sector/ PSUs/ Co-operatives/ Kudumbasree units/FPOs	200	
	Promotion of apiculture and production of honey and its value-added products through FPOs	25	
	Operational support to SFAC	75	
	Assistance to Kerala State Coconut Development Corporation for value-added products	100	
	Support to Agri start-up and Agribusiness incubators	100	
	FPO portal development and maintenance- NEW	10	
Revitalization of the Agriculture Sector in Wayanad	Integrated Pepper and Coffee Development	1,000	1,335
	Area expansion of nutmeg, ginger, and turmeric	125	
	Restoration and flood mitigation	210	
Rural Infrastructure Development Fund (RIDF)	Support to Kerala State Warehousing Corporation for the implementation of RIDF projects	750	750
	Agriculture infrastructure development projects		
Krishi Padasala - Approach to AEU-based cultivation	Training and awareness programmes	50	50
	Block Level Agriculture Knowledge Centres		
Development of the Agriculture Sector in Kuttanad	Infrastructure development works of various padasekharams of the Kuttanad region	1,150	1,350
	Supply and installation of vertical axial flow pumps	200	

deficiencies/physiological disorders in various crops. The pest/disease surveillance data is captured by field scouts/extension officers by using an integrated mobile application deployed on a smartphone device /tablet and uploaded to the centralized server for data process and analysis. Based on the field-level data, the system generates pest severity reports for the extension officers and researchers and necessary advisories for the farmers on a near-real-time basis.

8. **Climate Resilient Farming:** Through strategic research and technological demonstration, the project aims to improve farming's resilience to climate change and variability. Increasing the resilience of agriculture to climate change requires planned adaptation.

9. **Soil and Root Health Management & Productivity Improvement:** Given the reduced nutritional quality of the State's soil resource, improving soil health is critical for increasing agricultural output. Based on soil testing, services would be provided with a greater emphasis on applying soil test results to improve crop productivity. Based on soil analysis, quality inputs for adjusting soil pH as well as giving secondary and micronutrients to enhance crop production will be offered. The quantity of input required will be determined by the KAU based on the results of soil tests.

10. **Agro-Service Centres and Service Delivery:** At the block level, Agro Service Centres (ASCs) are developed to allow the integration of services such as mechanization, ATMA-based extension, credit support, weather advisory services, soil testing support, and other technology-based services. To provide full-fledged service to farmers at a single location, the varied needs of farmers, such as agricultural inputs, and farm-related information such as loans, marketing, and so on, must be unified under a single service centre. The Agro Service Centres help with technology transfer and service delivery.

11. **Contingency Programme to meet Natural Calamities and Pests and Disease Endemic**: The initiative aims to create a buffer stock of paddy and other annual crop seeds that would be distributed to affected farmers in the case of natural disasters and crop loss. Assistance for bund strengthening to prevent breaches during floods and debris removal would be provided in a need-based manner.

12. **Strengthening Agriculture Marketing:** In the State, appropriate and effective links between producers and sellers remain poor. It is necessary to increase market infrastructure, market intelligence, and institutional support. All these components are covered in this initiative.

13. **Punarjani - Restoration of Agricultural Sector in Post Flood Scenario:** Heavy floods and other natural disasters in 2018 and 2019 resulted in significant losses of standing crops, stored products, machinery, storage structures, infrastructural facilities, and other items on farmers' fields as well as department farms, office buildings, and other locations. Furthermore, the agricultural land loss must be compensated. The scheme aims to compensate for the losses incurred because of floods and landslides in 2018 and 2019. Employment and revenue-generating initiatives will be prioritized.

14. **Biodiversity and Local Germplasm Conservation and Promotion**: It is proposed that tribals, local farmer clusters, and other organizations assist tribals, local farmer clusters, and other organizations in cultivating and multiplying seeds of traditional and indigenous varieties of various crops, including paddy and millets, especially in tribal habitats. The funds set aside under the scheme will be used to purchase and distribute seeds of these indigenous varieties to promote their cultivation in other areas and districts. The Directorate of Agriculture's Organic Farming Cell will keep a registry of all indigenous crop varieties.

15. **Post-harvest Management & Value Addition:** To enhance Kerala's economy and farmers' income from agriculture, post-harvest management and value addition/ geoprocessing are essential. Under this initiative, the Small Farmers Agri-Business Consortium (SFAC) will support small and medium agro-processing businesses, as well as individual or SHG-based micro value addition units.

16. **Revitalization of the Agriculture Sector in Wayanad:** In recent years, the rural economy of the Wayanad district has been in decline. Price volatility has resulted in a significant level of insecurity in farm revenue. The Central and State Governments have devised intervention plans to help the affected communities reclaim their livelihoods. Furthermore, natural disasters during the southwest monsoon season of 2018 and 2019 resulted in massive crop losses and land degradation. It is planned to adopt a cafeteria of focused intervention, with proper backward and forward integration, to resuscitate the district's agrarian sector.

17. **Rural Infrastructure Development Fund (RIDF):** The primary goal of the Rural Infrastructure Development Fund (RIDF) is to give loans to State Governments for them to complete ongoing rural infrastructure projects. Infrastructure works in the agriculture sector in Kerala are being funded by NABARD's RIDF.

18. **Krishi Padasala - Approach to Agroecological Units based Cultivation:** Farmers are educated on the concept of agroecological units based agricultural production as well as scientific and technological variables at the field level under this programme for profitable farming.

19. Development of Agriculture Sector in **Kuttanad:** The Kuttanad Package includes funding for infrastructure development projects in several Kuttanad *padasekharams*, as well as the supply and installation of vertical axial flow pumps.

6.4.2. Livestock

A. Animal Husbandry

1. **Comprehensive Livestock Insurance Programme (Gaosamrudi):** The scheme aims towards the management of risk and uncertainties by providing a protection mechanism to the farmers against any eventual loss of their animals due to death or permanent total disability resulting in total loss of production or infertility, through insurance coverage. Under this scheme, a onetime insurance of an animal up to a maximum period of three years will be provided. The farmers will be provided an option to select, one year or three year insurance coverage period under the scheme. 50% of the total insurance premium under this scheme will be paid by the Animal Husbandry Department.

2. **Compensation to farmers**: Compensation for loss of livestock and poultry due to major outbreaks of diseases beyond control and for providing compensation in case of disasters like floods and droughts. Predator attacks will also be met from this provision.

3. **Conduct of camps, vaccinations and squads:** The budget provision under this component will be utilised for conducting vaccination camps as well as contingency fund during disasters including natural disasters for organizing animal health camps and distribution of essential medicines, feed etc.

4. **Disease mapping through GIS:** The disease prevalence in the recent years are plotted in GIS platform for surveillance work and the route of infection/ epidemiological studies like spread of disease etc. GIS mapping shall help in monitoring, assessing and working out strategies during natural disasters. This is done through the Bhumika App/Portal developed by IIITMK in association with the department.

Table 6.2: Schemes in livestock sector with adaptation components (2021-22)

Programme	Key Activities Relevant to Adaptation	Amount	Total Outlay
		Lakh INR	
Comprehensive Livestock Insurance Programme (Gaosamrudi)	Insurance coverage for cattle death including natural calamities	600	600
Compensation to farmers	Compensation for loss of livestock and poultry including natural calamities	150	150
Conduct camps, vaccinations and squads	Organising animal health camps and purchase of essential medicines during natural disasters	40	40
Disease mapping through GIS	Enable monitoring and assessing the impact of natural disasters during natural disasters.	70	70
Production and conservation of fodder in farmer's fields and dairy co-operatives	Comprehensive & massive fodder cultivation in barren & unutilized lands of selected areas	81.45	94.7
	Irrigation assistance of fodder plots	13.25	

B. Dairy Development

1. **Comprehensive & Massive Fodder Cultivation in Barren & Unutilized Lands of Selected Areas**

The major components are:

- Undertaking intensive fodder cultivation programme in selected zones of the State where barren / unutilized land is available for fodder cultivation.
- Ensuring fodder cultivation in barren land available by integrating and ensuring the participation of the department, LSGD, Dairy Co-operative Societies, PSU's, progressive farmers etc.
- Ensuring 8,670 MT of additional green fodder per annum.
- Developing sustainable and model fodder development programmes in selected areas. Integration of mechanization activities to be ensured.
- Narrowing the gap between fodder requirement and availability of the State.
- Developing sustainable, effective and profitable fodder cultivation models so as to encourage individuals, JLG, SHG and Government agencies to take up fodder development activities.
- Utilizing cultivable forest lands for fodder cultivation.
- Irrigation assistance of fodder plots

6.4.3. Coastal Fisheries

The State of Kerala is heavily reliant on the fishing industry – a major source of income for a large portion of the population, particularly the economically disadvantaged. Impact assessment studies reveal that climate change is impacting the sector adversely. Currently, there are policies and initiatives in place at the federal and State level to strengthen the fishing sector. Some of the important policies and measures are discussed here and elements of adaptation are presented in **Table 6.3**.

Central Policies and Schemes

1. **National Fisheries Policy, 2020:** The policy provides a well-thought-out plan for developing, harnessing, managing, and regulating responsible and sustainable capture and culture of fish. To achieve the goals of the 'Blue Economy, the policy will assure a productive integration with other economic sectors like agriculture, coastal region development, and eco-tourism. It emphasizes Centre-State and interstate collaboration, as well as socio-economic upliftment and economic prosperity for fishers and fish farmers, particularly traditional and small-scale fisheries.
2. **Pradhan Mantri Matsya Sampada Yojana (PMMSY):** PMMSY is a major project that aims to strengthen India's fisheries sector. It is based on Atma Nirbhar Bharat. The plan has implemented several modern approaches to boost fish productivity, including extension, species intensification, diversification, and efficient land and water use.
3. **National Scheme of Welfare of Fishermen**: The 'National Scheme of Welfare of Fishermen' aims to provide financial assistance to fisher-folks for the construction of houses, community halls for recreation and common working spaces, and the installation of tube-wells for drinking water, as well as assistance during lean times.

Table 6.3: Central and State sponsored schemes in coastal fisheries sector with adaptation components (2021–22)

Programme	Key Activities Relevant to Adaptation	State/ Central	Total Outlay
			Lakh INR
Central Sponsored Schemes			
Pradhan Mantri Matsya Sampada Yojana	This scheme targets to increase the rate of fish production and aquaculture production	40:60	2,580
	It also aims to generate employment opportunities and help in increasing the income levels of the fishermen.		
	It focuses on minimizing the post-harvest losses		
National Scheme of Welfare of Fishermen	Development of Model Fishermen Villages Development of basic civic amenities such as houses, drinking water facilities		
	Group Accident Insurance for Active Fishermen -providing insurance against death and total or partial disability to the fisherfolks		
	Providing financial assistance to the fisherfolks during lean times		
Blue Revolution- Integrated Development and Management of Fisheries	Increasing overall fish production sustainably and helping in generating employment and export earnings.	40:60	560
State Sponsored Schemes			
Group insurance schemes for fishermen	It provides financial assistance and social protection to the beneficiary	100%	1,000
Coastal social infrastructure	The construction cost of dispensaries or lighthouses is covered under this scheme. It provides healthcare facilities.	NA	NA

4. **Blue Revolution - Integrated Development and Management of Fisheries:** All ongoing programmes have been integrated under the Blue Revolution umbrella by the Ministry of Agriculture and Farmers Welfare, Department of Animal Husbandry, Dairy & Fisheries. This reformed system attempts to emphasize fisheries development and management, encompassing inland fisheries, aquaculture, marine fisheries, including deep-sea fishing, mariculture, and all activities carried out by the National Fisheries Development Board (NFDB).

State Policies and Schemes

Some of the important State schemes include:

1. **Kerala State Fisheries Policy, 2019:** This strategy intends to boost yield in the fisheries industry from the sea, inland, and fish farming through environmentally friendly, scientific, and sustainable ways, as well as improve the living conditions of fishermen through increased income.
2. **Group insurance schemes for fishermen:** The Kerala Fishermen Welfare Fund Board (KFWFB) ensures insurance for active fishermen in the State. The Group Insurance Scheme covers the accidental death of fishermen, missing, heart attacks, permanent and partial disability. The Central and State Governments split the annual insurance premium evenly.
3. **Coastal social infrastructure:** The funds provided in this scheme will be used to develop coastal areas, including the building of dispensaries, guide lights, and other amenities. The existing fishing dispensaries are insufficient to address the fishermen's healthcare needs.

Other policies include:

- The Kerala Marine Fisheries Regulation Act, 2021
- The Kerala Monsoon Fishery (pelagic) Protection Act, 2007
- Kerala Inland Fisheries and Aquaculture Act, 2021
- Kerala Fish Seed Act, 2014
- The Kerala Fish Procurement, Marketing, and Maintenance of Quality Act, 2021

6.4.4. Forests and Biodiversity

Major Central and State sponsored schemes and initiatives for protecting and conserving existing forests, increasing forest coverage, and protecting forest flora and fauna are:

Table 6.4: **Major forest and biodiversity sector policies and their implications for adaptation**

Policies/Statutes	Implications for adaptation
Forest Conservation Act, 1980	This act attempts to protect forests while also curbing deforestation. It also has the goal of limiting the use of forest land for non-forest uses. This will result in increased forest cover and biodiversity conservation, both of which have adaptive implications.
National Forest Policy, 1988	There is no direct link between this policy and climate change. However, policies based on the maintenance of the ecological balance approach would enhance biodiversity protection, making forests more robust to climate change. Furthermore, involving local stakeholders in the management of local forest resources improves communities' coping capacities in the face of climate change.

Policies/Statutes	Implications for adaptation
Joint Forest Management, 1990	This guideline, which led to the development of a large-scale JFM programme across India, has beneficial adaptation implications for forest ecosystems and populations. Ecosystem: Natural forests are under less stress, allowing species to thrive and adapt to climate change. Community: Diversified livelihood prospects are crucial because communities that rely on a single or few forest products are expected to be more vulnerable to climate change than communities that have access to a diverse variety of resources.
Wildlife (Protection) Act, 1972	Recommends the creation of strict conservation zones free of all habitations, modern-day facilities, tourism, and other activities, which are vital for preventing habitat fragmentation and degradation. These management tools could encourage adaptation.
National Wildlife Action Plan	
National Biological Diversity Act, 2002	Promotes biodiversity protection, because biodiverse natural forests are better suited to climate change and resistant to pest and fire attacks.
Forest Rights Act, 2006	Recognizes forest-dependent communities' rights and allows for the application of local knowledge to forest management and adaptation. This Act permits human activity within forests, which may have detrimental consequences for forest regeneration due to increased disturbance from grazing, land use change, and other factors. This has the potential to make forests more vulnerable to climate change.
State Forest Policy, 2009	This policy envisages environment protection, enrichment of biological diversity, addressing climate change, ensuring the livelihood of the forest-dwelling communities including the tribals, increasing the forest cover along with the protection and conservation of the existing forest, and giving emphasis to agroforestry in the State.
Kerala Forest Act, 1961	Unifies and amend the laws governing the protection and management of forests in Kerala. This Act governs the protection and management of Kerala's forests. As per the Act, the government may declare any area it has at its disposal as Reserved Forest.
Environment (Protection) Act, 1986	Enacted in 1986 to provide for environmental protection and improvement. It authorizes the Central Government to create authorities [under section 3(3)] tasked with preventing all forms of environmental pollution and addressing specific environmental concerns that are unique to different parts of the country.
Eco-restoration Policy, 2021	Envisages securing the ecological and hydrological security of the State with the participation of forest-dependent communities.
Kerala Preservation of Trees Act, 1986	This act provides for the preservation of trees in the State of Kerala.

Policies/Statutes	Implications for adaptation
Kerala Forest (Vesting and Management of Ecologically Fragile Land), 2003	Provides for the vesting in the Government of ecologically fragile lands in the State of Kerala and for the management of such lands to maintain ecological balance and conserve biodiversity.

1) **National Afforestation Programme (NAP):** The NAP scheme's overall goal is to restore degraded forests and develop forest resources with people's participation, with a focus on improving the livelihoods of forest-fringe communities, particularly the poor. NAP aims to help and speed up the ongoing process of devolving forest conservation, protection, and management.

2) **Green India Mission (GIM)**: It is one of the National Action Plan on Climate Change's eight missions (NAPCC). It aims to maintain, restore, and enhance India's dwindling forest cover, as well as respond to climate change through adaptation and mitigation strategies. It envisions a comprehensive approach to greening that goes beyond tree planting. GIM focuses on a variety of ecosystem services, including biodiversity, water, biomass, the conservation of mangroves, wetlands, and critical habitats, as well as carbon sequestration.

3) **Intensification of Forest Management Scheme (IFMS):** Intensification of Forest Management Scheme" aims at forest fire control and management, survey, demarcation, and the preparation of working plans, along with improvements to infrastructure such as roads, camp offices, and watch towers, improved mobility, the provision of firearms, and the use of modern information and communication technology.

4) **Minimum Support Price (MSP) for minor forest produce:** The scheme is meant to provide support for NTFP collection by way of enhanced support price, improving facilities like collection centres, warehouses, value-addition units, branding of value-added products, and marketing support.

5) **Conservation of natural resources and ecosystem**: This programme focuses on preserving the diversity and integrity of plants, animals, and microorganisms; it also promotes ecological conservation research and other environmental elements, as well as providing educational, awareness, and training opportunities. Under this programme, both mangrove and coral reef conservation and management are envisaged.

6) **Forest protection:** Forest theft and encroachment must be avoided if the State's forests are to be managed effectively. This initiative makes use of modern survey technology to demarcate forest boundaries and enclosures, as well as repairs to broken cairns and equipment maintenance and upkeep. Forest fires threaten large regions of natural forests as well as plantations, which will be addressed by this programme. Sandalwood forests, shola forests, mountain ecosystems, and vayals are among the distinctive ecosystems protected by this project.

7) **Regeneration of denuded forest:** The funds allocated to this initiative will be used to improve damaged woods that have been treated in previous years under various programmes. Under this component, special protection of distinctive ecosystems such as shola woods, mangroves, and other ecosystems in special regions will be carried out.

8) **Biodiversity conservation:** The scheme's primary goal is the preservation of biological resources. Habitat improvement, rescue centre maintenance, fire protection, anti-poaching camps, water resource management, eco-development activities, wildlife week celebrations, and crop depredation prevention are among the activities. Research is also carried out, with the results being used to boost biodiversity conservation efforts.

9) **Eco-development programme**: The Eco-development programme tackles challenges of human-environment interaction, through planning and implementation support for alternative livelihood systems and resource management. Under this funding line, eco-development programmes in various sanctuaries will be implemented.

10) **Extension – Community forestry and agroforestry:** This programme aims to improve green cover outside of forests, raise public awareness about the importance of biodiversity conservation, and protect specific habitats outside of forests among the public and the younger generation.

11) **Measures to reduce human-wildlife conflict:** This plan addresses human-animal conflict particularly that exists between wild elephants and people living along the forest's fringe. It also provides financial assistance to victims of wildlife attacks and crop damage, habitat improvement, wildlife food and breeding grounds to keep animals away from forests, and costs associated with the Rapid Response Team (RRT).

12) **Integrated development of wildlife habitat:** This scheme aids the management of wildlife sanctuaries and national parks, community reserves, Project Tiger, and Project Elephant. Apart from this, several activities are funded under this scheme, such as management planning and capacity building planning in PAs, strengthening wildlife research, education, and awareness, promoting anti-poaching activities, strengthening infrastructure, and restoration of habitats.

Table 6.5: Schemes in forest and biodiversity sector with adaptation components (2021-22)

	Programme	Key activities relevant to adaptation	State/ Central	Outlay
				Lakh INR
1	National Afforestation Programme	Conservation and protection of forest resources, thereby biodiversity	40:60	329
		Improved participation of communities in the management of forests, thereby providing an opportunity for utilizing strategic indigenous knowledge on adaptation.		
		Inappropriate choice of species such as exotics/ invasive species may increase vulnerability.		
2	National Mission for Green India	Promotes ecosystem as well as community resilience through targeted activities for promoting adaptation through regeneration, restoration, and tree cover enhancement that helps connect forest fragments and promotes livelihood diversification activities, which reduces the vulnerability of forest-dependent communities.	40:60	NA

	Programme	Key activities relevant to adaptation	State/ Central	Outlay
				Lakh INR
3	Intensification of Forest Management Scheme	The protection of forests and fire protection	NA	NA
		The infrastructure development		
4	Minimum Support Price for Minor Forest Produce	Wild honey amounting	25:75	168
		Creation of storage facilities/warehouses		
		Establishment of local open markets and modernization of such existing markets		
5	Conservation of Natural Resources and Ecosystem	Nilgiri Biosphere Reserve-socio economic upliftment of local communities	40:60	100
		Agasthyamala Biosphere Reserve - habitat improvement activities (improvement of water holes, construction of check dams, soil and moisture conservation, riverbank protection, weed eradication)		120
		Wetland Conservation		170
		Alternate and supplementary livelihood		
6	Forest Protection	Improving the ecological status and economic value of forest	100% SS	5,200
		Rehabilitation of degraded areas and biodiversity conservation	40:60	160
		Protection of fragile ecosystems		
		Forest Fire Prevention, and Management Scheme		
7	Regeneration of Denuded Forest	Conversion of pulp wood plantation into the natural forest through eco-restoration.	100% SS	275
		Raising of seedlings		
		Watching over anti-poaching and forest fire activities		
8	Biodiversity Conservation	Habitat Improvement, maintenance of rescue centres, fire protection, anti-poaching camps, and water resources management.	100% SS	1,000
		Biodiversity Conservation	100% SS	800
		Integrated Development of Wildlife Habitats to Wayanad Wildlife Sanctuary for Voluntary Relocation of settlements from the Protected Area	40:60	300

	Programme	Key activities relevant to adaptation	State/ Central	Outlay
				Lakh INR
9	Eco-development Programme	Conducting training programmes for members of Eco-development committees and staff	100% SS	1,000
		Educational support to tribal students		
		Construction of weather shed, drainage canal, semi-permanent shed		
10	Extension -Community Forestry and Agroforestry	Enhancing tree cover outside the forest, creating renewable biomass resources in the degraded wasteland, minimizing the harmful effects of climate change	100% SS	1,000
11	Measures to reduce man-animal conflict	Improvement of wildlife habitat, preventive measures. Strengthening rapid response team, people's participation and early warning system, publicly funded insurance scheme, relocation of habitation from the interior forest, vayal maintenance, and vista clearance	100% SS	2,200
12	Integrated Development of Wildlife Habitat	Management of Wildlife Sanctuaries and National Parks, Community Reserves, Project Tiger, and Project Elephant	40:60	1,865

6.4.5. Health

To tackle the impacts of climate change on the health sector, there are various Central and State policies and strategies in place. Some of the major policies and programmes are delineated below and in **Table 6.6**.

Central Schemes

1. **National Health Mission (NHM):** The National Health Mission (NHM) aims to attain universal access to equitable, affordable, and quality healthcare services, accountable and responsive to people's needs, with effective inter-sectoral convergent action to address the wider social determinants of health.
2. Pradhan **Mantri Jan Aarogya Yojana (PM-JAY):** It is popularly known as Aysuhman Bharat, and it is a flagship project of the Government of India. It is primarily a health insurance scheme for the poor, lower class, and vulnerable populations.
3. **National Vector-Borne Disease Control Programme (NVBDCP):** It is an umbrella programme for the prevention and control of malaria and other vector-borne diseases. NVBDCP ensures disease surveillance, at the field level, health institution level, laboratory surveillance, case management and control measures of these diseases as per the national programme guideline. The programme ensures that the most vulnerable and marginalized people benefit from service delivery, ensuring that the National Health Policy and Rural Health Mission objectives are met.
4. **Integrated Disease Surveillance Programme (IDSP):** The key objective of the programme is to strengthen/maintain a decentralized laboratory-based, IT-enabled disease surveillance system for epidemic-prone diseases to monitor disease trends and to detect and respond to outbreaks in the early rising phase through a trained Rapid Response Team (RRTs).

Table 6.6: **Central and State sponsored schemes in health sector with adaptation components (2021-22)**

Programme	Key Activities Relevant to Adaptation	State/ Central	Outlay
			Lakh INR
National Health Mission (NHM)	Identifying the disease-prone areas and focusing on preventive healthcare.	40:60	32,000
Pradhan Mantri Jan Aarogya Yojana	It provides cashless access to healthcare services for the poor and vulnerable families at the point of service, that is, the hospital. This provides social protection to the beneficiaries by covering medical expenditures.	NA	26,000
National Vector-borne disease control programme	The surveillance for disease and outbreaks, Early diagnosis and prompt case management, Vector control through community participation and social mobilization, and Capacity building of the staff and the community are needed.	NA	NA

State Policies and Schemes

1. Kerala Health Policy, 2019

This policy pushes for improving human health by improving equality, social justice, gender equality, etc. It emphasizes decentralizing healthcare and creating community-based services that are accessible to all, regardless of income or status.

2. The State Action Plan on Climate Change and Human Health (SAPCCHH)

Under the National Programme of Climate Change and Human Health (NPCCHH), Kerala has prepared its SAPCCHH. The SAPCCHH has identified the current and future vulnerabilities to climate change in the State, the disease burden, and the initiatives to be undertaken by the State to reduce the disease burden and develop a climate responsive and sustainable health care ecosystem in the State.

3. Aardram Mission

Aardram mission is an initiative to bring in a people-friendly health delivery system in the State. It aims at ensuring dignified treatment of every patient in the State. The services include web-based appointment system, virtual ques, patient reception at registration centres, patient waiting rooms with Wi-Fi facilities etc.

4. e-Health Kerala

e-Health is the pioneer project funded by the Government of India and Department of Health and Family Welfare, Government of Kerala, under the State Digital Health Mission. The project is designed to provide a convenient centralized healthcare system. As the system is AADHAAR based, citizens will have unique identification and unified health care records.

6.4.6. Water Resources

There are policies and schemes in place at both the Central and State levels that can support adaptation in the Water Resources sector. Below are descriptions of some of the initiatives that are funded by the Central and State governments. The initiatives and their adaptive components are described in detail in **Table 6.7**.

Central Sponsored Schemes

1. **National Water Mission**: The National Water Mission is one of eight National Missions defined under the National Action Plan on Climate Change. The basic goal of NWM is to conserve water, minimize waste, and ensure that it is distributed more evenly between and within States through integrated water resource development and management.
2. **Flood Control/Management:** Assistance is provided for flood management works, which is the first phase of the programme, under the "Flood Management and Border Area Programme 2020-25." Another initiative, the NABARD RIDF support for Kuttanad, aims to improve infrastructure in Kuttanad to reduce crop loss and enhance paddy production. This plan calls for the construction of *padasekharam* outer bunds in Kuttanad's most susceptible areas.
3. **Rajiv Gandhi National Drinking Water Mission**: This mission is a part of The Accelerated Rural Water Supply Programme (ARWSP), which is aimed at accelerating the pace of coverage of drinking water supply in rural areas.
4. **Jal Jeevan Mission**: By 2024, this project aimed to deliver safe and sufficient drinking water to all rural Indian homes via individual household tap connections. Source sustainability measures, such as recharge and reuse through greywater management, water conservation, and rainwater collecting, will be obligatory aspects of the programme. The Jal Jeevan Mission will use a community-based approach, with substantial information, education, and communication as crucial components.

State Sponsored Policies and Schemes

Some of the State sponsored schemes in Kerala that have implications for adaptation in the water sector include:

1. **Drinking water drought mitigation:** It is proposed to take up works for providing water supply during natural calamities and other emergencies.
2. **Source improvement and water conservation:** This scheme was implemented to increase storage capacity at water sources and thereby boost scheme efficiency to bridge seasonal changes in water levels in *Padasekharams* in Kuttanad's most vulnerable areas.
3. **Major and medium irrigation:** Under this scheme, assistance is provided to aid in implementing the ongoing Major & Medium Irrigation projects for achieving their objectives envisaged in the original proposal by addressing the challenging issues in implementation. Considering the time lag, change in land use pattern, difficulties to acquire land, and similar other problems, the process is facilitated by taking steps to close the projects in a phase wise manner.
4. **Groundwater development:** This is a sub-scheme under Minor Irrigation Projects, it has four sub-components
   - *Investigation and development of groundwater resources* – aims to provide infrastructure for the development of groundwater resources in the State through proper groundwater investigation. The realistic assessment of groundwater resources will also be carried out through constant monitoring of groundwater levels and analyzing its trend of fluctuation and assessing its stage of development.
   - Conservation *of groundwater and artificial recharge* – the scheme envisages the conservation and recharge of groundwater through various artificial groundwater recharge techniques. The purpose of the scheme is to approach groundwater conservation scientifically by enhancing groundwater levels in an area by constructing recharge pit/dug well / bore well recharge structures, small check dams, and subsurface dykes. Priority will be given to water-stressed areas.
   - *Training of personnel* – which has the goal of providing training in relevant fields to the department's technical, scientific, and administrative personnel to upgrade/improve their knowledge, skill, and abilities by exposing them to the latest advancements in groundwater investigation, water well construction,

groundwater conservation, and management practices, modern computer application studies, etc.

- *Groundwater control and regulation* – this aims to control and regulate groundwater development through the execution of the Kerala Groundwater (Control and Regulation) Act 2002 to avoid the negative environmental impacts of groundwater exploitation and achieve equitable resource allocation. Issuance of permits, granting NOCs to drinking water bottling plants, and other industries which use groundwater as raw material are also included. Registration of drilling rigs and firms/agencies engaged in the construction of Groundwater abstraction structures are also included under this scheme.
- *Groundwater-based drinking water supply schemes* – this aims to provide community-based drinking water supply schemes to non-covered and partially covered areas by making use of bore wells/tube wells as the source. The yield of the wells should be scientifically assessed before energizing. The quality of groundwater should also be tested periodically, and an adequate groundwater recharging facility shall be provided for source sustainability.

5. **Minor Irrigation:** The surface water development component of this scheme, comprises projects such as lift irrigation, tank, and rivulet improvements, check dams, sluices, regulators, bunds, vented cross bars, saltwater barriers, channel, and drainage structure layout, and so on. Minor irrigation class-II works that can serve less than 50 hectares, routine maintenance of lift irrigation schemes, tank, and pond renovations, and so on.
6. **Flood Control in Kuttanad:** The scheme intends to mitigate floods in various *padasekharams* of the Alappuzha and Kottayam districts. Various flood management activities undertaken in Kuttanad under the scheme are:
    - cleaning/desilting of canals and improving the drainage facilities.
    - protection of outer bunds of *padasekharams.*
    - compartmentalization of *padasekharams.*
7. **Flood Management – (Part of PMKSY):** During the year 2019, the Kerala State Planning Board created a programme for the recovery of the flood-affected Kuttanad. The most important solution indicated in these publications is to improve infrastructure support for paddy agriculture. To avoid recurrent crop loss due to floods, the outer bund construction and reinforcement around *padasekharams* are vital.
8. **NABARD-assisted Rural Water Supply Schemes (Rural Infrastructure Development Fund - RFID):** This scheme provides piped water supply to rural areas of Kerala under the NABARD Infrastructure Development Assistance (NIDA) project.
9. **NABARD RIDF assisted Micro Irrigation Schemes:** The objective of the fund is to facilitate the State Government's efforts in mobilizing additional resources for expanding coverage under micro irrigation and incentivizing its adoption beyond provisions of Pradhan Mantri Krishi Sinchayee Yojana – Per Drop More Crop (PMKSY-PDMC).
10. **Jalanidhi:** A community-managed demand-driven water supply and sanitation project which is financed by the World Bank.
11. **State Water Policy, 2008**: The major objectives of this policy are to adopt an integrated and multi-sectoral approach for planning, development, and management of water resources; consider micro watersheds as the basic unit for the conservation and optimal utilization of water resources for achieving resources sustainability; integrate the problems and prospects of water resource systems by considering river basin as the basic unit; emphasize the importance of comprehensive watershed conservation and management plan, water quality management plan, long-term sub-basin, and river basin operation and monitoring plan and State water resource plan; and enable appropriate institutional mechanism and legal measures for sustainable water resource development and management.

Table 6.7: Central and State sponsored schemes in water resources sector with adaptation components (2021-22)

Programme	Key activities relevant to adaptation	State/ Central	Outlay
			Lakh INR
Central Sponsored Schemes			
National Water Mission	Focused attention to vulnerable areas, including over-exploited ones	NA	NA
	Promotion of basin-level integrated water resources management		
	State Specific Action Plan (SSAP) on Water Sector	100% CSS	51
Flood Control/ Management	Assistance For Kuttanad (NABARD RIDF)	100% CSS	2,900
	Flood Management and Border Area Programme	75:25	1,250
Rajiv Gandhi National Drinking Water Mission	Institutionalizing community-based demand-driven rural water supply programme with cost-sharing instruments by communities	50:50	NA
Jal Jeevan Mission	Providing Functional Household Tap Connection (FHTC) to every rural household.	50:50	40,000
State Sponsored Schemes			
Drinking water Drought mitigation	Works for improving the water supply during drought/natural calamities	100%	1,000
Source Improvement and Water Conservation	Construction of check dams for ensuring the sustainability of the source and for the protection of the source	100%	200
Major & Medium irrigation	Implementation of the ongoing Major & Medium Irrigation projects, Monitoring and Evaluation of Irrigation Projects, Specialized Training Programmes, and modernization-hydrology information system Establishing Flood Early Warning System (FEWS), Formation of River Basin Organisation, Benchmarking of Irrigation system in Kerala for Effective Irrigation Management	100%	22,025

Programme	Key activities relevant to adaptation	State/ Central	Outlay
			Lakh INR
Groundwater Development	Investigation and Development of Groundwater Resources, Conservation of Ground Water and Artificial Recharge, Training Control and Regulation of Ground Water Exploitation, Ground Water-based Drinking Water Scheme	100%	2,580
Minor Irrigation	Surface water Development, Renovation of Tanks and Ponds.	100%	13,073
Flood Control	Flood Management Programmes in Kuttanad	100%	3,000
	Kuttanad Flood Management Component (Pradhan Mantri Krishi Sinchayee Yojana)	50:50	550
NABARD Assisted Rural Water Supply Schemes Rural Infrastructure	Provides portable drinking water to the rural communities	100%	5,180
NABARD RIDF assisted Micro Irrigation Schemes	These micro-irrigation schemes will provide irrigation facilities to the farmers including small and marginal farmers, providing them with the security of good yield.	100%	151
Jalanidhi Project	Providing safe and potable drinking water through functional household tap connections to all rural households	100%	4,125
	Capacitating the community for long-term sustainable and reliable operation and maintenance of the rural water supply systems		
	Building awareness for valuing water Developing a culture of Valuing water through awareness building.		
	Ensuring sustainability of water sources through Ground Water Recharge, Rain Water Harvesting, and demand management.		

The above detailed sectoral activities at the time of its formulation may be focused towards sector-specific objectives and may not specifically address the possible climate change scenarios that are observed to be occurring in recent times having cross-sectoral impacts. This makes it imperative that strategies are devised to specifically address such events which may be otherwise bypassed. After the extreme events of 2018, the Government of Kerala in partnership with the World Bank initiated a strategic engagement to build multidimensional resilience in the State through the Resilient Kerala Development Policy Operation by extending support to the Rebuild Kerala Development Programme (RKDP). The major components

of RKDP are: a) improved irrigation agriculture linkage, b) river basin management, c) shifting to sustainable and climate-resilient agriculture, d) risk-informed land use planning and updating disaster management plans and e) fiscal reforms to ensure greater investments for preparedness and rehabilitation. Under this programme, a dedicated institution - the Rebuild Kerala Initiative (RKI) - was set up to coordinate, manage and monitor the roll-out of RKDP across various government departments and agencies. As part of this, the State has already initiated reforms such as local disaster risk mapping, performance-based road contracting, shifting agricultural and river basin management practices to align with agroecological conditions and introducing risk-informed master planning for cities and towns.

6.5. Key Sectors for Adaptation

Based on departmental consultations, literature review and the relevance based on key statistics like the proportion of employment, dependency of the population and the share of GDP, seven sectors for adaptation planning have been identified and prioritized. These sectors are - agriculture, livestock, coastal fisheries, forests, health, tourism, and water sectors (**Table 6.8**). Four out of the seven sectors are primary sectors, employing almost 20% of the workforce and contributing about 11% to the Gross State Value added (GSVA). Aggregately, over 50% of the workforce depends on these prioritized sectors. Thus, these sectors are significant for communities, economy, and the environment. Furthermore, there are considerable interdependencies that exist among these seven sectors. As such, any climatic or non-climatic impacts on one sector may have cascading impacts on the other sectors.

The inherent vulnerability of these sectors and the impacts of climate change have been detailed in **Annexure 4.1**. The same is also briefly presented in **Table 6.8**. In the adaptation interventions mentioned, specific interventions for the tourism sector have not been suggested as the vulnerabilities of other sectors once addressed have the potential of addressing the vulnerabilities of the tourism sector.

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Table 6.8: **Key Sectors – the Vulnerability, Impacts and Rationale**

Sectors	Vulnerability of Sector		Impacts of climate change	Rationale for prioritization
Agriculture	Nine out of fourteen districts (Palakkad, Wayanad, Kasaragod, Idukki, Kozhikode, Malappuram, Kottayam, Kannur and Thiruvananthapuram) were ranked as being highly vulnerable in terms of agriculture. The drivers of vulnerability include • Poor irrigation coverage and high variation in pre-monsoon groundwater levels, as well as soil moisture • Comparatively uneven spatial spread of agricultural institutions including credit societies and Krishi Bhavans per unit of agricultural area. • Insufficient storage infrastructure and road connectivity • Inadequate uptake of integrated and collective farming • Insufficient crop insurance coverage		• With the increase in temperature and variations in rainfall, future rice yields have been projected to decrease. • Similarly, the productivity of important spice crops such as black pepper, cardamom, etc., is projected to decline with variations in temperature, humidity, and rainfall during critical growth phases. • Commercial plantation crops such as coconut, areca nut, cashew, etc., are projected to be impacted by extreme rainfall causing severe button shedding and pest infestation lowering overall productivity. Other crops like rubber, tea, and coffee are also affected with a significant impact on crop yields.	Different cropping systems in the State are projected to be significantly impacted by climate hazards in the future. As the majority of the districts are highly sensitive to potential impacts, the agriculture sector in Kerala needs to be prioritized for adaptation. As the agriculture sector can be a source of greenhouse gas emissions, some adaptation strategies have the potential also to mitigate emissions from crop production - particularly those targeted towards crop switching, integrated nutrient management, and enhancing crop productivity.
Livestock	Four districts were ranked as being highly vulnerable (Palakkad, Kasaragod, Idukki and Kollam) and five were ranked as being moderately vulnerable, which has the potential to increase with climate change impacts if the drivers of inherent vulnerability are not addressed. The drivers of vulnerability include: • Low ratio of local breeds to cross breeds • High variation in dairy productivity • Insufficient veterinary services (doctors and hospitals), processing units, and cooperative societies • Poor insurance coverage		• The percentage of livestock population residing in multi-hazard-prone areas ranges from 26.18 % in Kasaragod to 89.88 % in Palakkad. • Heat stress is known to significantly affect the productivity of high-yielding milch animals and poultry. With climate change, the probability of the occurrence of heat and water stress (drought) is projected to increase. • Increased mortality rates of livestock are projected with the projected increase in extreme rainfall events and floods.	With a high probability of occurrence of hazards such as heat stress, floods, and drought, high exposure of livestock in the districts of Kerala to these hazards, coupled with high to moderate vulnerability of the livestock sectors in the majority of the districts, the sector needs to be prioritized for adaptation and be climate proofed. Adaptation strategies that are aimed at improving livestock productivity through improved feed could also provide mitigation co-benefits by helping to lower methane emissions from enteric fermentation.
Coastal Fisheries	Kerala has nine coastal districts, out of which four districts – Kasaragod, Kannur, Malappuram and Thiruvananthapuram were ranked as being highly vulnerable. The drivers of coastal fisheries vulnerability include: • Limited aquaculture production • Low per capita income of fisherfolk • Fewer cold storage facilities • High percentage of the landless population among fisherfolk • Inadequate capacity of relief camps (shelters for disaster relief) • High percentage of fisherfolk living within 50 m of the High Tide Line		• The coastal areas of Kerala are densely populated, and thousands of people are already being relocated annually due to coastal flooding. • The State's coastline is already prone to severe degradation and erosion. • Both coastal flooding and erosion are projected to increase with rising sea levels and extreme rainfall due to climate change. • Marine heatwaves, which are also projected to increase due to global warming, have observably impacted and will continue to impact the marine biodiversity of the Arabian Sea.	As a large portion of the population in coastal districts of Kerala is dependent on coastal fisheries for their food and livelihood, climate-proofing the sector is imperative. Furthermore, Nature Based Solutions (NBS) for adaptation need to be prioritized to regenerate coastal resources and prevent further degradation of coastal areas. Conservation and regeneration of marine ecosystems such as mangroves, salt marshes and seaweed ecosystems as a potential adaptation strategy can also play a key role in mitigating climate change through their ability to store carbon.

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Sectors	Vulnerability of Sector		Impacts of climate change	Rationale for prioritization
Forest	According to the forest sector vulnerability assessment, four districts – Kollam, Kottayam, Wayanad and Kasaragod – were ranked as highly vulnerable. The drivers of vulnerability include: ● Less area under forests, and poor. biological richness ● Fewer protected forest areas. ● Fewer establishments and inadequate human resources for forest conservation ● High occurrence of forest fire		Climate change has been projected to adversely impact existing forest vegetation, forest type, and biodiversity, coupled with an increased incidence of forest fire that could potentially lead to forest dieback and mortality in the State. This change has been projected under both moderate and high emission scenarios, in the short and long term for the districts of Ernakulam, Idukki, Kottayam and Pathanamthitta. It, however, also projects an increase in the Net Primary Productivity (NPP) of forests across the State.	Forests provide important ecosystem services that are essential for the sustainable productivity of a State's economy. The potential loss or degradation of forest resources due to climate change can have cascading impacts on other sectors. Adaptation strategies to protect and regenerate forest resources have the added value of providing mitigation co-benefits through carbon sequestration.
Health	Kasaragod, Malappuram, and Palakkad were ranked as being highly vulnerable in terms of human health. The drivers of vulnerability include: ● Presence of a large inherently sensitive population (below 6 and over 65 years of age and people living with disabilities) ● Inadequate number of healthcare professionals and establishments ● Fewer number of households provisioned with treated water supply ● Poor ground and surface water quality.		Climate change can affect human health directly (e.g., impacts of heat stress, death/injury/disease/ displacement due to floods and storms) and indirectly through changes in the ranges of disease vectors (e.g., mosquitoes), water and food availability and quality, and air quality.	With climate change, the probability of the occurrence of climate hazards that have severe implications for human health and well-being is increasing. Strategies to help the health sector in Kerala adapt to these potential hazards are essential to lower human morbidity and mortality.
Tourism	Idukki, Wayanad and Kasaragod were ranked as being highly vulnerable in terms of tourism. The drivers of vulnerability include: ● Inadequate number of local administrations with a functional waste collection system ● Poor road connectivity ● High variation in the number of domestic tourists ● Lack of tourism-centred human resources, organisations, and programmes such as community tour leaders/tour operators, responsible tourism units, tourist information/facilitation centres, ecotourism units and cultural/village tourism programmes. ● High prevalence of communicable diseases and a high population burden on healthcare facilities ● Higher percentage of the tourism-dependent population. ● Poor surface water quality The priority interventions mentioned in the plan have significant impact on checking the vulnerabilities of the tourism sector.		Climate change has severe implications for the tourism industry. Climate hazards such as floods, coastal erosion, droughts, heatwaves, forest fires, infectious diseases, etc. can affect a consumer's choice of destinations, tourist activity, as well as their safety.	As a significant population in the State depends on tourism for their livelihoods, the sector needs to be climate proofed. As the sector is interdependent with several other sectors such as forests, health, water, etc., convergence plans to address the overlapping drivers of vulnerability and development of no-regret adaptation strategies may be conceived.
Water	Wayanad, Alappuzha, Kottayam and Kozhikode were ranked as being highly vulnerable. The drivers of vulnerability include: ● Poor surface water quality ● inadequate irrigation coverage ● insufficient storage capacity of reservoirs ● fewer households connected with treated water supply		Climate hazards such as droughts, floods, and sea level rise (saltwater intrusion) can impact the availability and quality of freshwater required for drinking, domestic, and irrigation purposes.	As the productivity of most sectors is dependent on access to quality water, prioritising the water sector for adaptation is imperative under a changing climate.

6.6. Strategies, Interventions and Actions

Adaptation planning was done in three steps starting with the development of strategies based on the vulnerability assessments. The strategies were used to conceive the interventions required and the actions to be proposed along with their financial outlay. All these steps were completed through the tier method detailed in Section 1.5. The SDG and the NDC goals corresponding to each intervention were also mapped.

6.6.1. Addressing the vulnerabilities and their driving factors

Even though, Kerala is multi-hazard prone, considering its Human Development Index, it might be expected that the people have a relatively high adaptive capacity. However, they are also at greater risk of loss and damages due to climatic or non-climatic hazards and disasters, with pockets of vulnerability that need targeted interventions to strengthen the resilience of the State's population and natural resource base. As such, adaptation strategies need to incorporate components of disaster risk reduction – preparedness, response, recovery, and risk mitigation. The State has taken robust steps towards building the resilience of communities, natural resources, and infrastructure through the Rebuild Kerala Development Programme (RKDP), in response to the natural calamities of 2018 mostly attributed to the changing climate scene in the State.

Of the fourteen districts in the State, nine (Wayanad, Kozhikode, Kasaragod, Palakkad, Alappuzha, Idukki, Kannur, Malappuram, and Kollam) were ranked as highly vulnerable based on the Composite Vulnerability Index (CVI) (Section 4.6.1). The CVI was constructed using indicators that holistically capture the sensitivity and adaptive capacity at the district level. For these highly vulnerable districts, drivers of vulnerability were identified and included:

1. High percentage of the inherently sensitive population (below 6 and over 60 years of age and people living with disabilities)
2. High incidence of communicable diseases
3. High population burden on healthcare professionals and institutions
4. Fewer households with treated water supply
5. Poor irrigation coverage and high crop yield variability
6. Limited groundwater availability
7. Poor surface and groundwater quality
8. Fewer relief shelters available relative to the district's population
9. Poor spread and coverage of local meteorological monitoring stations

Adaptation planning in these districts would be to develop new strategies or strengthen existing policies to address these drivers of vulnerability. The recurring themes in these highly vulnerable districts appear to be **human health, disaster management, and natural resource management.** The adaptation strategies to alleviate the inherent vulnerability by addressing the above drivers have been described briefly below and, in more detail, as sectoral interventions in Sections 6.6.2 to 6.6.8.

Some of the key policy, institutional and investment proposals envisaged by the State relevant for adaptation and will correspondingly address the above drivers of composite vulnerability include:

1. Embedding Disaster Risk Management (DRM) based on the Sendai framework, as a cross-cutting theme across all major development activities. This would encompass:
   - Updating or preparing State, District and City level Disaster Management Plans, to include short- and long-term strategies to address coastal zone disasters, improve drought preparedness and mitigate flood and landslide risks.
   - Reviewing and upgrading flood protection design standards of infrastructure; conducting comprehensive land-use, hazard, exposure, vulnerability, and risk mapping and providing access to disaster risk information to all in coordination with Kerala State Spatial Data Infrastructure (KSDI)[1], National Database for Emergency Management (NDEM)[2] and on all existing platforms. Identification of any trade-offs and obstacles to risk management for prioritized private and public action.
   - Improving hydro-meteorological early warning and 'last mile' hazard communication systems. Strengthen State Disaster Response Force, Fire and Rescue Services, and Police with appropriate equipment.
   - Increasing the capacity of disaster relief shelters for communities in districts most at risk, along with the construction of shelters for livestock and other productive assets such as mechanised farm implements, particularly for protection against floods.
   - Monthly assessment of the Groundwater Drought Index and management of groundwater resources based on the regulations envisaged under the District Disaster Management Authority.
2. Development of a platform (MIS) for data and information sharing among all line departments. This platform should include information regarding,
   - Climatic and non-climatic risks to a sector and sectoral productivity (potential disruption to service provisioning).
   - Impact Assessments – loss and damages incurred due to calamities.
   - Ongoing projects, programmes and adaptation efforts being undertaken by all departments for monitoring, evaluation, and learning.
   - New and innovative technologies developed to lower risks and impacts across sectors.
3. Developing State Biodiversity Strategies and Action Plans for the conservation of eco-sensitive areas:
   - Establishing a baseline for biodiversity across the State, highlighting threatened species, habitats, and ecological systems, for targeted conservation.
   - Improving conservation and integrated management of forests, coastal zones and wetlands, including strengthening district-level monitoring mechanisms.
   - For forests, the conversion of plantations to natural forests with maintenance should be prioritised.
4. Integrated Water Resources Management:
   - Assessing water storage capacity of dams, lakes, wetlands, and other water bodies in the State, with investment to increase the storage capacity. This should also include targeted basin/catchment area treatment for key catchments, to reduce runoff and siltation of water bodies.
   - Preparing risk-mitigating projects targeted at Kuttanad and other critical flood plains.
   - Improving irrigation coverage with a focus on provisioning water and energy-efficient technologies like solar pumps and drip/sprinkler irrigation to rainfed croplands.
5. Climate resilient agriculture: promoting integrated farming (crops with animal husbandry, agroforestry, and fisheries) with the flood, drought, and heat stress resilient crop varieties specific to agro-ecological zones of the State. This will also include:
   - Leveraging private sector resources and capacities to market and create value

1 The Kerala State Spatial Data Infrastructure (KSDI) is an Internet based Geo-spatial Data Directory for the State that facilitates users of the system to share and explore data related to political and administrative boundaries, natural resources, transportation and infrastructure, demography, agro and socio economy, etc of the State.

2 National Database for Emergency Management (NDEM) is a web based geo-spatial national repository of data coupled with a set of decision support tools to assist the disaster managers at various levels in decision making for managing emergency situations.

addition of crops, milk, meat, fish, and poultry products to increase profitability and sustainability for producers.

- Introducing calamity-resistant dairying/ livestock/poultry farming technology and infrastructure.
- Extensive fodder development programme, with fodder banks.

6. Leveraging the Jal Jeevan Mission to ensure the delivery of reliable, efficient, and sustainable piped water to all citizens of Kerala. Reforming water allocation principles and modalities, including pricing, to ensure more equitable and efficient sharing of water resources for key water stakeholders, especially considering the needs of the poor and the vulnerable.
7. To lower the incidence of diseases across the State, sanitation and waste management strategies need to be developed and strictly implemented. These should include,
   - Development of infrastructure for septage management and stormwater drainage in both urban and rural areas.
   - Leveraging proposals made under the RKDP for investment and establishment of water treatment plants in both urban and rural areas of vulnerable districts for water conservation and reuse.
8. As Kerala becomes increasingly urban, the urban bodies should undertake investments in climate-resilient infrastructure covering energy, housing, roads, transport, drainage, solid and liquid waste management, sanitation, etc.
   - Urban infrastructure systems for the energy, transport, telecommunications, water and wastewater, solid waste, buildings, and food sectors are highly interdependent. Climate risks and impacts have been known to cause ripple effects across sectors, with damaged facilities and reduced services in one system impacting others. Similarly, adaptation action in one sector can often result in synergies and trade-offs in another sector. Thus, urban infrastructure systems with critical interdependencies need to be mapped, to utilize limited financial resources efficiently, lower duplication of work, avoid possible trade-offs in other sectors and maximize resilience.
   - Reviewing and upgrading existing infrastructure will be of much significance.
   - Wherever possible, urban landscapes should integrate green infrastructure to mitigate the impacts of floods, landslides, drought, and extreme heat.
9. Poverty alleviation would be through focused livelihood and insurance development programmes focused on the most vulnerable segments such as BPL or MGNREGS job card holders, SC/ST, fisher folk, differently abled, informal workers, petty traders, etc.
   - Livelihood programmes would concentrate on strengthening self-employment avenues and skilling initiatives.
   - Establishing a livelihood start-up fund for Nano-enterprises along the lines of Start-up Village Entrepreneurs.
10. Mainstream the use of insurance as a tool to mitigate loss and damages due to climate hazards. Insurance Schemes must be developed and extended to include all potential hazards (for example lightning) and all forms of assets associated with livelihoods. For example, insurance in the fisheries sector should be extended to ensure fishing boats or crafts.

6.6.2. Agriculture

The drivers of vulnerability for the agriculture sector include poor promotion and uptake of collective and integrated farming systems, inadequate number of storage facilities, insufficient number of primary agricultural credit societies and crop insurance coverage, poor irrigation coverage, reduced capacity to expand the area under agriculture, inadequate representation of Krishi Bhavans and agricultural markets in major agricultural regions, high variation in soil moisture, low connectivity by road, and high pre-monsoon variation in groundwater levels. The following strategies are envisaged to address the above-mentioned drivers of vulnerability.

1. **Enhancing agricultural productivity:** The 14th Five Year Plan Approach Paper emphasised the need to enhance the productivity of major crops in the State. Although the State has limited scope to expand the area under agriculture as land is a limiting factor, this driver of vulnerability can be addressed by substantially enhancing the productivity of existing farms, by treating watersheds, expanding irrigation coverage, and using climate-resilient agriculture practices and essentially using precision farming technologies, including;
   a. Field productivity zoning (plant more densely in the areas with greater productivity, while treating areas with lower productivity particularly addressing nutrient deficiency).
   b. Planting high-yielding and climate-resilient crop varieties.
   c. Technological interventions including biotechnology and nanotechnology.
   d. Preserving buffer stock of high-quality seeds.
   e. Biodiversity and germplasm conservation and promotion.
   f. Accurate and more localised weather prediction.
   g. Precision irrigation and fertiliser application.
   h. Plant disease, weed and pest prevention and management.
2. **Integrated and collective farming**: Integrated farming systems aim to sustainably use natural resources with a complimentary combination of farm enterprises such as crop production, livestock rearing, fodder, trees, fishery, poultry, beekeeping etc., to maximise farmer's income in an ecologically sound manner. Collective farming, on the other hand, is when multiple farmers run their holdings as a joint enterprise, which can provide them with social and financial security. Small and marginal farmers must be brought together in forms of group production and marketing. Farmer Producer Companies/Organisations, Farmers Co-operatives and other such collectives shall be promoted. The integrated and collective farming systems need to be strengthened along with training and information about:
   a. Diversified or mixed cropping systems (including agroforestry practices), crop switching to those most suitable to the soil and local climate: Agro Ecological Unit (AEU) based farming implementation of agricultural practices at the landscape level instead of at a field level through promotion of collective and environmentally sound agricultural practices.
   b. Good Agricultural Practices (GAP)- use of crop residue, farmyard manure, legumes, green manures, organic wastes, and bio-fertilizers, biological pest control, reduced or no-tillage. These practices also provide GHG mitigation co-benefits.
   c. Decentralised water harvesting and conservation (on-farm), watershed management with in-situ soil and moisture conservation techniques and existing policies that incentivize their construction.
   d. Water and input use efficiency through new and innovative technologies. This will also have the potential for GHG mitigation.
   e. Soil fertility (micro and macronutrient deficiencies).
   f. Availability of improved and high-yielding seeds, drought/flood resistant varieties of crops, etc.
   g. Weather and pest forecasts.

h. Available agro-processing, value addition and cold storage centres.

i. Farm mechanisation (fuel and energy efficient or renewable, such as solar pump sets, mills, drones, etc.)

j. Available farmer-oriented institutions such as Krishi Bhavans, Agro Service Centres, etc.

k. Agricultural markets, market trends, prices, crop insurance, etc.

l. Available Centre/State-sponsored financial aid for investment in the above sustainable agricultural practices.

Providing farmers with access to information is a powerful tool for planned adaptation. Public-private partnerships should be explored for the better establishment of markets. Several of these activities mentioned above have the added value of addressing water stress and provisioning mitigation co-benefits, particularly those that focus on energy and water use efficiency, crop switching, organic farming, input management, and agroforestry.

3. **Improving storage infrastructure**: Farmers observe considerable financial benefits by storing their produce to tide over unfavourable market fluctuations. Storage also attempts to cut down on wasteful field losses. There is a need to establish more storage and warehouse infrastructure in the districts that have been identified as being highly vulnerable in terms of agriculture. These may be established by providing financial assistance to Kerala State Warehousing Corporation, public or private Agricultural Organisations, Farmer Producer Organisations (FPOs) etc. for creating storage, warehousing, and cold-storage facilities.

4. **Primary Agricultural Credit Societies (PACSs)**: The co-operative credit institutions in Kerala provide short to medium-term loans to their members for various agricultural activities. There is a need for a policy push in the State to increase the coverage of PACSs, particularly in vulnerable districts. Farmers, especially those in the socially backward classes of society must be encouraged to seek membership in PACSs and Kerala Farmers Welfare Fund Board (KFWFB). Alternatively, existing rural banks may be incentivized to provide loans with similar interest rates of PACSs to farmers and a mass awareness programme can be conceived to educate farmers about other banking options that have tailor-made, value-added products for each major customer segment in existing banks.

5. **Public and private crop insurance schemes**: In a highly variable climate with increased occurrence of climate-induced hazards impacting crop yields and quality of produce, crop insurance as a safety net for farmers is essential. The Restructured Weather Based Crop Insurance Scheme (RWBCIS) may be leveraged and promoted in the State in collaboration with meteorological monitoring stations, Krishi Vigyan Kendras (KVKs), and the Government of India's national flagship programme – the Pradhan Mantri Fasal Bima Yojana (PMFBY). Campaigns focusing on the potential impacts of climate-induced hazards on crop productivity can be used to encourage farmers to apply for weather-based crop insurance. These campaigns must include information regarding the documentation required and insurance premium costs. Farmers may also be given sufficient exposure to different private insurance policies available and its online provisions.

6. **Krishi Bhavans**: These technical institutions established at the Grama Panchayat level facilitate the implementation of various programmes and schemes of the Local Self Governments (LSGs) and the Department of Agriculture to enhance the production of both food and cash crops in the State. Agricultural research, education, and extension are its important functions. There is a need to realign the involvement of Krishi Bhavans based on the proportion of the agricultural area. At present, a Krishi Bhavan has been established in every Grama Panchayat of Kerala. However, some Grama Panchayats either have more farmers or more area under cultivation as compared to others. As such, the capacity of these Krishi Bhavans needs to be increased through hiring additional staff/re-deploying the staff to cater to a larger area or a greater number of farmers. Awareness campaigns among farmers need to be conducted to highlight the services provided by Krishi Bhavans in the State.

7. **Agricultural markets**: Currently, in the State, there is a high burden on existing agricultural markets, and as such, there is a need for the construction of more agricultural market infrastructure, including storage facilities for perishable goods and all other associated infrastructure relevant to hygiene – drainage, waste disposal facilities, toilets, etc. There is also a need to establish the link between farmers and markets. Farmers must be provided with real-time information regarding market trends and prices. A regulated supply-chain network shall be built for principal agricultural commodities. Efforts must be made to create a consortium of markets to ensure viable linkages with the value-addition and processing sectors.

8. **Improving rural connectivity**: Kerala has the inherent advantage of both high road density and a network of potential inland waterways. Investing in improving connectivity through further repair/development of these networks has the potential to increase agricultural competitiveness and production as it improves timely and economical access to essential inputs and markets. This can also lead to diversification of crop portfolios, substantial uptake of productive agricultural inputs and technologies, and increase in agricultural hiring and commercialization of farm output. Boosting corporate investment in infrastructure development is a potential option to increase connectivity, particularly in remote rural areas.

6.6.2.1 Proposed interventions for adaptation in the agriculture sector

Based on these adaptation strategies to address the major drivers of agricultural vulnerability, projects have been conceived and presented in **Table 6.9**. Priority districts(highly vulnerable) for the implementation of adaptation projects in Agriculture are Palakkad, Wayanad, Kasaragod, Idukki, Kozhikode, Malappuram, Kottayam, Kannur, and Thiruvananthapuram. The Department of Agriculture Development and Farmer's Welfare (DADFW) shall be the lead implementing entity. Kerala Agricultural University (KAU) shall be engaged to facilitate the planning and implementation of components requiring support from Krishi Vigyan Kendras (KVKs). Five scalable projects have been proposed, all of which are linked and are aimed at holistically improving the productivity and profitability of agriculture in vulnerable districts. The productivity zonation needs to be based on the agro-ecological zones and units identified for the State.

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Table 6.9: **Proposed projects/objectives and actions for Agriculture Sector (2023-2030)**

	Total Outlay (INR Crore) :	**4086.80**												
	Vulnerable Districts	**High**		Palakkad, Wayanad, Kasaragod, Idukki, Kozhikode, Malappuram, Kottayam, Kannur, Thiruvananthapuram										
		Medium		Thrissur, Pathanamthitta, Kollam										
	Projects / Objectives	**Planned Activities/Actions**		**Priority Districts**	**Implementing Agencies**		**Outlay (INR Crore)**							
							2023 -24	**2024 -25**	**2025 - 26**	**2026 -27**	**2027-28**	**2028 -29**	**2029 -30**	**2030 -31**	**Total**
		Outcome 1.1 Enhanced productivity; Climate-proofed agriculture systems and farm incomes; lowered energy and GHG emission intensity of crop and livestock production.												
1	**Sustainably enhancing agricultural productivity**	1	Crop Suitability Assessment and Productivity Zoning – mapping the least productive farmlands	All Kerala	Department of Soil Survey and Soil Conservation, KSREC, KSLUB, DADFW		0.5	0.6	0.6	0.7	0.7	0.0	0.0	0.0	**3.1**
		2	Periodic updating of soil health cards to assess nutrient needs of crops and assess Soil Organic Carbon (SOC) content to highlight carbon sequestration through climate-resilient agriculture. Measures will be adopted to popularize the usage of soil health cards. (e.g. incentives)		DADFW, Department of Soil Survey and Soil Conservation, KAU		4.0	4.4	4.8	5.3	5.9	6.4	7.1	7.8	**45.7**
		3	Promotion of Integrated farming and agroforestry with the use of improved seeds, precision, and timely irrigation, and input application preference to least productive areas of most vulnerable districts.		DADFW, Department of Soil Survey and Soil Conservation, KFD, MGNREGS, KAU		15.0	15.0	16.0	16.0	16.0	16.0	16.0	16.0	**126.0**

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		4	Plantation based Agroforestry Programme[3]	All Kerala	KDISC, DADFW		7.3	4.0	2.3	2.3	2.3	2.3	2.3	0.0	**22.8**
		5	Promotion of agrobiodiversity[4] , promotion, and cultivation of Climate Resilient crops, traditional varieties etc., and shifting from risky crops (except paddy) to integrated farming systems to lower risks of crop loss.		DADFW, KDISC, KSBB, KAU		2.0	2.2	2.4	2.7	2.9	3.2	3.5	3.9	**22.8**
		6	Promotion of closed loop agricultural practices - Research & Training		DADFW, KAU		5.0	5.5	6.1	6.7	7.3	8.1	8.9	9.7	**57.3**
		7	Promotion of collective farming.		DADFW		75.0	82.5	90.8	99.8	109.8	120.8	132.9	146.2	**857.8**
		8	Promotion of spice and plantation crop cultivation including training and supply of climate-resilient planting materials		DADFW, Spices Board, Rubber Board, Coffee Board, Tea Board, Plantation Corporation of Kerala, CPCRI, KAU		19.0	20.9	23.0	25.3	27.8	30.6	33.7	37.0	**217.3**
		9	Development of climate resilient agricultural practices and varietal trials		DADFW, KAU		3.0	3.3	3.6	4.0	4.4	4.8	5.3	5.8	**34.2**
		10	Crop pest surveillance system to assist beneficiary farmers with pest management (leverage information, databases, and tools created under the first SAPCC).		DADFW		1.0	1.1	1.2	1.3	1.5	1.6	1.8	1.9	**11.4**

3 K-DISC initiated the Climate Smart Coffee project in Wayanad as part of the Wayanad Package. The project includes creating a Package of Practices to utilise the GI tag of Wayanad Coffee and Watershed Studies.

4 Conservation of agricultural biodiversity, particularly rice varieties indigenous to Kerala, has been actively undertaken since 2009, at the Thanal Agroecology Centre, Wayanad.

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		Outcome 1.2: Increased mechanization, number of crop advisory services (units), training imparted, number of farmer producer organizations and marketing linkages established													
	SDG - 1, 2, 3, 5, 10, 11, 12, 13, 15 NDC - 6	11	Community based mechanization - Adoption of energy efficient technologies - UAVs with targeted financing and training to farmers. (Under the Agro-service centres)	All Kerala	DADFW		20.0	22.0	24.2	26.6	29.3	32.2	35.4	39.0	**228.7**
		12	Short term crop advisory		DADFW, KAU		2.0	2.2	2.4	2.7	2.9	3.2	3.5	3.9	**22.8**
		13	Training on climate resilient practices.				2.0	2.2	2.4	2.7	2.9	3.2	3.5	3.9	**22.8**
		14	Create market linkages - GI Tagging, Apps				1.5	1.7	1.8	2.0	2.2	2.4	2.7	2.9	**17.2**
		15	Creation and strengthening of Farmer Producer Organizations (FPOs)		DADFW		18.0	19.8	21.8	24.0	26.4	29.0	31.9	35.1	**206.0**
		16	Support to take up in-situ water harvesting, soil, and moisture conservation works in the priority district-farmers lands with MGNREGS convergence.		DADFW, Department of Soil Survey and Soil Conservation, MGNERGS		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
		Total					**175.3**	**187.4**	**203.4**	**222.1**	**242.3**	**263.8**	**288.5**	**313.1**	**1895.9**
		Outcome 2: Reduced post-production losses, Higher farm incomes, Food and nutrition security, GHG emissions avoided.													
2	**Enhanced Storage / Processing Infrastructure** SDG - 1, 2, 3, 5, 8, 10 NDC – 2, 3, 6	1	Food processing infrastructure	All Kerala	DADFW, KINFRA		8.0	8.8	9.7	10.6	11.7	12.9	14.2	15.6	**91.5**
		2	Flood resilient warehouses for agriculture products		Kerala State Warehousing Corporation, DADFW		8.2	3.1	2.1	5.0	7.6	6.6	2.9	2.0	**37.5**

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		3	Climate proof temporary grain storage structures with drying facilities for large padasekharams	Palakkad, Thrissur, Alappuzha, Kottayam	Kerala State Warehousing Corporation, DADFW		5.0	5.5	6.1	6.7	7.3	8.1	8.9	9.7	**57.3**
		4	Bring in energy efficiency in food processing units and storage facilities	All Kerala			3.0	3.3	3.6	4.0	4.4	4.8	5.3	5.8	**34.2**
		Total					**24.2**	**20.7**	**21.5**	**26.3**	**31.0**	**32.4**	**31.3**	**33.1**	**220.5**
		Outcome 3: Capacity built to undertake more sustainable and profitable agricultural ventures.													
3	**Access to agricultural credit** SDG - 1, 2, 5, 8, 10, 12 NDC - 6	1	Identifying regions where the population burden on existing credit societies are high - Strengthening existing credit societies, wherever necessary	Palakkad, Wayanad, Idukki, Malappuram, Pathanamthitta, Thrissur, Kollam, Thiruvananthapuram	DADFW, Department of Cooperation, NABARD		2.5	2.8	3.0	3.3	3.7	4.0	4.4	4.9	**28.6**
		2	Comprehensive agricultural development through PACS and the popularization of the Kisan Credit Card	All Kerala			5.5	6.1	6.7	7.3	8.1	8.9	9.7	10.7	**63.0**
		3	Higher incentives for farmers taking up sustainable agriculture practices, particularly women				3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	**24.0**
		Total					**11.0**	**11.9**	**12.7**	**13.6**	**14.8**	**15.9**	**17.1**	**18.6**	**115.6**
		Outcome 4: Crop insurance based on weather and productivity information in place, awareness created, and agro advisories extended.													
4	**Weather induced Risk Management** SDG - 1, 2, 5, 8, 10, 12 NDC - 6	1	Awareness campaign in most vulnerable districts on the impacts of climate change on crop productivity and the provisions of weather-based crop insurance	All Kerala	DADFW, KAU, K-DISC		0.5	0.6	0.6	0.7	0.7	0.8	0.9	1.0	**5.7**

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		2	Identify districts that have uneven coverage of meteorological monitoring stations (MMS) and invest in establishing them to work with KVKs to provide farmers with agro-advisories.	All Kerala	DADFW, KAU, K-DISC		2.0	2.2	2.4	2.7	2.9	3.2	3.5	3.9	**22.9**
		3	Leverage the restructured Weather Based Crop Insurance Scheme[5] being implemented in Kerala, in collaboration with MMS, KVKs, with attractive premiums and easy claims, especially in project districts				100.0	110.0	121.0	133.1	146.4	161.1	177.2	194.9	**1143.6**
		Total					**102.5**	**112.8**	**124.0**	**136.4**	**150.1**	**165.1**	**181.6**	**199.8**	**1172.3**
		Outcome 5: The capacity of farming communities and agricultural systems enhanced, reduced post-production losses, and markets created, and farm incomes enhanced.													
5	**Strengthened institutional framework** SDG - 10, 12 NDC-6	1	Strengthening of Krishi Bhavans based on net sown area-Enhance capacity of existing Krishi Bhavans– with a focus on human capital and technical skill to expand coverage of extension services	Wayanad, Kasaragod, Idukki	DADFW, Department of Food and Civil Supplies, Department of Cooperation, NABARD, KIIFB, KAU		20.0	22.0	24.2	26.6	29.3	32.2	35.4	39.0	**228.7**
		2	Create new market infrastructures where needed, with all supporting amenities[6]	Idukki, Wayanad, Kasaragod, Malappuram, Palakkad			6.0	6.6	7.3	8.0	8.8	9.7	10.6	11.7	**68.7**
		3	Development of agro parks, post-harvest management facilities, cold-chain supply system	All Kerala			50.0	30.0	30.0	33.0	30.0	33.0	36.3	39.9	**282.2**

5 *Transparently disseminate information (daily weather parameters value, alerts on deviation, insurance pay out eligibility on occurrence of peril conditions) to farmers, agriculture department officials etc.*

6 *Infrastructure including drainage, toilets, waste management, and energy. Ensure new market infrastructure is flood proofed in flood-prone areas.*

		4	Strengthening Agri Knowledge Centres, Farm Schools	All Kerala	DADFW, Department of Food and Civil Supplies, Department of Cooperation, NABARD, KIIFB, KAU		2.0	2.2	2.4	2.7	2.9	3.2	3.5	3.9	**22.8**
		5	Incubation Centres and Start-ups				2.0	2.2	2.4	2.7	2.9	3.2	3.5	3.9	**22.8**
		6	Strengthening Farmers Service Centres				5.0	5.5	6.1	6.7	7.3	8.1	8.9	9.7	**57.3**
		Total					**85.0**	**68.5**	**72.4**	**79.7**	**81.2**	**89.4**	**98.2**	**108.1**	**682.5**
														Grand Total	**4086.8**
	* The Implementing agency first mentioned in the list shall be the lead implementing entity and the other agencies mentioned shall be included by the lead as per the requirement of the actions/ objectives. Also, the first agency was the lead consulting agency for the plan preparation and reporting lead in the M&E mentioned later in the plan Agencies cited: DADFW-Department of Agriculture and Farmers Welfare; KSREC-Kerala State Remote Sensing and Environment Centre; KSLUB- Kerala State Land Use Board; KFD-Kerala Forests & Wildlife Department; MGNREGS-Mahatma Gandhi National Rural Employment Guarantee Scheme; KAU-Kerala Agriculture University; NABARD-National Bank for Agriculture and Rural Development; KIIFB-Kerala Infrastructure Investment Fund Board; KINFRA-Kerala Industrial Infrastructure Development Corporation; K-DISC-Kerala Development and Innovation Strategic Council; CPCRI-Central Plantation Crops Research Institute; KSBB-Kerala State Biodiversity Board														

6.6.2.2 Potential barriers to implementation of adaptation projects in the agriculture sector

- **Sustainably Enhancing Agricultural Productivity (SEAP)**
  - The project has a combination of components that aim to enhance the productivity of agriculture systems along the entire value chain and will require substantial convergence with other departments and sectoral experts for development of project design documentation and implementation.
  - Financing the project may be difficult, particularly to show scalability. Here, additional funds from external sources can be mobilised to fill resource gaps.
  - Technical skill of staff will need to be built to think outside the box. Currently, departments are used to working in silos and there is no skill sharing or ideation among different departments that are clearly interdependent.
- **Enhanced storage / processing infrastructure**
  - Project may face financial constraints – material intensive investment.
  - Technical capacity to design and construct 'green' food processing and storage facilities needs to be built. Department can consult with experts in the green infrastructure space to optimise resources (construction materials and funding). Procurement of energy-efficient appliances may also be a limiting factor.
- **Access to agricultural credit**
  - Institutional barriers to implementation. The formulation of new and functional credit societies may observe push-back from existing financial institutions.
  - Securing sufficient funding to create new credit societies may also be a barrier for implementation.
  - Technical skill of members of credit societies to identify and grade the value added by sustainable agriculture ventures proposed by loan applicants may need to be built in order to provide the proposed incentives.
  - Unless agriculture is climate proofed, the existing trend of high rate of overdue in primary agricultural credit societies arising out of crop failures due to natural calamities will lead to stagnation of credit societies, thereby lowering their reliability to provide any support to agricultural activities in prioritized areas.
- **Weather induced risk management**
  - Technical and financial barriers may be foreseen for the creation of more meteorological monitoring stations in prioritised districts – availability of skilled personnel in the State as well as capital to invest in required infrastructure. Furthermore, capacity to comprehend the subtle impacts of weather anomalies on the agriculture sector is essential for the development of crop and income saving agro-advisories.
  - Institutional barriers to developing and promoting new types of insurance schemes.
- **Strengthened institutional framework**
  - Financial barriers to implementation, given limited resources.
  - Lack of technical skill to ensure new market infrastructure is decarbonized and climate resilient.

6.6.3. Livestock

Livestock has been found to be highly vulnerable in four districts in the State - Palakkad, Kasaragod, Idukki and Kollam, and five were ranked as being moderately vulnerable, which has the potential to increase with climate change impacts, if the drivers of inherent vulnerability are not addressed. The drivers of vulnerability include - low ratio of local breeds to cross breeds, high variation in dairy productivity, insufficient veterinary services (doctors and hospitals), processing units, and cooperative societies and poor insurance coverage. Reducing climate stress on livestock must focus on the aspects of animal nutrition, housing, breeding, and health. The major strategies for adaptation planned are:

1. **Breeding strategies**: There is a need to identify and strengthen local/ endemic breeds

that have well adapted to local climatic stresses and feed sources. As currently, there are more high-yielding, cross-bred livestock in the State, there is a need to improve livestock genetics through crossbreeding with heat and disease-tolerant local breeds, so that future bloodlines can tolerate climate stress while still being highly productive.

2. **Expanding and improving the productivity of poultry**: At present, in districts that have been ranked as highly vulnerable in terms of animal husbandry; poultry farms are underperforming. As such, there is a need to make environmental modifications (providing sufficient shade and ventilation), and nutritional and drinking water manipulation (modification of diet composition, changing both the feeding time and the frequency) in existing commercial poultries to boost productivity. Backyard poultry can be promoted among poorer sections of the community.
3. **Improving productivity of milch animals**: Strategies to sustainably improve the productivity of milch animals include providing extra concentrate minerals supplementation and feed additives; making changes to micro-climate in cattle shed/stall by the installation of shade, sprinklers, or evaporative cooling systems; plantation of fodder tree lines around animal shed/house to lower heat stress; ensuring livestock are both stall-fed and grazed in pastures; change feeding schedules to late afternoon and early morning; reducing livestock numbers in some cases, or changing herd composition; and improving water resources (availability, access, and use). Strategies that are focused on improving animal feed also have the added benefit of mitigating methane emissions from enteric fermentation.
4. **Improving animal health**: The impacts of climate change extend beyond affecting the productivity of livestock to also changing patterns of endemic diseases in livestock. Districts identified as being highly vulnerable in terms of animal husbandry lack the necessary human resources and infrastructure to address such challenges. There is a need to develop effective animal health services associated with surveillance and emergency preparedness systems and animal disease control and prevention programmes. The State will first need to invest in the filling of vacancies at existing veterinary hospitals and clinics and create new infrastructure to provide veterinary services. Support is needed for the development of community-based animal healthcare services such as mobile dispensaries, with the training of farmers, para-veterinary practitioners, and extension workers to provide basic health and emergency veterinary services for livestock.
5. **Empowering women**: Owning and managing livestock, a productive asset, has the potential to empower rural women by providing them with a source of income and safeguarding their household's nutritional security. There is a need to create enabling policies such as index-based livestock insurance targeted at women and women-owned livestock as well as developing a separate fund to increase women's participation in the dairy sector. Their participation in dairy cooperatives needs to be encouraged.
6. **Other Strategies**:
    - Strengthening meteorological services (installation of additional weather monitoring stations) to provide local and timely weather and climate forecast/information;
    - Developing early warning systems to help farmers respond to both short-term/rapid onset climatic hazards such as cyclones, floods, storms, etc., as well as long-term/slow onset hazards (drought, saltwater intrusion, groundwater depletion, water stress, etc.);
    - Conservation of genetic resources of indigenous livestock;
    - Development and promotion of drought-tolerant and early maturing fodder crops;
    - Improve vaccination coverage – farmer sensitization, health camps;
    - Improve supply chain and trade networks;
    - Strengthening transport, storage, processing, and market infrastructure in the dairy sector.

6.6.3.1 Proposed interventions for adaptation in the livestock sector

Based on the above adaptation strategies to address the major drivers of livestock vulnerability, projects have been conceived and presented in **Table 6.10**. Priority districts for the implementation of adaptation projects in livestock are Palakkad, Kasaragod, Idukki and Kollam. Three interventions have been conceived. The Department of Animal Husbandry shall be the lead implementing agency. Collaboration with Kerala Veterinary and Animal Sciences University (KVASU) is needed, particularly for the provisioning of information on the breeding and rearing of native species, and the development of disease surveillance and emergency preparedness systems. The project, titled 'Climate Resilient Livestock Production' has components that can co-benefit in mitigating methane emissions from enteric fermentation with dietary changes, as well as sequester carbon in fodder trees planted by livestock far.

6.6.3.2 Potential barriers to implementation

- **Climate-smart livestock production**
    - Although research was proposed under the first SAPCC to identify and strengthen indigenous breeds that have adapted to local climate stress and feed sources, the translation of research results into developing successful crossbreeding programmes and propagation of improved breeds could potentially be a barrier. Technical capacity needs to be built, wherein existing breeding programmes are refined to conserve indigenous germplasms as well as to improve their productivity through crossbreeding and marker-assisted selection.
    - Additional funds from developed countries or development banks may have to be mobilized to finance the project and to scale it up to cover the entire State.
    - Technical skills may be lacking to develop climate-resilient, high-yielding breeds of livestock.
    - To maximize climate co-benefits, a piecemeal approach (which is the business-as-usual strategy) to the implementation of project components should not be done. Selected beneficiaries must receive all the benefits of the project, including improved livestock breeds; climate-proofed cattle sheds; feed (concentrates); access to dairy, cold storage, and meat processing infrastructure, as well as insurance. Then, and only then, will project outcomes be achieved.
- **Push for poultry performance**
    - The project may observe pushback from established commercial poultries to deviate from business-as-usual models of production.
    - Technical skills in-house may be lacking to provide the necessary training on best practices in the poultry sector under climate change scenarios. Capacity to be built.
    - Sourcing financial resources for the project may be a constraint. This is very well reflected in the existing allocation for poultry development in the State.
- **Animal disease control and prevention programme**
    - Deficient skilled human resources and finances poses a serious technical and financial barrier to the project. Research and surveillance facilities need to be strengthened.

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Table 6.10: **Proposed projects/objectives and actions for Livestock Sector (2023-2030)**

	Total Outlay (INR Crore) :	**1281.20**												
	Vulnerable Districts	**High**	Palakkad, Kasaragod, Idukki, Kollam											
		Medium	Malappuram, Wayanad, Thrissur, Kozhikode, Ernakulam											
	Projects / Objectives	**Planned Activities/Actions**		**Priority Districts**	**Implementing Agencies**		**Outlay (INR Crore)**							
							2023 -24	**2024 -25**	**2025 - 26**	**2026 -27**	**2027-28**	**2028 -29**	**2029 -30**	**2030 -31**	**Total**
		Outcome 1: Capacity of livestock farmers increased and around the year quality fodder availability enhanced												
1	**Climate resilient livestock production** SDG - 1, 2, 3, 5, 8, 11, 12 NDC - 1, 6	1	Research on indigenous and crossbred dairy animals breeding and rearing - Creating a research repository and decision making support system	All Kerala	KVASU, AHD		30.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	**40.00**
		2	Research for selection, based on climate resilient traits among domestic animals and their promotion		KLDB, KVASU		2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**9.00**
		3	Improving micro-climate in cattle sheds for alleviating heat stress.[7]	Palakkad	DDD, KLDB, KVASU		0.38	0.42	0.46	0.51	0.56	0.61	0.67	0.74	**4.35**
		4	Establishment of fodder banks and provisioning of subsidized fodder to marginalized farmers.[8]	Palakkad, Kasaragod, Idukki, Wayanad, Kozhikode, Malappuram, Thrissur Ernakulam and Kollam			8.20	8.30	8.40	8.60	8.70	8.80	8.90	9.00	**68.90**
		5	Ensure animal shelters are climate resilient (particularly flood proofed) and increase the number of ambulances in vulnerable areas.[9]	Alappuzha, Ernakulam, Thrissur, Pathanamthitta, Palakkad.	DDD		8.65	8.65	8.68	8.70	8.72	8.74	8.78	8.80	**69.72**

7 *Shade, improved ventilation, easy access to drinking water, etc. - focus on agro-forestry and other nature-based solutions: fodder grass and suitable flora around cattle sheds including live fencing and paddock*

8 *Leverage financial aid, irrigation assistance, and fodder slips provided by Dairy Development Department for fodder cultivation on barren lands*

9 *Disaster relief shelters should be built for livestock on raised platforms for flood proofing in flood-prone locations elevated and community cattle sheds.*

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		6	Lowering CH4 emission intensity of milk production by providing extra concentrate minerals supplementation and feed additives; stall cum pasture grazing, etc.	All Kerala	DDD		53.60	53.70	53.80	53.90	54.00	54.10	54.20	54.30	**431.60**
		7	Capacity building and awareness programmes to be arranged in vulnerable districts.	Palakkad, Kasaragod, Idukki, Wayanad, Kozhikode, Malappuram, Thrissur Ernakulam, and Kollam	AHD, KVASU, DDD		1.00	1.20	1.30	1.40	1.50	1.60	1.70	1.80	**11.50**
		8	Establish / improve dairy, cold storage, and meat processing infrastructure in project locations.	Palakkad, Kasaragod, Idukki, Kollam and Wayanad	DDD, MPI, MILMA		1.00	1.20	1.30	1.40	1.50	1.60	1.70	1.80	**11.50**
		9	Increase coverage of livestock under climate-based insurance schemes, prioritizing livestock that is owned by women.	All Kerala	DDD, AHD		6.00	7.00	7.20	7.40	7.60	7.80	7.90	8.00	**58.90**
		10	Conduct veterinary health care camps during natural calamities and disease outbreaks.	Palakkad, Kasaragod, Idukki, Wayanad, Kozhikode, Malappuram, Thrissur, Ernakulam, and Kollam			0.42	0.44	0.46	0.50	0.55	0.57	0.60	0.62	**4.16**
		11	Contingency fund for dairy farmers in the wake of climate change-induced hazards.	All Kerala			1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.35**
		Total					**112.60**	**91.91**	**82.60**	**83.41**	**84.13**	**84.82**	**85.45**	**86.06**	**710.98**

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		Outcome 2: Productivity enhanced and higher farm incomes, with established circular economy models and increased livelihood opportunities.													
2	**Push for Poultry Performance** SDG - 1, 2, 3, 5, 8, 10, 12 NDC - 6	1	Revamp existing commercial poultries: provide training about productivity optimization techniques and financial aid to implement strategies .	Palakkad, Kasaragod, Idukki, and Kollam	AHD, KSPDC, Kudumbashree		1.30	1.32	1.34	1.36	1.38	1.40	1.41	1.42	**10.93**
		2	Promote backyard poultry in highly vulnerable districts .				18.10	18.20	18.30	18.40	18.50	18.60	18.70	18.80	**147.60**
		3	Promote conversion of poultry waste into commercially viable value-added products as an income-generating activity.		KVASU, KSPDC		0.19	0.20	0.20	0.20	0.20	0.20	0.20	0.20	**1.59**
		Total					**19.59**	**19.72**	**19.84**	**19.96**	**20.08**	**20.20**	**20.31**	**20.42**	**160.12**
		Outcome 3: Improved health care systems and reduced livestock mortality in the project districts													
3	**Animal disease control and prevention programme** SDG – 2, 3, 5, 8, 15 NDC - 6	1	Improve vaccination coverage of livestock for new and emerging diseases. Research on new and emerging diseases in livestock.	Ernakulam, Malappuram, Kasaragod. Wayanad, Kozhikode.	AHD, KVASU		30.10	30.20	30.30	30.40	30.50	30.60	30.70	30.80	**243.60**
		2	Develop surveillance and emergency preparedness systems – advisories to be provided to all farmers owning livestock.	All Kerala			10.00	10.10	10.20	10.30	10.40	10.50	10.60	10.70	**82.80**
		3	Strengthen existing veterinary hospitals and clinics, and create new infrastructure to provide veterinary services.	Wayanad, Palakkad, Kasaragod, Idukki and Kollam			3.20	3.30	3.40	3.50	3.60	3.70	3.80	4.00	**28.50**

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		4	Promote community-based animal healthcare services: installation of mobile dispensaries and training of farmers, para-veterinary practitioners, and extension workers to provide basic health and emergency veterinary services for livestock.	All Kerala	AHD, KVASU		1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	**11.60**
		5	Promotion of the One Health platform.				5.10	5.20	5.30	5.40	5.50	5.60	5.70	5.80	**43.60**
		Total					**49.50**	**50.00**	**50.50**	**51.00**	**51.50**	**52.00**	**52.50**	**53.10**	**410.10**
														Grand Total	**1281.20**
	* The Implementing agency first mentioned in the list shall be the lead implementing entity and the other agencies mentioned shall be included by the lead as per the requirement of the actions/ objectives. Also, the first agency was the lead consulting agency for the plan preparation and reporting lead in the M&E mentioned later in the plan Agencies cited: AHD- Animal Husbandry Department; KVASU-Kerala Veterinary and Animal Sciences University; DDD-Dairy Development Department; KLDB- Kerala Livestock Development Board; MPI- Meat Products of India; MILMA- Kerala Co-operative Milk Marketing Federation (known by its trade name Milma); KSPDC- Kerala State Poultry Development Corporation Limited.													

- Taking up various zoonotic diseases of public health importance through inter-sectoral collaboration between the Department of Health Services, Department of Animal Husbandry, and Kerala Veterinary and Animal Sciences University.

6.6.4. Coastal Fisheries

Kerala has a long coastline, and the majority of the State's districts (9 out of 14) are coastal districts. Marine and coastal systems are at extreme risk in the event of climate change. Sea level rise, coastal erosion and flooding, ocean warming and acidification, and increased frequency and occurrence of storms threaten to intensify the deterioration of coastal zones, which have a direct impact on the lives and livelihood of coastal fishing communities. According to the vulnerability assessment conducted for the sector, four out of the nine districts are highly vulnerable (Thiruvananthapuram, Kasaragod, Kannur, and Malappuram) due to their sensitivity and lack of adaptive capacity. The drivers of vulnerability in these districts have been identified to include limited aquaculture production, low per capita income of fisher folk, fewer freeze storage facilities, a high percentage of landless population among fisher folk, inadequate capacity of shelter camps, and a high percentage of the fisher folk living within 50 m from the high tide line. Local and nature-based adaptation strategies need to be prioritized to strengthen coastal ecosystems.

1. **Improving aquaculture production**: Investment in technological innovation and transfer to aquaculturists is the need. Expanding the production of fish seeds, through the development and installation of decentralized, state-of-the-art hatcheries focusing on the mass production of high-value fish. Improvements in breeding technology, disease control, feed, and nutrition (high-quality pellet feed), and low-impact production systems are interlinked areas where scientific knowledge can complement traditional understandings to improve efficiency. To ensure sustainability and lower the environmental impact of aquaculture, spatial planning and zoning can ensure that operations stay within an ecosystem's carrying capacity and can also lessen conflicts over resource use. Aquaculturists may also be incentivized for sustainable practices like free training, wastewater treatment, etc. The Department of Fisheries should leverage the latest information technology available (satellite and mapping technology, ecological modelling, climate information, open data sources, etc.) to improve spatial planning and monitoring, help the industry plan for and demonstrate sustainability, and mitigate potential climate change risks to the sector. Improving aquaculture production can also help reduce pressure on marine fisheries.
2. **Making the Coastal Villages Climate Resilient**: As per KSCADC, there are 221 fishing villages in Kerala and almost 8.9 lakh people live in these villages. It has been observed that the frequency of Tropical Cyclones (TC) has increased by 52 % during the recent epoch (2001-2019) in the Arabian Sea. This increasing trend is evident in its frequency, duration, and intensity. The increase in TC duration over the Arabian Sea is prominent during May, June, and October (Deshpande et al., 2021). Climate change and the shifts in the marine environment have already brought changes in the livelihood and culture of the people in these villages. The prominent of the changes is in the fishing calendar days of the fishing community and the changes are to impact small-scale fishermen the most. Programmes and interventions to holistically address underlying vulnerabilities and exposure to climate hazards in the coastal villages need to

be in place. There is a need to secure fisher folk incomes during the monsoon season when fishing activities are halted. Alternate livelihood options must be made available. Resilient Coastal Village Plans should prioritize, developing alternative livelihoods, enhancing fisheries-based incomes, improving the safety and energy efficiency of fishing as well as a general improvement in access to basic amenities such as drinking water supply, sanitation, and electricity to households in fishing communities.

3. **Develop Post-harvest infrastructure and technologies:** Many resources in the oceanic waters do not have ready market demand and require improved processing technologies. Inadequate cold storage infrastructure is affecting the potential to maximize profits. While new developments in marketing channels such as supermarkets are emerging in large cities with modern fish handling practices and facilities, small-scale fishermen are often unable to gain access to these marketing channels due to the poor quality of their products. These facilities need to be made available at landing centres, fishing harbours, and markets. The investment must be made in developing cold storage infrastructure that is close to processing units, with uninterrupted power and water supply, and locations with the availability of skilled and unskilled labour. Alternatively, refrigeration-enabled mobile fish vending kiosks may be promoted. Women-led Self-Help Groups involved in fish vending/ marketing may be encouraged and aided to invest and use such technology to maximize profits.
4. **Enhancing the income base of the fishermen:** The studies by CMFRI have shown that the trend in estimated marine fish landings (2011-2019) has shown a decline but trends in the estimated value of marine fish landings during the above period have increased. With the national trend in the number of persons involved in active fishing increasing (DoF, 2020). The income-generating capacity of the sector needs to be enhanced. However, it is suggested that from the currently fished areas, the country has reached a stage in which further increase in fishing effort and production must be viewed with caution. One of the innovative suggestions to enhance the income base of the fishing community is Pesca Tourism. The fishing vessels remain berthed at harbours during the fishing holiday. These could be put to constructive use, during the period or even during periods when fish availability was low, by temporarily converting them into tourism facilities. Standardization in fish marketing is yet another strategy to be suggested. Domestic marine fish market chains in India are generally characterized by unhygienic conditions, poor handling of fish and loss of quality (from the boat to the final market), and a subsequent reduction in profits. High levels of product losses through wastage (up to 15% of the harvest) are common (Vivekanandan, 2022).
5. **Safe housing for coastal communities**: Besides improving the capacity of relief shelters and having appropriate rescue relief and rehabilitation mechanisms in place in case of adverse climatic conditions, there is a need to provide safe housing to coastal communities on the landward side, beyond coastal hazard zones. Detailed mapping of communities at risk of future coastal hazards such as coastal flooding and erosion, saltwater intrusion, etc., needs to be conducted. Communities should be relocated out of potential hazard zones. Alternatively, investment in sustainable solutions including beach nourishment, and restoration of coastal wetlands, mangrove afforestation etc., can substantially reduce wave intensity and lower the risk of coastal erosion, thereby stabilizing shorelines and protecting coastal communities from coastal hazards. The specific interventions in this strategy require priority attention and have been detailed in the Priority Interventions in Section 6.6.8.

6. **Feasibility studies:** Studies to explore the possibility of cold-water fisheries for the improvement and conservation of indigenous fish species. Feasibility assessment for the development of resilient storm surge protection strategies and conversion of existing habitations to storm surge resilient habitations.
7. **Model fishermen village:** Envisages a sustainable coastal village including provision for the improvement of basic amenities such as safe drinking water, sanitation, provision for health facilities, houses, setting up of fish marketing centres, construction of fisheries schools, provisions to ensure alternate livelihood development programmes for the fishers, promotion of sustainable tourism, etc.
8. **Training:** Sensitization training for coastal communities to gain knowledge on climate change, impacts, and disaster responses and skill development on emergency rescue operations and safety measures both in marine and inland areas. Training on handling fresh including on-board and processed fish and its marketing will help improve income and the livelihood of fisher folks.

6.6.4.1 Proposed interventions for adaptation in the coastal fisheries sector

Based on the adaptation strategies to address the major drivers of coastal fisheries vulnerability, seven projects including training and feasibility studies have been conceived and presented in **Table 6.11**. Priority districts for the implementation of adaptation projects in coastal fisheries are Thiruvananthapuram, Kasaragod, Kannur, and Malappuram. The lead implementing agency will be the Fisheries Department. Disaster management information and support and provisioning of safe housing for coastal fishing communities at risk of impacts from coastal hazards shall be provided by the KSDMA. Investment in nature-based solutions (afforestation of mangroves) to stabilize coastlines and lower the impact of storm surges has significant potential to provision mitigation co-benefits through the storage of 'blue' carbon in mangrove trees. Replacement of existing kerosene run engines with diesel/petrol/LPG engines with higher fuel efficiency and reduced emissions is - also has mitigation co-benefits.

6.6.4.2 Potential barriers to implementation of adaptation projects in the coastal fisheries sector

- **Improving aquaculture production and management**
  - Technical barriers to enhancing aquaculture production exist. Capacity of Fisheries department need to be enhanced in order to integrate climate information into planning and decision making.
  - New technologies to maximise production in a sustainable way may not be locally available for cost-effective procurement, creating a financial barrier for project implementation. Technology and information transfer from developed countries might be needed.
- **Resilient coastal villages**
  - Similar to climate proofing projects proposed for the agriculture and livestock sectors, project components of this project should not be implemented in piecemeal in order to secure the incomes of fishing communities as a whole.
- **Efficient post-harvest management**
  - Project may face financial constraints – material intensive investment.

6.6.5. Forests and Biodiversity

The main drivers of vulnerability in the forest sector of Kerala are loss of biodiverse forest area and coverage, inadequate human resources, and establishments for forest conservation, as well as an increase in the number of forest fires. The districts of Kollam, Kottayam, Wayanad, and Kasaragod were classified as highly vulnerable. To lower the forest sector's inherent vulnerability,

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Table 6.11: **Proposed projects/objectives and actions for the Coastal Fisheries Sector (2023-2030)**

	Total Outlay (INR Crore) :	**3730.25**												
	Vulnerable Districts	**High**		Kasaragod, Kannur, Malappuram, Thiruvananthapuram										
		Medium		Kozhikode, Thrissur, and Alappuzha										
	Projects / Objectives	**Planned Activities/Actions**		**Priority Districts**	**Implementing Agencies**		**Outlay (INR Crore)**							
							2023 -24	**2024 -25**	**2025 - 26**	**2026 -27**	**2027-28**	**2028 -29**	**2029 -30**	**2030 -31**	**Total**
		Outcome 1: Enhanced aquaculture production and development of markets and training imparted in aquaculture production												
1	**Improving aquaculture production and management** SDG – 2,14 NDC - 6	1	Fish Stock Enhancement and Management	Kasaragod, Kannur, Kozhikode, Thiruvananthapuram, Kollam	DoF, KUFOS, CMFRI, KAVIL		5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	**40.00**
		2	Fish hatcheries - Fish seed production centres				20.00	20.00	10.00	5.00	5.00	5.00	5.00	5.00	**75.00**
		3	Surveillance and management systems[10]				5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	**40.00**
		4	Spatial planning and zoning to ensure that activities are within ecosystems carrying capacity and integration with climate information to protect aquaculture production from climate hazards				10.00	10.00	10.00	0.00	0.00	0.00	0.00	0.00	**30.00**
		5	Promotion of different aquaculture systems like cages, bioflocs, seaweed and mussel-oyster farming, aquaponics, and Integrated Multi Trophic Aquaculture (IMTA) at both riverine and open water systems				10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	**80.00**

10 *To Leverage the project outcomes of sustainable management of diseases implemented under the first SAPCC for fish seed, fingerlings, and information regarding diseases affecting aquaculture production.*

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		6	Device subsidies with an add-on product (e.g. insurance), assist aquaculturists to procure fish pens, cages, high-quality fish food, etc., while also protecting them from production losses due to extreme weather events	Kasaragod, Kannur, Kozhikode, Thiruvananthapuram, Kollam	DoF, KUFOS, CMFRI, KAVIL		10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	**80.00**
		7	Promotion of ornamental fish farming both at the backyard and entrepreneurship level				15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	**120.00**
		8	Promotion of live fish marketing and support for marketing and production				2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	**16.00**
		9	Training of aquaculturists in the latest available production technologies, mariculture techniques, high-value fish species, breeding technologies, disease control, and fish nutrition management				5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	**40.00**
		Total					**82.00**	**82.00**	**72.00**	**57.00**	**57.00**	**57.00**	**57.00**	**57.00**	**521.00**
		Outcome 2: Increased per capita income of fishing communities in the coastal villages. Reduced sensitivity of fisherfolk income (diversified income portfolios) -- Low carbon pathways established.													
2	**Resilient Coastal Villages** SDG - 1, 2, 3, 8, 11, 12,14 NDC - 1, 6	1	Leverage existing livelihood and skill development programmes for targeted skill development of fisherfolk living below the poverty line, landless, women, and youth, focusing on strategies to diversify their livelihoods, particularly during the monsoon season.	Kasaragod, Kannur, Thiruvananthapuram, Alappuzha, Malappuram,	DoF, KSDMA, MGNREGS, DADFW, LSGD.		15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	**120.00**

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		2	Pesca Tourism	All Kerala	DoF, DoT		15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	**120.00**
		3	Training is to be provided for the development of value-added seafood-based products and the making of artefacts and handicrafts from shells, bones, and bamboo.	Kasaragod, Kannur, Thiruvananthapuram, Kozhikode, Thrissur			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**8.00**
		4	Promotion of recycling of bycatch and fish waste for fertilizer and fish feed production.	All Coastal districts of Kerala			5.00	5.00	10.00	10.00	5.00	5.00	5.00	5.00	**50.00**
		5	Coastal communities are to be engaged through MGNREGS or other schemes for controlling marine littering and coastal pollution, especially for the removal of plastics and damaged nets, riverine and estuarine management[11] .	All Kerala	DoF, LSGD, HED, DoECC, SWAK, KCZMA		10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	**80.00**
		6	Incentives to support conservation programmes where some species/ ecosystems are supported in homesteads and other private lands - conservation of endangered marine tetrapods, conservation of turtle breeding grounds.		DoF, KFD, KSBB, KCZMA		10.00	10.00	5.00	0.00	5.00	5.00	5.00	5.00	**45.00**
		Total					**56.00**	**56.00**	**56.00**	**51.00**	**51.00**	**51.00**	**51.00**	**51.00**	**423.00**

11 *(Upscaling of Suchitwa Sagaram Project)*

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		Outcome 3: Increased fishery based income; value addition & livelihood of fisherwomen enhanced.													
3	**Enhancing fisheries based income** SDG - 1, 2, 8, 12,14 NDC - 1, 6	1	For fishing households having own land, promote integrated farming[12] .	All Kerala	DoF, KSCADC, KUFOS, CMFRI, DADFW, HED		20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	**160.00**
		2	Integrated multi-trophic aquaculture.	Kasaragod, Kannur, Kozhikode, Thiruvananthapuram, Kollam			10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	**80.00**
		3	Promoting climate-resilient seaweed farming.	All Coastal Districts			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**8.00**
		4	Promotion of mariculture of high-value marine species.				0.00	1.00	0.00	0.00	1.00	0.00	1.00	0.00	**3.00**
		5	Processed fish and value-added production.				15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	**120.00**
		6	Technology-driven supply chain and value chain management and promotion of innovations in marketing.	Malappuram, Kannur, Kasaragod, Alappuzha, Thiruvananthapuram			10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	**80.00**
		7	Improve participation of SHGs run by fisherwomen in livelihood development programmes and facilitate access to financial aid and insurance coverage.	Alappuzha, Thiruvananthapuram, Malappuram, Kozhikode, Ernakulam			10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	**80.00**
		8	Improvement of fish landings centres and post-harvest infrastructure.	All Coastal Districts			100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	**800.00**
		Total					**166.00**	**167.00**	**166.00**	**166.00**	**167.00**	**166.00**	**167.00**	**166.00**	**1331.00**

12 Crops, livestock, and fish culture; rice-cum-fish/shrimp farming in low-lying (inundated) salinized land areas, using salt-resistant paddy varieties

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		Outcome 4: Enhanced safety and energy efficiency of fishing													
4	**Improving the safety and energy efficiency of fishing** SDG – 1,3,8,9,13,14 NDC – 3,6	1	Establishment of village climate information system.	All Coastal Districts	DoF, KSDMA		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	**16.00**
		2	Tracking fishing boats by utilizing low-cost advanced airborne sensors (AAS) to aid rescue missions during extreme events and ensure the availability of safety equipment.				10.00	10.00	10.00	10.00	10.00	0.00	0.00	0.00	**50.00**
		3	Enrolment of all fisherfolk into the special insurance scheme (life and assets)				15.00	15.00	15.00	15.00	15.00	15.00	15.00	0.00	**105.00**
		4	Replacement of existing kerosene run engines with diesel/ petrol/LPG engines with higher fuel efficiency and reduced emissions				7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	**56.00**
		5	Berthing fenders, offshore anchoring				5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	**40.00**
		6	Ensuring all fisherfolk are enrolled in early warning system networks, revamping public alert systems in coastal villages, and establishments of well-equipped control-rooms in all districts.				10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	**80.00**
		Total					**49.00**	**49.00**	**49.00**	**49.00**	**49.00**	**39.00**	**39.00**	**24.00**	**347.00**

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		Outcome 5: Post-harvest infrastructures created, along with processing units reduced post-catch losses													
5	**Efficient Post Harvest Management** SDG - 1, 2, 3, 5, 8, 9, 12 NDC - 6	1	Investment in new cold storage infrastructure near landing centres, fishing harbours, and markets using green building models and energy efficient appliances.	Kozhikode, Malappuram, Kasaragod, Kannur	DoF		10.00	10.00	10.00	10.00	0.00	0.00	0.00	0.00	**40.00**
		2	Refrigeration enabled mobile fish vending kiosks for fisherwomen-run SHGs in project districts	All Coastal Districts			10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	**80.00**
		3	Development of extensive post-harvest storage and processing including marketing of processed products	Kozhikode, Malappuram, Kasaragod, Kannur			10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	**80.00**
		Total					**30.00**	**30.00**	**30.00**	**30.00**	**20.00**	**20.00**	**20.00**	**20.00**	**200.00**
		Outcome 6: Documented peer-reviewed reports													
6	**Feasibility studies** SDG - 1,2,5,12 , 14 NDC - 2, 6	1	Development of Cold-Water Fisheries for native varieties of Kerala	All Kerala	DoF, CMFRI, KUFOS		5.00	5.00	1.00	1.00	0.00	0.00	0.00	0.00	**12.00**
		2	To renovate existing habitations to withstand storm surges	All Coastal Districts			0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.25**
		Total					**5.25**	**5.00**	**1.00**	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**	12.25
		Outcome 7: Model fishermen's villages established.													
7	**Innovative interventions** SDG - 1, 2, 5, 8, 9, 12, 14 NDC- 1,2, 6	1	Model fishermen village, Integrated Aqua Park	All Coastal Districts	DoF, KSCADC		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	**800.00**
		Total					**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**800.00**
		Outcome 8: Enhanced capacity of the local fishermen to cope with the ill effects of climate change													
8	**Training** SDG – 12,13,14 NDC - 6	1	Providing sensitization training on basic impacts of climate change and disaster response as well as improving safety.	All Coastal Districts	DoF, KSDMA, Kerala Police		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**

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		2	Training on handling fresh (including on-board) and processed fish and marketing	All Coastal Districts	DoF		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	**16.00**
		3	Training and skill development in emergency rescue operations and safety measures both in marine and inland areas		DoF, KSDMA, Kerala Police, LSGD		10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	**80.00**
		Total					**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**96.00**
														Grand Total	**3730.25**
	* The Implementing agency first mentioned in the list shall be the lead implementing entity and the other agencies mentioned shall be included by the lead as per the requirement of the actions/ objectives. Also, the first agency was the lead consulting agency for the plan preparation and reporting lead in the M&E mentioned later in the plan Agencies cited: DoF-Department of Fisheries; KSDMA-Kerala State Disaster Management Authority; MGNREGS-Mahatma Gandhi National Rural Employment Guarantee Scheme; DADFW- Department of Agriculture and Farmers Welfare; LSGD-Local Self Government Department; HED-Harbour Engineering Department; DoECC- Directorate of Environment& Climate Change; KCZMA-Kerala Coastal Zone Management Authority; SWAK-State Wetland Authority Kerala; KAVIL- Kerala Aqua Ventures International Ltd.; KSCADC-Kerala State Coastal Area Development Corporation; KUFOS-Kerala University of Fisheries and Ocean Sciences; CMFRI-Centre Marine Fisheries Research Institute; KSBB-Kerala State Biodiversity Board.													

no-regret adaptation strategies must focus on afforestation to increase forest cover, biodiversity conservation, forest fire prevention and management, water harvesting and management in the forest, and management of human-wildlife conflict.

1. **Improving forest protection and enhancing forest cover:** The State's forest cover can be improved by assessing the existing state of the forest, developing a management plan based on it, and implementing programmes for forest regeneration. Afforestation under various centrally supported initiatives such as NAP, CAMPA, GIM, and others may be implemented in areas where afforestation and reforestation can be undertaken. Afforestation programmes can be carried out at a cluster level with tree planting on degraded lands, temples, schools, and other government spaces utilizing indigenous, rare, and endemic, fast-growing tree and plant species, incentivized by carbon market mechanisms. Convergence with social security schemes such as MGNREGA can also contribute to increasing forest cover in the State. Social forestry (agroforestry, farm forestry, and community forestry) with joint forest management needs to be promoted in addition to expanding forest cover to lower pressure on natural forests. Forest management programmes also need to be integrated with NABARD programmes to provide alternative livelihoods for SC and ST communities. Specific programmes like landscape-level agreements with private plantations to supply wood stocks to CHR for curing of cardamom so that tree felling in these areas is reduced, coupled with programmes to promote high-yielding and shade-loving varieties of cardamom in these regions need to be pursued. Kerala needs to develop models for agroforestry specific to its needs and potential. The Poplar culture model in UP can be a reference model for the State.
2. **Biodiversity Conservation:** It is critical to appropriately categorize forest areas for biodiversity conservation and management. This would improve the habitat and prevent anthropogenic activities from threatening fauna and flora conservation. To guarantee optimum protection, it is also necessary to identify ecologically important biomes for notification and preservation as Biodiversity Heritage Sites (BHS). Unique ecosystems such as shola-grassland forests, Myristica swamps, *vayals*, riparian forests, sacred groves, wetlands, mangroves, and other ecosystems should be given special protection by reducing habitat destruction, encroachment, and other developmental activities, as these ecosystems are home to diverse flora and fauna and are of high ecological importance. Large-scale landscape connectivity networks can be maintained for conservation objectives, connecting protected areas, corridors, and fragmented forests. In highly vulnerable districts, there is a need to strengthen the frontline staff in the forest departments and invest in the development of forest conservation establishments. Conservation efforts can be improved through capacity building and training programmes for personnel involved in forest conservation activities, as well as raising awareness about conservation practices in communities through education and involving stakeholders in wildlife and habitat protection and conservation. Controlling the spread of invasive and alien species - the participatory mechanism of forest management needs to be utilized more inclusively to employ this strategy.

3. **Enhancing the hydrological processes in forest-dominated ecosystems:** Forest water resource management is an important component that aids in the prevention of forest fires, the protection of biodiversity, and the improvement of forest cover. Management strategies may include identifying drought-prone forest areas and investing in works such as water harvesting and conservation structures, soil and moisture conservation, spring recharge, percolation tanks for groundwater recharge, etc., following a watershed development model. Capacity building and community participation and convergence with MGNREGS or NABARD may be explored to facilitate the development and implementation of water management plans.
4. **Management of forest fires:** The impact of fire is determined by the type of vegetation, the frequency and severity of the fire, and the season in which it occurs. Due to the high fuel load, fire causes considerable damage in deciduous woods and grasslands. Scientific management of forest fires requires planning and timely coordination. The Fire management plan should include long term data-based interventions. Establishing early warning systems and enhancing satellite and ground-based detection systems can enhance the effectiveness of fire management. Forest fire awareness among the fringe communities also is a necessary part of fire management. Proper training alongside firefighters and community firefighters, as well as equipping the force with the most up-to-date firefighting equipment and drones also can enhance fire management in the forests.
5. **Managing human-wildlife conflict**: Rapid urbanization and deterioration of wildlife habitats across the State are the primary reasons for human-wildlife conflict. There is a need for the development of pre and post-conflict strategies to mitigate potential conflicts. Vigilant groups may be established in all affected areas involving the public, forest officers, and members of local self-government and NGOs. Public and local political leaders must be sensitized about wildlife laws, wildlife habitat loss and resulting animal behaviour (forced migration of wild animals into farmlands and human habitations) and must be made willing partners to mitigate conflicts using ICT. Corpus funds for compensation need to be formed. Serious efforts must be taken to arrest the deterioration of habitats and promote conservation. Strengthening the participatory network in managing human-wildlife conflicts is necessary to address the issue sustainably and feasibly.
6. **Modernization/upgradation of technological systems:** This strategy must be seen as complementary to the previous strategies. Data-driven decision-making is very much a need for effective forest management. All the objectives mentioned here in fact could only be promptly achieved with proper data support systems in place. The Forest Management Information System (FMIS) establishment in the State needs to be revamped with sufficient professional engagement and effective and productive utilization of existing establishments. The conventional staffing pattern needs to be reconsidered with a sufficient influx of qualified professionals and proper integration of scientific know-how and technology. FMIS can effectively cater to address most of the climate change-induced challenges like forest fires, human-wildlife interface, forest resource management, managing forest dependency, habitat degradation, and effective protection. In addition to this, there is a need for a State-wide landscape management plan which is integrated with the unit level Management/ Working Plans. As proposed in the priority interventions The FMIS establishment can act as a database system for the State in the forest and biodiversity sector. The system needs to be updated and for this sufficient field, data units need to be established and properly updated and maintained. The use of geospatial technologies to cater to an informed decision-making process is essential.
7. **Enhancing Participatory Forest management:** Kerala has a model participatory forest management system in the country and has many successful actions that have resulted in enhancing forest protection. The forest-dependent communities could be the most prospective forest protectors as they have their community-specific incentives for forest protection. The FRA mechanism can be synchronised with the PFM system to enhance the resilience of the dependent communities, and thus enhance forest protection. The field level human resource deficiency in forest management which is one of the drivers of vulnerability in the forest and biodiversity sector can be addressed by strengthening the participatory mechanism.
8. **Research Studies:** Monitoring climate change responsiveness of forest and biodiversity specific to the State and the region it represents is necessary to frame informed decisions and to revise the existing management strategies and actions. Range shift of flora and fauna due to climate change need to be assessed. Also the response of invasive species and breeding migration of fishes need to be studied.

6.6.5.1 Proposed Interventions for adaptation in the Forests and Biodiversity sector

From the stakeholder consultations, eight adaptation projects have been conceived for the forest and biodiversity sector (**Table 6.12**), based on the identified strategies to address the major drivers of forest vulnerability. Four out of the eight adaptation projects conceived have mitigation co-benefits in the form of either CO_2 emissions avoided (preventing forest degradation or deforestation), or sequestration. Priority districts for the implementation of adaptation projects in the forest sector are Kollam, Kottayam, Wayanad, and Kasaragod.

6.6.5.2 Potential barriers to implementation of adaptation projects in the forest and biodiversity sector

- **Improving green cover and forest protection**
  - Land may be the major limiting factor, given the population density.
  - Farmer's willingness to plant indigenous tree species when more profitable tree species are available may pose a barrier to biodiversity conservation, which is a proposed intervention.
  - Tree species selection for afforestation activities within protected habitats needs special attention, as it can lead to the rapid spread of invasive species, pest and disease attacks and large-scale degradation of forest biodiversity.
- **Improving biodiversity**
  - Completely preventing anthropogenic interference with protected habitats may be very difficult to achieve.
- **Enhancing the hydrological process of the forest**
  - Push-back from forest dependent communities in soil and water conservation measures.
- **Integrated forest fire management**
  - Barriers to achieving the outcomes of the project are external as the major causes of forest fires in Kerala are:
  - Poachers setting fire to facilitate illegal activities and destroy evidence;
  - Peripheral habitations setting fires to prevent wild animal attacks, and
  - Farmers setting forest fires to aid in grazing.
- Community engagement will be pivotal to overcoming the barriers to project implementation in project districts.
- **Management of human-wildlife conflict**
  - Business-as-usual development and continued urbanization in the State could lead to further degradation and destruction of habitats, leading to increased human-wildlife conflict.

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Table 6.12: **Proposed projects/objectives and actions for the Forests and Biodiversity Sector (2022-2030)**

	Total Outlay (INR Crore) :	**3912.35**												
	Vulnerable Districts	**High**		Kollam , Kottayam, Wayanad, Kasaragod										
		Medium		Palakkad, Ernakulam, Malappuram										
	Projects / Objectives	**Planned Activities/Actions**		**Priority Districts**	**Implementing Agencies**		**Outlay (INR Crore)**							
							2023 -24	**2024 -25**	**2025 - 26**	**2026 -27**	**2027-28**	**2028 -29**	**2029 -30**	**2030 -31**	**Total**
		Outcome 1: Increased tree cover as identified by the net percentage increase from baseline for the plan period, and consolidated forest area												
1	**Improving green cover and improving forest protection** SDG - 3, 5, 10, 12, 13, 15 NDC - 1, 5	1	Afforestation programmes (indigenous species) in partnership with local bodies to improve green cover[13].	Kollam, Kottayam, Wayanad, Kasaragod	KFD, LSGD, Kudumbasree, KFRI, KSSB, KAU, PWD Education Department		2.00	2.00	3.00	3.00	1.00	1.00	1.00	1.00	**14.00**
		2	Site/location-specific planting in urban pockets, educational institutions, religious places, degraded common lands and other government-owned spaces.[14]				0.75	0.75	1.00	1.00	0.25	0.25	0.25	0.00	**4.25**
		3	Develop and propagate varieties of cardamom that are shade-loving and high yielding (especially for regions like the CHR).	Idukki, Wayanad	KFD, Spices Board, KAU, DADFW		1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	**5.50**
		4	Development of agroforestry, home gardens raising and distributing good quality saplings, and Incentives to farmers.	Kollam, Kottayam, Wayanad, Kasaragod, Malappuram, Palakkad, Ernakulam			0.50	0.50	0.50	0.25	0.25	0.25	0.25	0.25	**2.75**
		5	Consolidation and digitization of forest boundaries with high accuracy.	All Kerala	KFD		2.00	2.00	2.00	2.00	0.00	0.00	0.00	0.00	**8.00**

13 Including Non-governmental organizations, and educational institutions.
14 Project Reference-Vidya vanam, Nagara Vanam, Theera Vanam of KFD, Nagar Vadika of Government of India

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		6	Identification and setting up of High-Value Biodiversity Area (HVBA).	All Kerala	KFD		0.50	1.00	1.00	1.00	0.50	0.50	0.00	0.00	**4.50**
		Total					**6.75**	**7.25**	**8.50**	**8.25**	**3.00**	**2.50**	**1.50**	**1.25**	**39.00**
		Outcome 2: Biodiversity mapped, along with the spread, type and nature of invasive species and incorporated in the forest management/working plans, designated BHS/OECM/Marine Protected Areas/Fisheries Refugia.													
2	**Improving biodiversity** SDG - 3, 5, 10, 12, 13, 15 NDC - 1, 5, 6	1	Mapping of biodiversity, habitats, and sensitive areas outside the forest across Kerala. Inventory and documentation of biodiversity and preparation of online database.	All Kerala	KSBB, KFRI, KFD and JNTBGRI		0.50	0.30	0.00	0.00	0.00	0.00	0.00	0.00	**0.80**
		2	Designation of OECM/Marine Protected Areas/ Fisheries Refugia for preservation. (May follow the approach presented under the first SAPCC)		KSBB, KFD		0.00	0.20	0.20	0.00	0.00	0.00	0.00	0.00	**0.40**
		3	Scientific management of invasive alien species – flora and fauna		KFD, KSSB		5.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	**75.00**
		4	Identify biodiversity rich areas and notify them as Biodiversity Heritage Sites (BHS).		KSBB, KFD		0.30	0.30	0.00	0.00	0.00	0.00	0.00		**0.60**
		5	Ex-situ and in-situ conservation of RET species		KFD, KFRI, JNTBGRI		2.00	4.00	4.00	4.00	4.00	4.00	4.00	0.00	**26.00**
		6	Comprehensive protection strategy including Identification, consolidation and incentive programme for conservation of sacred groves and mangroves in Kerala.		KFD / KCZMA, DoR, LSGD		5.00	6.00	2.00	1.00	0.00	0.00	0.00	0.00	**14.00**

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		7	Conservation of wetlands and micro-habitats outside of forests.	All Kerala	KFD/SWAK, KSBB, LSGs		5.00	5.00	5.00	5.00	5.00	5.00	5.00	0.00	**35.00**
		Total					**17.8**	**25.8**	**21.2**	**20.0**	**19.0**	**19.0**	**19.0**	**10.0**	**151.8**
		Outcome 3: Critical water conservation areas mapped, restoration of degraded ecosystems including plantations (non-promising plantations and invasive species) and water harvesting works done and structures created.													
3	**Enhancing the hydrological process of the forests** SDG - 15 NDC- 1, 6	1	Mapping to identify critical areas within forests for soil and water conservation and management	Kottayam, Wayanad, Kasaragod, Malappuram, Palakkad, Ernakulam, Thiruvananthapuram, Idukki	KFD, Department of Soil Survey & Soil Conservation KFRI, NABARD, MGNREGS, JNTBGRI, LSGD		1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	**3.0**
		2	Riverbank stabilization.	All Kerala	KFD		0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.00	**1.8**
		3	Landscape-specific water harvesting structures.	Kottayam, Wayanad, Kasaragod, Malappuram, Palakkad, Ernakulam			1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	**13.00**
		4	Rejuvenating existing water harvesting structures.[15]	All Kerala			2.00	2.00	2.00	2.00	2.00	1.00	1.00	0.00	**12.00**
		5	Converting non-promising and unproductive teak plantations to natural forests and intensively managing the remaining promising plantation.				162.00	170.10	178.61	187.54	196.91	206.76	217.10	227.95	**1546.96**
		6	Eco-restoration (invasive monoculture plantations of eucalyptus, acacia and wattle)				66.00	69.30	72.77	76.40	80.22	84.23	88.45	92.87	**630.24**
		Total					**232.3**	**243.7**	**255.6**	**268.2**	**281.4**	**294.2**	**308.8**	**322.8**	**2206.9**

15 *Natural or manmade structures inside the forests and the activities including desilting, strengthening bunds, removal of weeds and the like*

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		Outcome 4: Fire management plan in place along with established fire incident response systems and reduced number of forest fires.													
4	**Integrated forest fire management** SDG - 13, 15 NDC - 1, 5	1	Preparation of an Integrated Forest Fire Management Plan	All Kerala	KFD, KAU, LSGD, KFRI		0.25	0.26	0.28	0.29	0.30	0.32	0.34	0.35	**2.39**
		2	Setting up of Incident Response Systems with infrastructures and systems, with the active participation of local communities.				2.00	4.00	4.00	2.00	2.00	2.00	2.00	0.00	**18.00**
		3	Awareness, training and capacity building of department staff and other departments like Fire and rescue and local communities. Joint training programmes for forest resource managers with firefighters.	Kollam, Wayanad, Palakkad, Thrissur, Ernakulam.	KFD		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	**4.00**
		4	Revamp current monitoring systems (patrolling fire-prone areas during the dry season, building watchtowers, etc.) with community participation.	Kollam , Wayanad, Palakkad, Thrissur Ernakulam.			1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.50	**7.00**
		5	Create additional firebreaks, buffer strips, and fire lines, as well as eliminate weeds.	Kollam , Wayanad, Palakkad, Thrissur, Ernakulam.			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	**2.00**
		6	Aerial Surveillance equipment and techniques.	Kollam , Wayanad, Palakkad, Thrissur, Ernakulam.			1.00	2.00	2.00	1.00	0.00	0.00	0.00	0.00	**6.00**
		7	Eco restoration of fire affected areas	All Kerala			0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	4.8
		Total					**5.5**	**8.5**	**8.6**	**5.6**	**4.7**	**4.7**	**4.3**	**2.3**	**44.2**

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		Outcome 5: HWC-Zonation done based on multiple parameters, identification of fragile areas requiring integration and integration established, and consolidation/ relocation in high conflict zones done under the PFM.													
5	**Management of Human-Wildlife Conflict (HWC)** **SDG-15** **NDC-1**	1	Identification of the nature/scale/ geography/ seasonality of Human-Wildlife Conflict in Kerala- leading to proper zonation	All Kerala	KFD, KVASU, KAU		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**8.0**
		2	Integration between fragile wildlife areas and proper landscape management practices	Wayanad, Palakkad, Pathanamthitta, Kannur, Idukki	KFD, DoR, LSGD		20.00	20.00	20.00	20.00	0.00	0.00	0.00	0.00	**80.00**
		3	Consolidation of private enclosures adjoining or inside forest lands witnessing high human-wildlife interface to natural forests with the participation of the local communities.	All Kerala	KFD, DoR, LSGD		100.00	100.00	100.00	100.00	100.00	0.00	0.00	0.00	**500.00**
		4	Landscape-suited barriers / structures				10.00	10.00	10.00	5.00	5.00	2.00	1.00	0.00	**43.00**
		5	Identification and Improving the health and quality of degraded habitats based on Disturbance Index	Ernakulam, Idukki Kottayam, Kollam Kasaragod	KFD, KSBB, KFRI, WII		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**8.00**
		6	Voluntary relocation of non-tribal private settlements inside the forest land	All Kerala	KFD, DoR		100.00	100.00	100.00	0.00	0.00	0.00	0.00	0.00	**300.00**
		7	Swapping of habitations of tribal communities from conflict zones to more suitable locations		KFD, STDD		100.00	100.00	100.00	100.00	100.00	0.00	0.00	0.00	**500.00**
		8	Facilitation of conflict reducing land use in the forest fringes		KFD, KAU, DADFW		1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	**7.00**
		9	Strengthening Rapid Response Team		KFD		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**8.00**
		Total					**334.00**	**334.00**	**334.00**	**229.00**	**209.00**	**6.00**	**5.00**	**3.00**	**1454.00**

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		Outcome 6: Long term integrated data-based decision support system in place													
6	**Modernization and integration of various technological systems used by the forest department at various levels** SDG - 13 NDC - 1, 6	1	Multipurpose Web GIS system for Forest Management -Synchronization of various data sources.	All Kerala	KFD		1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.00**
		2	Enhanced Forest Database Management System for the state				0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	**2.00**
		3	Automated Weather stations at various locations				1.00	2.00	1.00	0.00	0.00	0.00	0.00	0.00	**4.00**
		Total					**2.25**	**3.25**	**1.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**8.00**
		Outcome 7: Identified sustainable livelihood models along with established inclusive governance of forest ecosystems with an FRI integrated participatory mechanism at the divisional level,													
7	**Strengthening Participatory Forest Management (PFM) and livelihood** SDG- 5, 8, 10, 12 NDC - 1, 6	1	Identifying sustainable livelihood models involving forest protection.	All Kerala	KFD, STDD		0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00	**0.50**
		2	Enhance the process of reducing direct dependence on forests				0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	**2.00**
		3	Synchronization of FRA with PFM				0.25	0.25	0.25	0.25	0.00	0.00	0.00	0.00	**1.00**
		Total					**1.00**	**1.00**	**0.75**	**0.75**	**0.00**	**0.00**	**0.00**	**0.00**	**3.50**
		Outcome 8: Documented division/district-wise information for policy and decision-making on climate change Resilience/response of forests/ invasive species and the range shift of various fauna.													
8	**Research based information and studies on the impact of climate change on the forests and the biodiversity scene in the state** SDG - 3, 12, 13, 15 NDC - 6	1	Response and resilience of forest to climate change	All Kerala	KFRI, KSBB, WII		1.50	1.50	0.02	0.02	0.02	0.02	0.02	0.00	**3.10**
		2	Study and monitor the range shift of fauna with emphasis on amphibians, birds and butterflies due to climate change.				0.18	0.42	0.27	0.02	0.00	0.00	0.00	0.00	**0.89**

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		3	Study on climate change responses of invasive species	All Kerala	KFRI, KSBB, WII		0.25	0.25	0.02	0.00	0.00	0.00	0.00	0.00	**0.52**
		4	Impact of climate change on breeding migration of fishes				0.22	0.22	0.00	0.00	0.00	0.00	0.00	0.00	**0.44**
		Total					**2.15**	**2.39**	**0.31**	**0.04**	**0.02**	**0.02**	**0.02**	**0.00**	**4.95**
														Grand Total	**3912.35**
	* The Implementing agency first mentioned in the list shall be the lead implementing entity and the other agencies mentioned shall be included by the lead as per the requirement of the actions/ objectives. Also, the first agency was the lead consulting agency for the plan preparation and reporting lead in the M&E mentioned later in the plan Agencies cited: KFD-Kerala Forests & Wildlife Department; KFRI-Kerala Forest Research Institute; KSBB-Kerala State Biodiversity Board; KAU-Kerala Agriculture University; DoR-Department of Revenue; LSGD Local Self Government Department; NABARD-National Bank for Agriculture and Rural Development; JNTBGRI-Jawaharlal Nehru Tropical Botanical Garden and Research Centre; KILA- Kerala Institute of Local Administration; STDD-Scheduled Tribes Development Department; WII- Wildlife Institute of India; PWD-Public Works Department; DADFW-Department of Agriculture Development and Farmers Welfare; KVASU-Kerala Veterinary and Animal Sciences University; SWAK-State Wetland Authority Kerala; MGNREGS-Mahatma Gandhi National Rural Employment Guarantee Scheme; MBGIPS-Malabar Botanical Garden & Institute of Plant Sciences; KCZMA-Kerala Coastal Zone Management Authority.													

- Human resource deficiency at beat/range/ division level. The existing participatory mechanism has the potential to suffice the deficiency to some extent.
- **Strengthening Participatory Forest Management (PFM) and liveAvlihood**
  - Implementation and integration of the FRA might require restructuring of the PFM systems in the State. Also, the support of statutes and guidelines in implementing the FRA needs to be prepared.

6.6.6. Health

In the health sector, the districts of Kasaragod, Malappuram, and Palakkad, are classified as highly vulnerable. The assessment highlights the high population burden on healthcare professionals (doctors, frontline workers, etc.) and healthcare facilities. These districts also have a high percentage of the population that are inherently sensitive (below 6 and over 60 years of age, people living with disabilities), a low percentage of households with treated water supply, poor groundwater quality, high infant mortality rates, the prevalence of waterborne diseases, and poor insurance coverage. The sector's vulnerability in these districts can be reduced by adopting no-regret adaptation strategies targeted at improving healthcare infrastructure and service provisions, water supply and insurance coverage, and emergency healthcare services for inherently sensitive populations. Healthcare facilities are highly dependent on critical community services including electricity, clean drinking water, waste disposal and treatment. Strategic interventions in the health sector thus have cross implications with other sectors, especially the water resources sector. As such the interventions proposed here must be considered along with the sectoral interventions in the water resources sector and the priority interventions.

1. **Targeted healthcare for inherently sensitive populations/ vulnerable communities:** In the districts identified as being highly vulnerable, a large portion of the population is either very young, very old, or living with disabilities. These age classes are known to be particularly susceptible to climate-induced health impacts such as heat stress, asthma, etc. Within these districts, communities with the largest proportion of sensitive populations need to be mapped for the implementation of targeted adaptation strategies. These should include the establishment of neonatal, paediatric, and general emergency healthcare facilities with skilled healthcare professionals, regular awareness campaigns, with the training of village health workers to provide emergency healthcare.

   Lowering infant mortality rates in these districts is critical and can be achieved by training doctors, nurses, and midwives for early diagnosis and treatment of common childhood illnesses, as well as maternal care during pregnancy and delivery. Women should be encouraged and assisted to take advantage of the Pradhan Mantri Surakshit Matritva Abhiyan's antenatal care and institutional delivery provided under the Janani Suraksha Yojana (JSY). Special immunisation weeks can be organised to improve the health of neonates, particularly in areas where immunisation coverage is poor. Nutritional rehabilitation centres should be established to address cases of acute malnutrition in babies. There are other vulnerable communities including the tribal, coastal, and highland communities. Limited accessibility to tribal hamlets has been pointed out as a major hindrance in health service delivery to these communities. Addressing this as well needs priority.

2. **Increasing access to functional health care:** Extreme heat events and generally warmer summers are expected to increase heat-related illnesses and exacerbate chronic diseases (Costello et al., 2009; Hoffmann et al, 2008). Studies have also linked extreme heat events with increased healthcare facility visits (Knowlton et al., 2009; O'Neill, 2003). In order to address the heat related ailments, there should be a comprehensive heat adaptation plan for the State. During pre-heat seasons, the health department should be devoted to develop an early warning systems, communication plan of alerts to the general public, health care professionals, and voluntary groups (caregivers) with emphases on training and capacity building of these groups. The summer months should be in high alert, continuous monitoring and coordination with all the department's agencies concerned on one hand, and general public & media, on

the other hand. Post summer months, there should be an evaluation and updation of the heat management plan. Continuous updation of plan is a necessity, as there could be an increase in frequency, intensity and duration of heat waves and attributable deaths in coming years. A brief outlook on the roles of different departments is presented in the **Annexure 6.1**.

A functional healthcare system could cater to climate-sensitive ailments diagnosis and continuous health monitoring systems. This is essential to reduce the strain on the healthcare systems and to have an integrated health service. Maintaining efficient supply chains, such as essential drugs also need to be addressed. The hub and spoke model of lab services has relevance at this point. The shortage of healthcare professionals can be addressed by establishing more medical education institutions and training facilities in rural and semi-urban areas, as well as increasing the competencies of Kerala's medical employment by pushing for an increase in remunerations and incentives for healthcare professionals. The private sector should be incentivised (tax benefits, etc.) to contribute to enhancing rural healthcare infrastructure and services. The capacity of rural communities needs to be built to use eHealth Kerala. Infrastructure creation should be inclusive of sustainable practices from a climate change point of view including climate-proof stand-alone power facilities and emergency patient response systems.

3. **Safe drinking water along with safe and scientific sanitation:** Access to safe drinking water and the maintenance of a water supply infrastructure is essential to reducing the burden of water-borne disease. Decentralised wastewater treatment systems that recycle and reuse treated wastewater can provide access to water for other household purposes or irrigation, reducing the strain on freshwater sources. Another alternative is rainwater harvesting. During the pre-monsoon season, it is critical to monitor surface and groundwater water quality, especially in areas prone to diarrhoea and other water-borne infections. Keeping infective agents at bay requires proper sanitation and a reliable wastewater delivery system. Awareness campaigns for communities about water-borne infections and their transmission should be regularly conducted. This strategy has cross implications with the strategies devised to address the vulnerabilities in the water resources sector. The interventions, envisaged, under this strategy are specified in the section dealing with water resources sector interventions as well.

   Contaminated water and poor sanitation are linked to the transmission of diseases such as cholera, diarrhoea, dysentery, hepatitis A, typhoid, etc. Absent, inadequate, or inappropriately managed water and sanitation services expose individuals to preventable health risks. The vulnerable districts have been observed to have a low percentage of households with treated water supply, and poor groundwater quality, adding to the prevalence of water-borne diseases. It is necessary to ensure safe and scientific sanitation added with proper management of industrial effluents and proper greywater management is done in these districts

4. **Waste Management (solid and liquid):** Solid waste and plastic pollution are risk factors for vector-borne diseases and urban zoonoses (Krystosik et al., 2020). The Kerala State Action Plan for Climate Change and Human Health ascribes the prevalence of zoonotic and vector-borne diseases to accumulated waste and its poor management. Proper management of both liquid and solid waste is essential to prevent water-borne diseases. With an average of more than 120 days of annual rainfall in the State, specific interventions to manage waste to prevent contamination of surface water bodies are necessary. Treatment of biomedical waste is another important strategic intervention. The establishment of decentralised biomedical waste treatment plants like IMAGE in Palakkad and ensuring that the CPCB Guidelines are followed by all hospitals in the vulnerable districts. The establishment of STP and CETPs in vulnerable districts based on the existing gaps is necessary. It is also vital to halt indiscriminate garbage disposal by leveraging the Swachh Bharat Abhiyan Mission (SBAM).

5. **Maximizing Insurance Coverage:** Low per capita income is a factor which aggravates the climate change woes. Health insurance coverage in prioritised districts can be increased by organising campaigns and programmes to provide accurate information about various schemes and their benefits, as well as to urge poorer families to enrol by providing them with attractive premium prices and benefits. Beneficiaries may be given a list of empanelled hospitals and services under the Karunya Arogya Suraksha Padhathi (KASP) in Kerala, along with smart cards for cashless transactions.

6.6.6.1 Proposed projects/objectives and actions for the health sector

Based on these adaptation strategies to address the major drivers of health vulnerability, five projects have been conceived and presented in **Table 6.13**. Priority districts for the implementation of adaptation projects in the health sector are Kasaragod, Malappuram, and Palakkad. The Aardram Mission may be leveraged to implement project components of the proposed projects for the health sector.

6.6.6.2 Potential barriers to implementation of adaptation projects in the health sector

- **Safe drinking water and sanitation**
  - Land is a major limiting factor. Construction of waste treatment plants shall require sufficient space within villages to be built.
  - The project may face financial barriers to implementation, as land acquisition will be a substantial expense, besides the investment in technology and infrastructure.
- **Increasing access to functional healthcare**:
  - Financial and institutional barriers foreseen.
- **Insurance for sustainable healthcare**
  - Disinterest of communities and unsatisfactory uptake of health insurance schemes can affect achieving the outcome of this project.

6.6.7. Water Resources

In terms of water resources, the districts of Wayanad, Alappuzha, Kottayam, and Kozhikode were ranked as being highly vulnerable. They were ranked as such because they observe poor drainage density and irrigation coverage, as well as the insufficient storage capacity of reservoirs. Furthermore, surface water quality is low; and the number of surface water and meteorological monitoring stations is limited. The population density is high, exacerbating water stress, and many people live below the poverty line with only a limited number of households connected with treated water supply and fewer villages still with limited access to water throughout the year. Some of the interventions which have cross-cutting relevance are mentioned in the priority interventions part of this plan. The no-regret adaptation strategies for the water resources sector are:

1. **Sustainable access to safe drinking water**: Ensuring all households in highly vulnerable districts to sustainable and treated drinking water supply can be ensured under the existing Jal Jeevan Mission (JJM) and its associated projects. The speedy implementation of the JJM in the priority districts is the strategy proposed. JJM is being implemented by the Kerala Water Authority as well as the KRWSA. Roof-top rainwater harvesting structures may be promoted for other domestic uses to optimize drinking water availability and use. Capital subsidies for rainwater harvesting structures may be devised. In areas where piped connections are risky or difficult to be extended, appropriate alternative measures like protecting the existing water sources and establishing rainwater harvesting structures and gravity schemes can be undertaken. Also, in places where water quality issues are prevalent, quality enhancement and monitoring measures need to be in place. Community-based drinking water projects should be promoted.

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Table 6.13: **Proposed projects/objectives and actions for Health Sector (2023-2030)**

	Total Outlay (INR Crore)	**1937.8**												
	Vulnerable Districts	**High**		Kasaragod, Malappuram, Palakkad										
		Medium		Kannur, Wayanad, Kozhikode, Thrissur, Ernakulam, Alappuzha, Kollam										
	Projects / Objectives	**Planned Activities/Actions**		**Priority Districts**	**Implementing Agencies**		**Outlay (INR Crore)**							
							2023 -24	**2024 -25**	**2025 - 26**	**2026 -27**	**2027-28**	**2028 -29**	**2029 -30**	**2030 -31**	**Total**
		Outcome 1: Reach and service to inherently sensitive populations enhanced and access to healthcare improved, Emergency management facilities increased and essential social security establishments in place in the vulnerable districts.												
1	**Targeted healthcare for sensitive populations** SDG -1, 3, 10, 13 NDC- 1, 6	1	Mapping of the community-wise proportion of the sensitive population in the priority districts and assessing the gap in the services to the identified groups (very young, very old, or living with disabilities).	Kottayam, Alappuzha, Malappuram, Palakkad, Kannur, Kasaragod, Wayanad.	DHS		0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	**0.10**
		2	Strengthening emergency healthcare services (general, neonatal, and paediatric] in the priority districts.	Kottayam, Alappuzha, Malappuram, Palakkad, Kannur, Kasaragod, Wayanad.			0.15	1.50	1.00	1.00	1.00	1.00	1.00	0.00	**6.65**
		3	Special initiatives for addressing the health of residents of old age homes, juvenile homes, destitute and single-living elderly populations.	All Kerala			0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	**5.60**
		4	Integrating climate data into disease surveillance and warning systems.		DHS, DME, IMD, KSDMA, DoECC		0.15	0.15	0.15	0.10	0.10	0.10	0.10	0.10	**0.95**
		5	Development of an integrated disease surveillance system for zoonotic diseases in vulnerable areas.		DHS, AHD		0.15	0.01	0.01	0.01	0.01	0.01	0.01	0.01	**0.22**
		Total					**1.20**	**2.41**	**1.86**	**1.81**	**1.81**	**1.81**	**1.81**	**0.81**	**13.52**

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		Outcome 2: Reach of health services to tribal; Coastal and highland communities enhanced.												
2	**Health care service delivery to other vulnerable communities** SDG- 3, 10, 13 NDC - 1, 6	1	Ensuring 100% health services including transportation to Tribal hamlets.	Idukki, Wayanad, Palakkad, Malappuram, Kasaragod, Kannur	DHS, KFD, STDD, DoR, Kerala Police		0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	**1.60**
		2	Ensuring 100% health services for Coastal and highland Communities.	All Kerala	DHS, DoF, DoR		0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	**0.80**
		Total					**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**2.40**
		Outcome 3: Addition to health infrastructure/equipment/professionals in the vulnerable districts.												
3	**Increasing access to functional healthcare** **SDG- 1,3, 8** **NDC-1**	1	Investment to create new medical infrastructure including equipment and systems in project districts. Incentivize the private sector to assist in this investment.	Palakkad, Malappuram, Kasaragod, Idukki, Wayanad	Department of Health and Family Welfare, NHM, DHS, DME		2.00	2.00	2.20	2.42	2.66	2.93	3.22	3.54	**20.97**
		2	Increasing the competitiveness of healthcare employment in project districts: incentives and capacity building for skilled healthcare professionals to ensure adequate staffing of existing and new medical facilities.	Palakkad, Malappuram, Kasaragod, Idukki, Wayanad	Department of Health and Family Welfare, NHM, DHS, DME		1.00	1.00	1.10	1.21	1.33	1.46	1.61	1.77	**10.48**
		Total					**3.00**	**3.00**	**3.30**	**3.63**	**3.99**	**4.39**	**4.83**	**5.31**	**31.45**
		Outcome 4: AC pipes in the vulnerable districts replaced.												
4	**Safe drinking water (Major project interventions proposed in the Water Resources sector)** **SDG- 3, 6, 12** **NDC - 1, 6**	1	Replacement of AC Pipes.[16]	Palakkad, Malappuram, Kasaragod, Alappuzha, Kottayam.[17]	KWA		10.00	10.00	10.00	0.00	0.00	0.00	0.00	0.00	**30.00**
		Total					**10.00**	**10.00**	**10.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**30.00**

16 *Asbestos Cement*
17 *This is a very significant intervention and is preferred to be implemented in the entire State.*

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		Outcome 5: Surface water systems proofed from existing/ potential contamination from unscientific sanitation.													
5	**Safe and Scientific sanitation** **SDG - 1,3,4, 6,13** **NDC - 1, 6**	1	Provide public/ community sanitary complexes with scientific onsite treatment systems.	Alappuzha, Ernakulam, Thrissur, Kottayam, Palakkad, Malappuram.	Suchitwa Mission, LSGD		10.00	10.00	15.00	15.00	5.00	5.00	5.00	5.00	**70.00**
		2	Energy-efficient and climate-proof crematoria for humans and animals.	All Kerala			10.00	10.00	15.00	25.00	25.00	25.00	0.00	0.00	**110.00**
		Total					**20.00**	**20.00**	**30.00**	**40.00**	**30.00**	**30.00**	**5.00**	**5.00**	**180.00**
		Outcome 6: Legacy wastes removed and door-to-door waste collection system in place.													
6	**Solid waste management** **SDG - 3, 6, 11,12** **NDC - 1, 6**	1	Ensuring door-to-door collection of wet and dry waste - the institution of green collection mechanisms.	All Kerala (with special emphasis on urban centres)	Suchitwa Mission, LSGD		10.00	10.00	10.00	10.00	10.00	5.00	5.00	5.00	**65.00**
		2	Setting up climate resilient solid waste management facilities (flood-resilient structures, fireproofing, etc.)	All Kerala			25.00	25.00	25.00	50.00	25.00	25.00	25.00	25.00	**225.00**
		3	Establishment of compost marketing facilities at the LSG level for local farming (business support, etc)		Suchitwa Mission, LSGD, Haritha Keralam MIssion		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	**16.00**
		4	Removal of legacy waste dump sites to control GHG emissions.	All Kerala (With special focus on Urban LSGs)	Suchitwa Mission, LSGD		10.00	10.00	10.00	10.00	5.00	5.00	5.00	5.00	**60.00**
		5	Development of biomethanation based waste to energy plants.	All Kerala (With a special focus on Urban LSGs)			10.00	10.00	10.00	10.00	10.00	10.00	5.00	5.00	**70.00**
		Total					**57.00**	**57.00**	**57.00**	**82.00**	**52.00**	**47.00**	**42.00**	**42.00**	**436.00**

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		Outcome 7: Identified sustainable livelihood models along with established inclusive governance of forest ecosystems with an FRI integrated participatory mechanism at the divisional level,												
7	**Liquid waste management SDG – 3, 6,11,12, 13 NDC - 1, 6**	1	Grey water management and its reuse for flushing/ irrigation, etc.	All Kerala (with a special focus on Urban LSGs)	Suchitwa Mission, LSGD		10.00	10.00	10.00	10.00	20.00	20.00	20.00	10.00	**110.00**
		2	Setting up climate-resilient decentralized wastewater treatment plants (STPs) and faecal sludge treatment plants.				0.00	50.00	50.00	100.00	100.00	100.00	100.00	0.00	**500.00**
		3	Remediation interventions to rejuvenate water bodies/ wetlands contaminated with hazardous pollutants.	Ernakulam	KSPCB		5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	**40.00**
		4	Industrial effluent monitoring to check infiltrations into surface water bodies.	All Kerala			3.00	3.00	2.00	2.00	2.00	2.00	2.00	2.00	**18.00**
		Total					**18.00**	**68.00**	**67.00**	**117.00**	**127.00**	**127.00**	**127.00**	**17.00**	**668.00**
		Outcome 8: Surface water systems proofed from potential contamination from most probable sources. Reduced cases of water-borne diseases.												
8	**Decentralised biomedical waste treatment and management** **SDG - 3, 11, 12,13 NDC - 1, 6**	1	Creation of decentralized biomedical waste treatment and management facilities.	Kollam, Thiruvananthapuram, Pathanamthitta	Department of Health and Family Welfare, KSPCB.		50.00	50.00	2.00	2.00	2.00	2.00	2.00	2.00	**112.00**
		2	Establishing STPs and CETPs in vulnerable districts.	Ernakulam, Thrissur, Kozhikode, Palakkad, Malappuram, Kasaragod, Kannur, Wayanad, Alappuzha.	Suchitwa Mission, DHS, NHM		50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	**400.00**
		Total					**100.00**	**100.00**	**52.00**	**52.00**	**52.00**	**52.00**	**52.00**	**52.00**	**512.00**

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		Outcome 9: Enhanced ease of reach and service delivery to the vulnerable population, manage health emergencies and proper integration of services and facilities, Database Management System established and M&E in place.													
9	**Mainstream the use of digital mode for functional healthcare** **SDG - 3, 8** **NDC - 1, 6**	1	Digital patient/ public friendly platforms and networking and Mapping of services including private facilities.	All Kerala (preferential districts Palakkad, Malappuram, Kasaragod, Idukki)	DHS, DME, E&ITD, Private Sector		0.25	0.25	0.10	0.10	0.05	0.00	0.00	0.00	**0.75**
		2	Identification, training, and capacity building for service providers.	All Kerala			0.50	0.50	0.55	0.61	0.67	0.73	0.81	0.89	**5.26**
		3	Monitoring and evaluation of patient data inputs from all institutions.				0.10	0.10	0.11	0.12	0.13	0.15	0.16	0.18	1.05
		Total					**0.85**	**0.85**	**0.76**	**0.83**	**0.85**	**0.88**	**0.97**	**1.07**	**7.06**
		Outcome 10: Enhanced service delivery and resource management efficiency gained through reduced costs and reduced loss.													
10	**Hub and spoke model for lab services** **SDG - 3, 9,12** **NDC - 6**	1	Identification of Hubs and Spokes	Palakkad, Malappuram, Kasaragod, Idukki	DHS, NHM, K-DISC		0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	**0.10**
		2	Infrastructure establishments				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**8.00**
		3	Modes and means for sample transportation and networking for result delivery.				0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	**5.60**
		Total					**1.75**	**1.75**	**1.70**	**1.70**	**1.70**	**1.70**	**1.70**	**1.70**	**13.70**

		Outcome 11: Enhanced health insurance system with enhanced and inclusive coverage and increased awareness campaigns.												
11	**Insurance for sustainable healthcare** **SDG – 1,3, 8** **NDC - 6**	1	Identification and Mapping of under-covered populations, organising campaigns and awareness programmes to promote State and Central health insurance schemes.	All Kerala	DHS, NHM, SHA		0.50	0.50	0.55	0.61	0.67	0.73	0.81	0.89	**5.26**
		2	Provide attractive premium prices, smart cards for cashless transactions, and easy claims, targeted towards BPL households, women-headed households, and people living with disabilities.				0.50	0.50	0.55	0.61	0.67	0.73	0.81	0.89	**5.26**
		Total					**1.00**	**1.00**	**1.11**	**1.22**	**1.34**	**1.46**	**1.62**	**1.78**	**10.52**
		Outcome 12: Database on climate variables and mental health variables, suited for analytics diagnosis research and decision making established at the State level.												
12	**Addressing mental health issues in the context of the frequent occurrences of extreme events** **SDG - 3** **NDC - 1, 6**	1	Database formation / State specific research on the vulnerabilities of mental health from changes in climate variables, screening, detection, treatment, and follow-up by linkages through existing programmes.	All Kerala	DHS/DME, NHM, Social Justice Department.		0.15	0.15	0.15	0.00	0.00	0.00	0.00	0.00	**0.45**
		Total					**0.15**	**0.15**	**0.15**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.45**

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		Outcome 13: Capacity/awareness programmes conducted for sustainable lifestyle.													
13	**Capacity building for climate action** **SDG - 13** **NDC - 1**	1	Programmes to raise awareness among the public regarding the effects of climate change on health.	All Kerala	DHS, Social Justice Department, NHM, LSGD, General Education Department		0.10	0.10	0.11	0.12	0.13	0.15	0.16	0.18	**1.05**
		2	Capacity building for village health workers and medical professionals about climate change impacts on human health in Kerala with a focus on heat stress, vector- and water-borne diseases.		DHS, NHM		0.10	0.10	0.11	0.12	0.13	0.15	0.16	0.18	**1.05**
		3	Community engagement to control vector and water-borne disease spread (activities for school children to trace sources within their households)	Thiruvananthapuram, Wayanad, Kasaragod, Kannur, Kollam			0.00	0.10	0.11	0.12	0.13	0.15	0.16	0.18	**0.95**
		4	Development of research programmes to encourage studies on climate change impact on the health sector of Kerala.	All Kerala	DHS, DME		0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	**2.00**
		5	Training for Local body members		KILA, LSGD, DHS, NHM		0.25	0.25	0.25	0.25	0.25	0.00	0.00	0.00	**1.25**
		Total					**0.95**	**1.05**	**1.08**	**1.10**	**0.64**	**0.45**	**0.48**	**0.54**	**6.30**

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		Outcome 14: Periodic Air quality data acquisition mechanism in place, integration with the Climate database under DHS												
14	**Air quality management and monitoring of climate sensitive diseases** **SDG - 3, 11, 13** **NDC - 1, 6**	1	Air quality management and Health Impact Assessment	All Kerala	DHS, KSPCB, NHM, DME		0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.00	**0.30**
		2	Establish Continuous Ambient Air Quality Monitoring Stations (CAQMS)		KSPCB		0.10	2.00	1.00	1.00	1.00	1.00	1.00	1.00	**8.10**
		3	Source Apportionment studies		KSPCB		3.00	3.00	2.00	2.00	2.00	2.00	2.00	2.00	**18.00**
		Total					**3.20**	**5.10**	**3.10**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**26.40**
														Grand Total	**1937.80**
	* The Implementing agency first mentioned in the list shall be the lead implementing entity and the other agencies mentioned shall be included by the lead as per the requirement of the actions/ objectives. The first agency was the lead consulting agency for the plan preparation and reporting lead in the M&E mentioned later in the plan. Agencies cited: DHS-Directorate of Health Services; DME-Directorate of Medical Education; IMD-India Meteorological Department; KSDMA-Kerala State Disaster Management Authority; DoECC-Directorate of Environment and Climate Change; AHD-Animal Husbandry Department; KFD-Kerala Forests and Wildlife Department; STTD-Scheduled Tribe Development Department; DoR-Department of Revenue; DoF-Department of Fisheries; NHM-National Health Mission; KWA-Kerala Water Authority; LSGD- Local Self Government Department; KSPCB-Kerala State Pollution Control Board; E&ITD-Electronics & Information Technology Department; SHA-State Health Agency; KILA-Kerala Institute of Local Administration; K-DISC-Kerala Development and Innovation Strategic Council.												

2. **Integrated Water Resources Management**: The sustainability of the water resources in the State must be assessed to understand the carrying capacity of the existing sources to cater to the water supply demands of the districts. Integrated Water Resources Management (IWRM) is a process that promotes the coordinated development and management of water, land, and related resources to maximize economic and social welfare equitably without compromising the sustainability of vital ecosystems. The concept is to aim at multiple outcomes by managing the water resources in a people and technology-integrated manner.
3. **Availing and disseminating Information on the water resources of the State**: Data availability is a crucial factor that determines the effectiveness of policies and decisions. As part of the MIS already mentioned in 6.6.1, information on the availability and nature of water resources needs to be timely updated and pooled to the MIS. The Kerala Water Resources Information System (K-WRIS) is already in place. The scaling up of K-WRIS and its integration with the MIS is an essential strategy.

6.6.7.1 Proposed projects/objectives and actions for the water sector

Based on these adaptation strategies to address the major drivers of water vulnerability, five projects have been conceived and presented in **Table 6.14**. Priority districts for the implementation of adaptation projects in the water sector are Wayanad, Alappuzha, Kottayam and Kozhikode. .

6.6.7.2 Potential barriers to implementation of adaptation projects in the water resources sector

- **Safe Drinking water programme**
  - Water as a resource itself may be a limiting factor. As such, if water sources (both surface and groundwater with potable quality) are not rejuvenated, the outcome of the project may not be achieved.
  - High financial implications involved.

6.6.8. Priority Adaptation Strategies

Apart from the above-mentioned adaptation strategies and projects in the specific sectors, eight adaptation strategies that have priority implications are identified and projects devised, based on the composite vulnerability assessment, climate profile and stakeholder suggestions/ recommendations. These adaptation projects are essential to building resilience against the risks of climate change that are of priority concern and have cross-sector implications.

1. **Land use planning and zoning**: In the changing climate scenario, the State needs a comprehensive review of its land use planning, so that the land can be consolidated and directed towards its best ecosystem usage. Creating land use zoning enables the re-deployment of the land to maximize its natural ecosystem functions. The State presently does not employ specific spatial planning and zonation other than the various statutory demarcations like the ESAs, ESZ, CRZ, wetlands and the regulations imposed by the government from time to time.

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Table 6.14: **Proposed projects/objectives and actions for Water Resources Sector (2023-2030)**

	Total Outlay (INR Crore) :	**11038.4**												
	Vulnerable Districts	**High**	Wayanad, Alappuzha, Kottayam, and Kozhikode											
		Medium	Kannur, Idukki, Palakkad, Kollam, and Malappuram											
	Projects / Objectives	**Planned Activities/Actions**		**Priority Districts**	**Implementing Agencies**		**Outlay (INR Crore)**							
							2023 -24	**2024 -25**	**2025 - 26**	**2026 -27**	**2027-28**	**2028 -29**	**2029 -30**	**2030 -31**	**Total**
		Outcome 1.1: District-level water stress/source sustainability identified, and improvement measures done wherever needed.												
1	**Sustainable access to safe drinking water in the priority districts** SDG - 1, 3, 5, 6, 10, 11, 13 NDC - 6	1	Assessment of water stress and identification of sustainable water sources.	All Kerala	KWA, Irrigation Department, KFD		2	0.5	0	0	0	0	0	0	**2.5**
		2	Improving source sustainability including a measure to prevent siltation.		KWA, Irrigation Department, KFD, Department of Soil Survey and Soil Conservation		75	50	50	30	30	30	30	30	**325.0**
		Outcome 1.2: Number of villages having access to round-the-year water supply increased.													
		3.a	Leveraging Jal Jeevan Mission in the priority districts.[18]	Kasaragod, Kannur, Wayanad, Idukki, Kozhikode, Palakkad, Kottayam, Malappuram.	KWA, KRWSA, GWD		1960.0	3935.0	0.0	0.0	0.0	0.0	0.0	0.0	**5895.0**
		3.b	Financial support to Panchayats-15% panchayat share in implementing the Jal Jeevan Mission.		KWA, LSGD		840.0	1687.0	0.0	0.0	0.0	0.0	0.0	0.0	**2527.0**
		Outcome 1.3: Stress reduction achieved by reducing loss and establishing alternative source of water supply.													
		4	Non-Revenue Water[19] management and to ensure equitable distribution.	All Kerala	KWA		5.0	5.0	5.0	5.0	5.0	4.0	4.0	4.0	**37.0**

18 JJM is mandated to connect all households in Kerala with safe drinking water by 2024 prioritizing BPL households.
19 Non-revenue water is water that has been produced and is "lost" before it reaches the customer.

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		5	Supply of tertiary treated sewage for gardening, construction, and agriculture purposes (pilot basis).	Thiruvananthapuram.	KWA		5.0	5.0	5.0	5.0	2.0	2.0	2.0	2.0	**28.0**
		6	Measures to ensure uninterrupted power supply during extreme weather events -laying of underground cables.	All Kerala			4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	**32.0**
		7	Desalination plants (including vehicle-mounted mini plants) in vulnerable coastal districts for providing access to safe drinking water.	Alappuzha, Kozhikode			50.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0	**150.0**
		8	Flood proofing pump houses – elevated platforms and automation to increase accessibility during floods and to avoid disruptions in the water supply.	Alappuzha, Ernakulam, Thrissur, Kottayam			46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**46**
		Total					**2987**	**5736.5**	**114.0**	**44.0**	**41.0**	**40.0**	**40.0**	**40.0**	**9042.5**
		Outcome 2: Water security plan prepared for the priority districts, water harvesting/recharging systems created, and grey water managed by employing participatory approach at GP level.													
2	**Community-based sustainable drinking water interventions** SDG - 3, 5, 6, 10, 11,12, 13 NDC – 1, 6	1	Revision of the 2012 Water security plan (WSP) and sharing with all the panchayats and KRWSA- (priority to the vulnerable districts).	Kottayam, Kozhikode, Wayanad (182 GPs)	KRWSA, CWRDM		2.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	**9.0**
		2	Construction of rooftop rainwater harvesting structures for households that cannot be connected to the treated water supply.	Idukki, Kasaragod, Kozhikode, Palakkad	KRWSA		30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	**240.0**

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		3	Well-recharging through rooftop rainwater harvesting.	Alappuzha, Kottayam, Wayanad (166 GPs)	KRWSA		20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	**160.0**
		4	Community-based grey water management in the rural area.	Kottayam, Kozhikode, Wayanad (182 GPs)			2.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	**9.0**
		5	Water quality enhancement (for existing schemes).	Kozhikode			0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**4.0**
		6	Community-based Water Quality Monitoring & Surveillance.	All Kerala			2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	**20.0**
		7	Capacity building IEC				15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	**120.0**
		8	Sustainability support for community-managed Water Supply Schemes.				50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	**400.0**
		9	Conversion of domestic wells into protected and sustainable drinking water sources.	Kottayam, Kozhikode, Wayanad (182 GPs)			19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	**154.4**
		Total					**142.7**	**139.1**	**139.1**	**139.1**	**139.1**	**139.1**	**139.1**	**139.1**	**1116.4**
		Outcome 3: State-wide water resources data generating systems established, database on water resources created,(WRIS) and upscaled and a transparent data-sharing platform established.													
3	**Availing and dissemination of water resources information of the State SDG – 6,11, 13 NDC - 6**	1	Scaling up of Kerala-WRIS ensuring data access to all line departments.	All Kerala	Irrigation Department, IMD & other stakeholder Departments		5.5	5.5	4.0	0.0	0.0	0.0	0.0	0.0	**15.0**
		2	Establishment of additional real-time hydro-meteorological stations & collection of river cross-section data of selected river basins.				2.5	1.5	1.0	1.0	1.0	1.0	1.0	1.0	**10.0**
		3	Establishment of real-time coastal data collection stations for supporting the coastal information and management system.				5.0	5.0	0.5	0.5	0.5	0.5	0.5	0.5	**13.0**

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		4	Development of cadastral level river bank information system and updating.	All Kerala	ILDM		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	**2.4**
		6	Assessment of climate change impacts on water resources at micro-scale		IDRB, CGWB, CWRDM		0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	**0.5**
		Total					**13.5**	**12.5**	**5.9**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**40.9**
		Outcome 4: Legacy wastes removed and door-to-door waste collection system in place.													
4	**Integrated Water Resources Management** **SDG- 6, 11, 13** **NDC - 1, 6**	1	Conservation, Renovation & protection of existing water resources under participatory approach.	All Kerala	Irrigation Department, LSGD, KSPCB, SWAK		85.0	95.0	120.0	140.0	50.0	55.0	60.0	50.0	**655.0**
		2	Interlinking of river basins, based on the feasibility assessments done following the principles of SuDS.		Irrigation Department		5.0	10.0	15.0	20.0	20.0	25.0	0.0	0.0	**95.0**
		3	Development of Rain shadow areas.	Palakkad, Idukki			15.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	**85.0**
		4	Sustaining groundwater resources through climate adaptation	Palakkad, Kasaragod, Wayanad, Thrissur	GWD		0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.8**
		Total					**105.8**	**115.0**	**145.0**	**170.0**	**80.0**	**90.0**	**70.0**	**60.0**	**835.8**
		Outcome 5: Campaigns, workshops, and on- the- Job training													
5	**Water Conservation – Sensitization and Capacity Building** **SDG - 6, 13** **NDC - 1, 6**	1	Sensitizing communities for the need for water conservation in a changing climate.	All Kerala	GWD, CGWB		0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	**1.20**

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		2	Training programmes on river management and water literacy campaign.	All Kerala	ILDM		0.5	0.5	0.3	0.3	0.0	0.0	0.0	0.0	**1.60**
		Total					**0.8**	**0.8**	**0.6**	**0.6**	**0.0**	**0.0**	**0.0**	**0.0**	**2.80**
														Grand Total	**11038.40**
	* The Implementing agency first mentioned in the list shall be the lead implementing entity and the other agencies mentioned shall be included by the lead as per the requirement of the actions/ objectives. Also, the first agency was the lead consulting agency for the plan preparation and reporting lead in the M&E mentioned later in the plan. Agencies cited: KWA-Kerala Water Authority; KRWSA- Kerala Rural Water Supply and Sanitation Agency; LSGD-Local Self Government Department; IMD-India Meteorological Department; GWD-Ground Water Department; KFD-Kerala Forests& Wildlife Department; CWRDM-Centre for Water Resources Development and Management; ILDM-Institute of Land & Disaster Management; IDRB- Irrigation Design & Research Board; SWAK- State Wetland Authority Kerala; KSPCB-Kerala State Pollution Control Board; CGWB-Central Ground Water Board; GPs-Grama Panchayats.												

The proposed strategy envisages generating and regularly updating high-resolution (at least cadastral scale) spatio-temporal land use/land cover GIS database for the State. Considering these data and all the prevailing regulations/rules/notifications/master plans; a risk informed land use zonation/regulation shall be devised. The land use zonation should be climate risk-informed and strictly adhered to. This has cross-sectoral implications for the management of resources and sustainable life. The strategies mentioned in all the sectors have significance, concerning comprehensive spatial planning and planned land use. The task of risk informed land use planning and zoning might be more complex than what can be envisaged at this point and might require modification of the existing baseline regulations. However, this cannot be delayed in the State and should start with specific baseline spatial assessments. Assessment of coastal inundation/ flood and landslide proneness shall be a vital component in formulating land use plans in the State.

2. **Sustainable shore protection and stabilization**: Protection and stabilization of State's coastal stretches and river banks through the adoption environmentally and socially appropriate solutions are highly essential. The techno-economic feasibility of sustainable coastal and river bank protection measures for the State needs to be assessed. Based on this assessment, Shoreline/ Riverbank Management Plans shall be prepared. The shore protection/riverbank stabilization works should be taken up based on the above plan. Adoption of soft options like beach nourishment, sand bypassing, dune planting and offshore submerged reefs etc. shall be promoted along the coast.

   A sustainable coastal protection system using nature-based solutions such as bio shielding shall be tried in the selected stretches identified through the above-mentioned feasibility study.

   The bank stabilization could be done through mangrove afforestation in downstream estuarine stretches and by planting suitable native riverine species along the upstream stretches. Construction of hard structures should be minimised and undertaken only in severe erosion-prone areas based on Shoreline/ Riverbank Management Plan. Reformation of the sunken sea walls shall also be carried out based on the Shoreline Management Plan. Shore protection must be supplemented with other measures such as the rehabilitation of vulnerable communities and the maintenance of a buffer zone from the High Tide Line (HTL) / Hazard Line along the coastal belt to enhance climate resilience.

3. **Rehabilitation of vulnerable communities:** The vulnerable communities in the State who need to be rehabilitated fall mainly in the coastal areas and the highlands. The State Fisheries Department conducted a detailed survey in 2017-18 to collect details regarding the inhabitants within 50 m of HTL and it is found that 18685 families are residing within 50 m of HTL. However, similar assessments have not been done for other coastal flood prone regions, like the low lying regions in Ernakulam and Kollam. It is equally important to conduct similar assessments in the highland regions which are prone to hazards like landslides and soil piping. A comprehensive Rehabilitation and Resettlement plan for the vulnerable communities needs to be prepared. Rehabilitation should be based on ample compensation paid to the communities so that they are incentivized to the rehabilitation move. The rehabilitation move should be further incentivized with linked benefits like better insurance coverage, provisioning of infrastructure and support for livelihood.

4. **Sustainable drainage systems for better flood management**: Sustainable removal of sand and silt from the rivers and lakes/ estuaries and its restoration, ensuring the environmental flows in these ecosystems is a priority strategy in addressing flood havoc. Interventions like coastal inlet development and management, periodical cleaning and bank stabilization of estuaries and river channels, etc. need to be done. This strategy shall keep coastal inlets sustainably open, ensuring water quality by facilitating adequate mixing and dilution. This will also ensure the proper drainage of the flood waters from the upstream water bodies.

   Sustainable dam desiltation is another strategy in drainage maintenance. There are major dams/barrages that are heavily silted up due to soil erosion, floods and landslides.[20] For instance, the Malampuzha Dam has lost 27% of its capacity due to siltation, Aruvikkara Dam 43% and Malankara Dam 48%. This has grossly affected the total water-holding capacity of dams/barrages thereby affecting flood management in the State. Catchment area treatment with soft/ green measures shall be undertaken in selected watersheds of high flood-impacted river basins.

20 *Annual Report 2020 – 21, Kerala Engineering Research Institute, Peechi.*

Installation of the high flood level markers and proper documentation is another essential strategy to be followed. Demarcation and fixing of riverbank boundary, removal of encroachments and protection of river puramboke, and installation of Jendas/ markers and its periodic monitoring and maintenance are also other priority interventions required.

5. **Integrated Coastal Zone Management Plan (ICZMP)**: Kerala's coastal ecosystem is important for biological and economic productivity, storm protection and provides a host of ecosystem services, which are crucial for human well-being. The sustainable management of the coastal and marine resources, therefore, is essential. The Ministry of Environment, Forests & Climate Change has initiated Integrated Coastal Zone Management (ICZM) Project in India to protect and conserve the coastal and marine ecosystems and its environment through a holistic coastal management and to implement the National Environment Policy 2006, recommendations of "Final Frontier 2009", Public Accounts Committee (2009–2010) [PAC], and CRZ Notification, 2011 and IPZ Notification, 2011 regulatory framework with public participation. The provisions of the project are to:

   - Achieve sustainable development of the coastal and marine areas.
   - Reduce vulnerability to natural hazards which have major implications on the coastal areas and coastal communities, especially concerning Sea Level Rise (SLR) and increased frequency of cyclones and storm surges.
   - To conserve and protect the fragile coastal ecosystems such as the mangroves, brackish water wetlands and coral reefs, including addressing the pollution of coastal waters and livelihood improvement of local communities.
   - Strengthen institutional and governance capacity for Integrated and Sustainable Coastal Management as per the National Environmental Policy 2006.
   - Capture and disseminate lessons in best practices, both locally and globally.

   Adoption of the Integrated Coastal Zone Management (ICZM) framework can provide a mechanism to allow developmental activities well suited to time and space, integrating environmental and socio-economic concerns of the State. A comprehensive plan to manage the shoreline of the State needs to be in place. Coastal and marine biodiversity inventorization and resource mapping should be carried out for the coastal stretch of the State as part of the Marine Spatial Planning (MSP) of ICZMP. This is essential to identify and prioritize the interventions needed and to identify the quantum and direction of sustainable coastal management activities for the State.

6. **Climate Change Monitoring and Database Management Mechanism**: Investment in research to address the climate change knowledge gap in the State is another priority intervention. For this high-quality spatio-temporal, accessible climate data is imperative, and has widespread applications, such as monitoring climate variability and change, supporting decisions for disaster risk reduction, and aiding future climate predictions and projections. Managing climate data has many challenges that may not scale necessarily with the frequency of stations in the network. Climate data processing is becoming increasingly sophisticated and needs standardised data at specific frequencies as basic inputs. This is often combined with other environmental data for informed decision-making. Thus, standardized automatic digital instrumentation for weather monitoring, suitable expertise and passable operational budgets are necessary.

   The sea level monitoring and river gauging stations should necessarily be part of this network. The Hydrographic Survey Wing of the State has identified five potentially suitable locations (Vizhinjam, Neendakara, Munambam, Beypore, and Azheekal) for establishing the sea level monitoring systems. These tide monitoring centres are essential to understand the tidal characteristics and to ensure the safety of fishermen, improve their catches, navigation of vessels, coastal infrastructure protection, tidal mixing of near shore waters, etc. Furthermore, the data at various ends need to be pooled systematically and timely and updated into the Centralized Climate Change Data Management System (CCCDMS), which should be accessible to all stakeholders for the decision-making process. Provisions shall be given in the CCCDMS for incorporating Community Based Climate Monitoring Programs in the State.

7. **Climate Responsive Local Governance**: Successful decentralised planning is one of the strengths of the State. The role of the local self-governments is evolving and has become more significant in the changing climate scenario. Climate change actions from the local level are strategically important and effective. The annual plan of these local bodies if sufficiently climate proofed may support the climate action of the State more efficiently.

   A comprehensive mechanism to capture the initiatives for reducing carbon emission, improving the carbon sequestration potential, initiatives to adapt to climate change if any and addressing disaster risk management at the local level is thus a strategic requirement. This may be achieved by facilitating the LSGs to take climate informed actions according to their capabilities and local needs thus enabling the LSGs to develop climate leadership over time. The convergence status of the projects in the LSGs at various levels needs to be identified. Necessary training to enhance the capacity of the Local Self Governments to intensify climate resilience building and disaster management activities by creating awareness among elected representatives, implementation officers, and working groups also need to be part of the strategy. This will additionally support the preparation and implementation of the Local Action Plan on Climate Change (LAPCC) in all the local bodies.

8. **Climate Education and Awareness**: Environment education in the State has been trickled down into curricula at various levels in the State, however, the focus has not yet been specific to climate change. Climate science has advanced, and the human understanding on the subject matter has widened. The climate change action should begin at school level and the necessary changes in the curriculum can be brought about by forming an Environment and Climate Change Curriculum Committee and the State level specialists and decision makers brought together in the platform to discuss and suggest the necessary incorporations to be made to the curriculum in the State. Building up a climate change informed citizenry especially from the school level can be the best receptors of climate action programmes in the State in its long run. The general public needs to be educated about climate change and encouraged to replicate the best practices. Further, enhancing the awareness on climate change at the decision makers' level should also be prioritized at the earliest. The academia, the bureaucracy, and the political heads of the State need to be sensitized on climate change. The various national and international efforts being done to address climate change, and necessarily the Sustainable Development Goals have to be disseminated to the various levels.

6.6.8.1 Proposed projects/objectives and actions for the priority interventions

Based on these adaptation strategies, to address the major drivers that have cross-cutting implications, eight projects have been conceived and presented in **Table 6.15**.

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Table 6.15: **Proposed projects/objectives and actions for Priority Interventions (2023-2030)**

	Total Outlay (INR Crore) :	**12420**												
	Projects / Objectives	**Planned Activities/Actions**		**Priority Districts**	**Proposed Implementing agencies**		**Outlay (INR Crore)**							
							2023 -24	**2024 -25**	**2025 - 26**	**2026 -27**	**2027-28**	**2028 -29**	**2029 -30**	**2030 -31**	**Total**
		Outcome 1; Spatially data acquired and shared, spatially planned land use, demarcated land zones.												
1	**Land use planning and zoning (to be linked to the RIMP proposed under objective 7)** **SDG- 9, 11, 13, 16** **NDC- 1, 6**	1	Acquisition of high-resolution spatial data of the State (multi-user license).	All Kerala	KSREC, KSDI KSLUB, LSGD Planning, DoR		15.0	0.0	0.0	0.0	15.0	0.0	0.0	0.0	**30.0**
		2	Updating of Land Use database.				3.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	**6.0**
		3	Enhancement of existing database-building, storing and sharing infrastructure.				10.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	**15.0**
		4	Development of Mobile and Web GIS platforms for mapping and decision support.				1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	**2.0**
		5	Cadastral plot level mobile app-based Land Use Survey				10.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	15.0
		6	Land use Zoning				2.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	3.0
		7	Regular mechanism for timely updating of spatial data.				0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	3.0
		Total					**41.0**	**0.0**	**0.0**	**3.0**	**30.0**	**0.0**	**0.0**	**0.0**	**74.0**
		Outcome 2; Spatially identified, planned, implemented and strengthened sustainable shore and river bank protection measures in place												
2	**Sustainable protection and stabilization of shores and river banks** **SDG- 13, 14** **NDC- 1, 6**	1	Identification, zonation and techno-socio-economic-feasibility study to select the suitable protection measures.	All Kerala	Department of Irrigation, KSCADC, HED, KCICM, NCCR, CWRDM, SWAK, KCZMA		20.0	20.0	20.0	0.0	0.0	0.0	0.0	0.0	**60.0**

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		2	Estuarine/ river bank stabilization using mangrove and riverine vegetation.	All Kerala	KFD, LSGD, Department of Irrigation, DoF		1.5	1.5	1.5	1.5	0.8	0.8	0.8	0.0	**8.4**
		3	Shore protection using soft measures -beach nourishment, sand bypassing, stabilizing dunes/ berms, geotextiles and offshore geo tubes.	All Coastal Districts (with a special focus on highly eroding regions)	KSCADC, Department of Irrigation, KERI, HED		500.0	500.0	500.0	500.0	0.0	0.0	0.0	0.0	**2000.0**
		4	Reformation of sunken sea wall and construction of other sustainable shore protection/stabilization structures - Geo tagging for the entire Kerala Coast.	All Coastal Districts	Department of Irrigation, KIIDC, HED		100.0	90.0	110.0	110.0	110.0	110.0	110.0	0.0	**740.0**
		5	Nature based solutions for coastal defence system - Bio shielding with mangroves and other suitable native vegetation.		KSCADC, KFD, Department of Irrigation		6.0	6.0	6.0	6.0	6.0	6.0	0.0	0.0	**36.0**
		Total					**627.5**	**617.5**	**637.5**	**617.5**	**116.8**	**116.8**	**110.8**	**0.0**	**2844.4**
		Outcome 3: Identification of highly vulnerable communities and communities rehabilitated, with strengthened disaster response systems including awareness established.													
3	**Rehabilitation and Resettlement of vulnerable communities.**[21] **SDG - 13, 15** **NDC - 1, 6**	1	Comprehensive Rehabilitation and Resettlement Plan for vulnerable coastal communities- Identification of priority intervention areas.	All Coastal Districts	DoF, KSCADC, Life Mission, HED,		1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	**2.0**
		2	Rehabilitation of fishing communities exposed to coastal erosion based on the above plan.[22]		DoF, KSDMA, LSGD, KSCADC, HED.		1000.0	1000.0	1000.0	400.0	400.0	400.0	400.0	400.0	**5000.0**

21 Please refer-6.6.4. This intervention is relevant to address the vulnerabilities in the coastal fisheries sector as well.
22 In reference with the fisheries department's comprehensive survey report for rehabilitation.

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		3	New relief shelters and improving the facility and capacity of existing relief shelters.	All Coastal Districts	DoF, KSDMA, LSGD, KSCADC, HED.		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	**80.0**
		4	Sea rescue operations for fishermen.				10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	**80.0**
		5	Improve awareness of communities living in coastal hazard-prone areas regarding potential risks				1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**8.0**
		6	To renovate existing habitations to withstand storm surges				50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	**400.0**
		7	Assessment and Rehabilitation of other vulnerable communities prone to climate induced hazards.	All Kerala	LSGD, KSDMA		300.0	300.0	400.0	400.0	400.0	400.0	400.0	400.0	**3000.0**
		Total					**1372.0**	**1372.0**	**1471.0**	**871.0**	**139.1**	**871.0**	**139.1**	**871.0**	**8570.0**
		Outcome 4: Identification of new and enhanced drainage systems and a spatial-digital database on drainage systems and flood information established in the State.													
4	**Plan and maintain Sustainable Drainage Systems (SuDS) to reduce flood impact** **SDG – 1,2,11,13, 15** **NDC - 1, 6**	1	Feasibility study and spatial mapping of potential project locations for new drainage systems using principles of SuDS.	All Kerala	CWRDM, IDRB		25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	**50.0**
		2	Documentation of High-Water Marks (HWMs), determination of hazard line above MSL and installation of Flood level markers, river gauges		ILDM, SoI, DoR,		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	**4.8**
		3	Green infrastructure for storm water drainage to lower the risks of flooding				25.0	15.0	10.0	10.0	1.0	1.0	1.0	1.0	**64.0**

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		4	Catchment area treatment with 'soft' green infrastructure in watersheds to prevent landslides and erosion. Mini Reservoirs in catchment areas of Main Dams	All Kerala	Department of Irrigation/ Department of Soil Conservation		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	**40.0**
		5	Sustainable removal of sand and silt from rivers and estuaries		Department of Irrigation, ILDM, LSGD, DoR, KCZMA, SWAK		20.0	22.0	24.2	26.6	29.3	32.2	35.4	39.0	228.7
		6	Sustainable protection and management of estuaries and lakes		Department of Irrigation, SWAK, KCZMA		15.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	85.0
		7	Coastal inlet development and management	Ernakulam, Thiruvananthapuram, Kozhikode, Thrissur	KSCADC, KCZMA, KSDMA, KMB		20.0	20.0	20.0	20.0	20.0	0.0	0.0	0.0	100.0
		8	Addressing emergency systemic support in the case of extreme weather events	All Kerala	Department of Irrigation, KSDMA		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	80.0
		9	Protection of river puramboks, demarcation and fixing of river bank boundary, and installation of Jendas/ markers and regular monitoring		ILDM, DoR, Department of Irrigation		8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	64.0
		Total					**128.6**	**115.6**	**87.8**	**90.2**	**83.9**	**66.8**	**70.0**	**73.6**	**716.5**
		Outcome 5: Conservation and management of coastal and marine ecosystems of the State.													
5	**Integrated and Planned Coastal Zone Management** **SDG - 13, 14, NDC - 1, 6**	1	Coastal Resource Mapping	All Coastal Districts	KCICM, NCSCM		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.2**
		2	Coastal and Marine biodiversity inventory		KSBB, KFD, KUFOS,		1.3	1.3	1.3	1.3	1.5	0.0	0.0	0.0	**6.5**
		3	Shoreline Management Plan[23]		NCESS, HED, KCZMA		3.5	4.5	6.0	3.0	0.0	0.0	0.0	0.0	17.0
		Total					**4.8**	**5.8**	**7.3**	**4.3**	**1.5**	**0.0**	**0.0**	**0.0**	**23.7**

23 To be linked with the planned actions (1) proposed under objective 2

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		Outcome 6: State-wide climate data collection and database systems established.													
6	**Climate Change Monitoring and Database Management** **SDG- 13, 14** **NDC - 1, 6**	1	Establishment of Sea level monitoring systems.	All Kerala	HSW, Maritime Board, DoECC		6.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**6.7**
		2	Installation of automated weather monitoring systems and the establishment of maintenance and monitoring wing.		IMD, IDRB, KSDMA, KSEB, ICCS		0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0	**2.5**
		3	Enhanced high-resolution spatial data acquisition systems		SCCC-DoECC		10.0	10.0	10.0	10.0	10.0	0.0	0.0	0.0	**50.0**
		4	GHG Monitoring Mechanism				1.0	0.5	0.0	0.0	0.0	0.0	0.6	0.0	**2.1**
		5	Centralized Climate Change Database Management System (CCCDMS)				2.0	0.5	0.5	0.5	0.5	1.0	0.5	0.5	**6.0**
		Total					**19.5**	**11.6**	**11.1**	**11.1**	**11.1**	**1.1**	**1.2**	**0.6**	**67.3**
		Outcome 7: Integrating Climate Change and Disaster Action into the LSG Development Plan													
7	**Climate responsive local governance** **SDG - 1,2,11,13, 15** **NDC - 1, 6**	1	Decentralized climate action and disaster management project governance in convergence with project planning, management, and monitoring of local governments a)LAPCC b) Downscaling of climate data	All Kerala	KILA, SCCC-DoECC, KSDMA, LSGD Planning		5.0	5.0	5.0	2.0	2.0	2.0	2.0	2.0	**25.0**
		2	Risk-Informed Master Plan (RIMP) for local governments(Urban plans on a pilot scale envisaged)				5.0	5.0	5.0	1.0	1.0	1.0	1.0	1.0	**20.0**
		3	Integrated disaster risk management and climate action tracking tool for Local Self Governments				2.0	2.0	3.0	3.0	1.0	1.0	1.0	1.0	**14.0**

		4	Capacity building and awareness creation at the Local Self Government level to facilitate LSGs to take up advanced and complex climate change actions and DRM incrementally by using the step ladder approach	All Kerala	KILA, SCCC-DoECC, KSDMA, LSGD Planning		2.0	2.0	2.0	2.0	2.0	2.0	22.0	2.0	**36.0**
		5	Financing for incentivization of climate and disaster reduction actions of Local Self Governments based on DCAT-Programme for Results (PfoR) incentives and State Disaster Mitigation Fund				5.0	5.0	5.0	2.0	2.0	2.0	2.0	2.0	**25.0**
		Total					**19.0**	**19.0**	**20.0**	**10.0**	**8.0**	**8.0**	**28.0**	**8.0**	**120.0**
		Outcome 8: Cluster level awareness campaigns done among decision makers, and curriculum designed.													
8	**Climate Change Education and Awareness**	1	Incorporation of climate change into curriculum	All Kerala	SCCC, DoECC, Department of Education		0.1	0	0	0	0	0	0	0	**0.1**
		2	Awareness				0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**4.0**
		Total					**0.6**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**4.10**
														Grand Total	**12420.00**
	* The Implementing agency first mentioned in the list shall be the lead implementing entity and the other agencies mentioned shall be included by the lead as per the requirement of the actions/ objectives. Also, the first agency was the lead consulting agency for the plan preparation and reporting lead in the M&E mentioned later in the plan. Agencies cited: KSREC-Kerala State Remote Sensing and Environment Centre; KSLUB-Kerala State Land Use Board; LSGD- Local Self Government Department; DoR-Department of Revenue; KSCADC-Kerala State Coastal Area Development Corporation; KCZMA-Kerala Coastal Zone Management Authority; KFD-Kerala Forests& Wildlife Department; DoF-Department of Fisheries; KERI-Kerala Engineering Research Institute; HED-Harbour Engineering Department; KIIDC-Kerala Irrigation Infrastructure Development Corporation; CWRDM-Centre for Water Resources Development and Management; IDRB-Irrigation Design & Research Board; ILDM-Institute of Land and Disaster Management; SoI-Survey of India; KCICM-Kerala Centre for Integrated Coastal Zone Management; NCSCM-National Centre for Sustainable Coastal Management; KSBB- Kerala State Biodiversity Board; KUFOS-Kerala University of Fisheries and Ocean Studies; NCESS-National Centre for Earth Science Studies; HSW-Hydrographic Survey Wing; DoECC-Directorate of Environment &Climate Change; IMD-India Meteorological Department; KSDMA-Kerala State Disaster Management Authority; SCCC-State Climate Change Cell; KILA-Kerala Institute of Local Administration; KSDI-Kerala State Spatial Data Infrastructure; NCCR-National Centre for Coastal Research; SWAK-State Wetland Authority Kerala; KMD-Kerala Maritime Board; ICCS-Institute for Climate Change Studies; KSEBL-Kerala State Electricity Board Ltd.													

6.6.8.2 Potential barriers to implementation

- Identification of the source of funding.
- Inter-sectoral coordination for implementation, monitoring and evaluation.
- Lack of local specific historic climate data for the preparation of LAPCC.
- Shortage of skilled manpower.

6.7. Climate Action – Women, Youth and Communities

Kerala has many positive governance initiatives, favourable for an-inclusive action plan. One of the factors that enables this is the strong decentralized governance, where more than 50 percent of the elected representatives are women. The State level women empowerment programme – Kudumbashree mission forms a network of organized women self-help and neighbourhood groups. The mission has made a significant contribution to the State's development, with microenterprises filling the gaps in manufacturing and services sector.

Community participation as a strong response to disasters has been a mark of innate adaptive capacity of the State. The Youth demography in the State is another forte which has leveraged the climate actions especially in times of disaster. Kerala has about 23% of its population in the age group-15-29. In this backdrop, the State has formulated a Kerala Youth Volunteer Action Force to mobilize the youth for relief activities. The idea for this volunteer force emerged from the exemplary role played by the youth in rescue and relief efforts during the recent floods. About 3.5 lakh volunteers has enrolled in the programme.

Community actions have been encouraged at various levels in the State. The first successful Participatory Forest Management system in the nation has been worked out in the State and has a successful network of eco development communities engaged in forest protection reciprocally enjoying community development. In the agriculture sector, the Scheduled Tribes Development Department (STDD) and Kerala Development and Innovation Strategic Council (K-DISC) undertook a community-based pilot project to revive the traditional sustainable agricultural practices of tribal communities of Attappadi, Palakkad, to enhance livelihoods and nutritional security. To reduce plastic pollution in the seas off the coast of Kerala that was affecting fishing activities as well as the quality of fish catch, the State government in association with the Network for Fish Quality Management and Sustainable Fishing (NETFISH), Boat Operators Association Kollam, Fisheries and Harbour Engineering Department, Suchitwa Mission and Society for Assistance to Fisherwomen (SAF) implemented a project called Suchitwa Sagaram (Clean Sea), in 2017.

The Meenachil River Rain Monitoring programme – a citizen science network, equipped with rain gauges and water scales across the Meenachil River in Kottayam that monitors the rainfall and the river water level, is now assisting the District Administration to take necessary actions during the extremes. Similarly, The Killiyar City Mission, which was launched in 2018 by the Thiruvananthapuram Municipal Corporation to rejuvenate the Killi River through people's participation, aimed at finding solutions to better solid and liquid waste management and identify points of pollution by sewage and drainage seepage along the riverside. Several other notable projects include the Ini Njan Ozhukatte (Now, Let Me Flow) project; Zero Waste Cities; Pachathuruth, an initiative by the Haritha Keralam Mission; Climate Resilient Health System - Pozhuthana Family Health Centre; and Carbon Neutral initiatives in Meenangadi (especially, the Tree Mortgage Scheme) and Kattakada, Carbon Neutral Agriculture. These activities mostly beyond the annual plan stream of the sectoral departments have high success rates and are found to be more effective in time bounded implementations. More such community activities in the State that has potential climate change response relevance need to be identified and encouraged. The best practices need to be documented and reproduced across the State.

6.8. Summary

The adaptation actions proposed are to be seen as flexible and the institutional mechanism mentioned later in the plan provides for the induction of necessary changes whenever or wherever. The involvement of the local level institutions in the action part is envisaged through Local Action Plans on Climate Change (LAPCC) to be prepared after the SAPCC. Preparedness will also incorporate systematically managing disasters. Early warning and management of hazards would thus become an integral part. The major disaster response institutions have to be networked and a system to disseminate warnings and directions need to be effectively planned and implemented. The scope of intelligent decision support systems cannot be ignored, data is a crucial factor in effectively addressing climate variations. The data management interventions proposed in the Action Plan need priority attention. The project design documents of each project/objective should preferably be prepared with the engagement of all sectoral experts, as there are significant interdependencies and value can be added through convergence. All the interventions mentioned shall be strictly monitored for their progress and their safeguards to not adversely affect the climate change scene in the State. Also, the implementation of the action proposed requires an integrated approach, as many of the actions have cross-sectoral and cross-departmental significance.

7. Finance

7.1. Overview

Climate finance refers to local, national, or transnational financing—from the public, private or other alternative sources of financing to support mitigation and adaptation actions that will address climate change. Mitigation requires considerable changes in technologies and innovations and large-scale investments are required to significantly reduce emissions, and thus mitigation necessitates large-scale investments. Climate finance is equally important for adaptation, as significant financial resources would be required in the short term to build resilience.

The UNFCCC Article 2.1(c) of the Paris Agreement states that 'making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development is imperative'. Financial assistance from Parties with more financial resources to those that are less endowed and more vulnerable has been what was envisaged by the UNFCC, the Kyoto Protocol, and the Paris Agreement. This recognizes that the contribution of countries to climate change and their capacity to prevent it and cope with its consequences vary enormously. Moreover, mitigation has a transcontinental significance, and it has more relevance in concentrated and joint efforts by all the major GHG-emitting nations.

Climate change mitigation and adaptation remain a major challenge for the State government, considering the financial commitment involved. This section analyse the extent and nature of climate finance available for climate change actions at the global, national, and state levels. It provides information on how climate finance is provided to different sectors in recent years. Finally, the section discusses the financial mechanisms that can be adopted for executing mitigation and adaptation projects and programmes.

7.2. Climate Finance - Global

There are several sources of climate financing globally that aid in serving the global climate agreements and it includes:

1. Global Environment Facility (GEF)
2. Green Climate Fund (GCF)
3. Special Climate Change Fund (SCCF)
4. Least Developed Countries Fund (LDCF)
5. Adaptation Fund (AF)
6. International Climate Initiative (IKI)

According to the Global Landscape of Climate Finance 2021 report, total climate finance has increased over the last decade and has reached USD 632 billion in the year 2019–2020, and still, it is not sufficient to limit global warming to 1.5^{0}c (**Figure 7.1**). The public sector accounted for about USD 322 billion (51%) and the remaining USD 310 billion (49%) was accounted for by the private sector. All the funds are targeted to achieve climate resilience and sustainable development. The funds are disseminated in the form of loans, grants, equity, result based payments, guarantee or co-financing and other forms. The majority of the funds are made available to attain adaptation, mitigation, and sustainable development.

7.3. Climate Finance – National

The Government of India developed the National Action Plan on Climate Change (NAPCC) in 2008 as a policy response to address climate change impacts and achieve its low carbon emission goal towards the Kyoto Protocol. The MoEFCC serves as the nodal agency for the overall formulation, implementation, coordination, and supervision of climate policy in India. The NAPCC mainly addresses energy efficiency, clean technology, and resource efficiency. According to India's NDC, at least 2.5 trillion USD (~INR 200 lakh Crore) is required between 2015 and 2030 for meeting climate change actions. This translates to around INR 13 lakh Crore of annual fund requirement. However, the finance flows were only INR 1.11 lakh Crore and INR 1.37 lakh Crore for 2016–17 and 2017–18, respectively (CPI, 2020). The total tracked green finance for the year 2016 –2018 is estimated to be 2.48 lakh Crore (**Figure 7.2**). The above funds are made available by Foreign Direct Investments, bilateral and multilateral

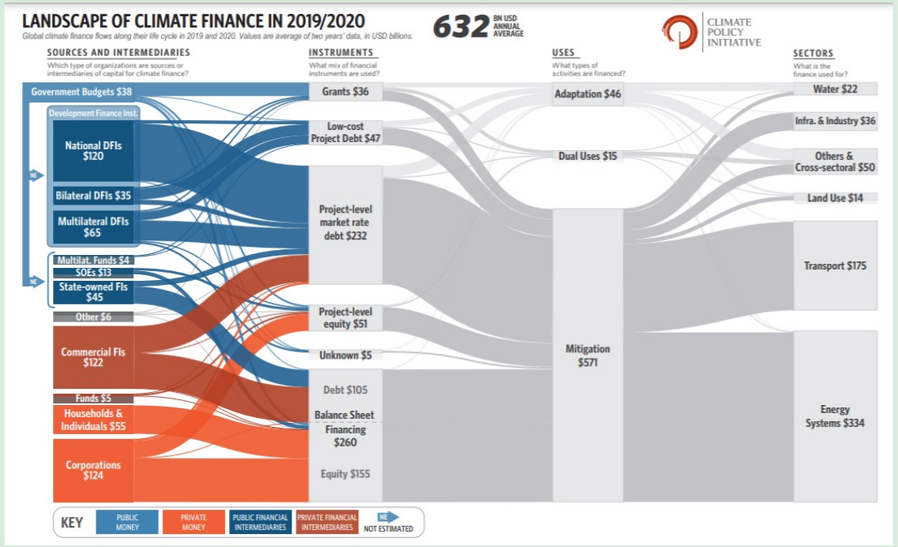

Figure 7.1: Global climate finance flows in 2019-2020
Source: Climate Policy Initiative (Global Landscape of Climate Finance 2021)

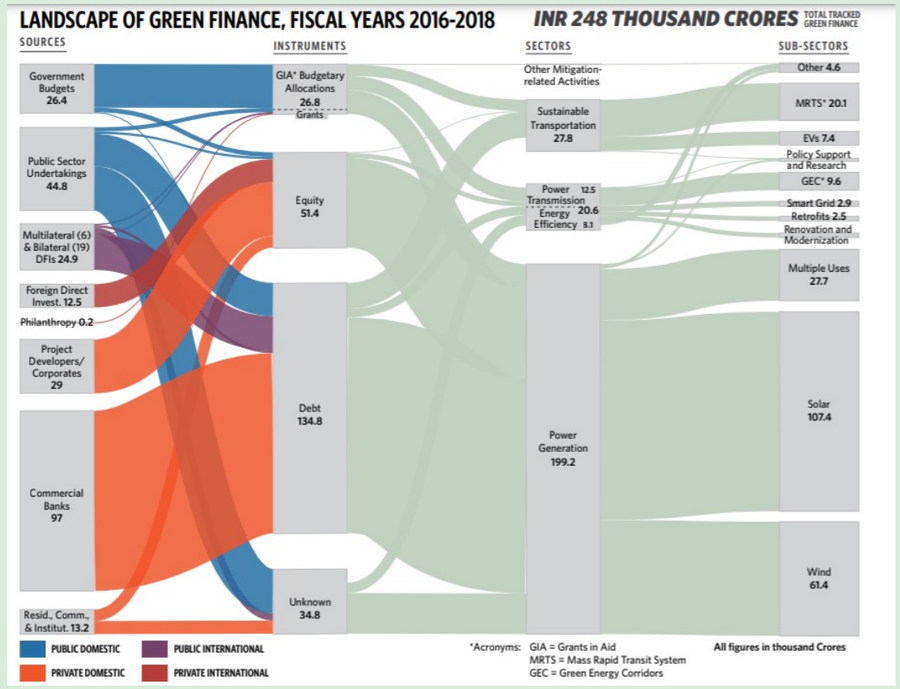

Figure 7.2: Climate fund sources in India

Source: Climate Policy Initiative, (Landscape of Green Finance in India, 2020)

finance institutions, government budgets, project developers, public sectors, and commercial banks; the main source being State budgetary allocations (Mathur, 2021; Ray, 2019).

The major climate finance frameworks in India are: (i) the National Adaptation Fund for Climate Change (NAFCC), and (ii) the Climate Change Action Programme (CCAP).

The NAFCC is a Central Sector Scheme which was set up in the financial year 2015-16. The Adaptation Fund is to assist States that are particularly vulnerable, based on the needs and priorities identified under the SAPCC and the relevant Missions under NAPCC. The activities under this scheme are implemented in a project mode. National Bank for Agriculture and Rural Development (NABARD) is the National Implementing Entity (NIE). The overall aim of the fund will be to support concrete adaptation activities which are not covered under on-going activities through the schemes of State and National Government that reduce the adverse effects of climate change facing community and sectors.

The CCAP is a Central Sector Scheme with a total estimated outlay of ~USD 42.4 million to build and support the Central and State climate change initiatives and to strengthen the scientific and analytical capacity for climate change assessment by establishing institutional frameworks and implementing climate related actions. The funds under the CCAP would be provided to States on programme and project basis.

7.4. Climate Finance in the States

SAPCCs are mainly funded by Union and State budgets through various centrally and state-sponsored programmes and schemes. The Climate Change Action Programme (CCAP) under the Central budget is the major source of financing for the improvement of climate-dependent sectors and also for the implementation of the SAPCCs. Funds will be provided for incentivising actions of the State governments and help them to meet the incremental / full cost of the mitigation and/ or adaptation activities, as the case may be[1]. Grants will be based on transparent criteria to be developed and agreed / approved by the National Steering Committee on Climate Change. Funds will be approved by the National Steering Committee on Climate Change for the eligible projects under SAPCC on first come first serve basis and the availability of funds.

State governments may also seek additional funding from the following sources for implementation of various activities:

1. National Missions under NAPCC
2. Allocation by Finance Commission
3. Compensatory Afforestation Management and Planning Authority
4. Bilateral and Multilateral Agencies
5. Carbon Offsetting and Trading Schemes (domestic and international)

7.5. Climate Finance in Kerala

The State government shall allocate the resources for implementing the SAPCC in the plan outlay approved by the State Planning Board for the respective sectors within the fiscal space available. In addition, there are few programmes and schemes implemented in various departments, which are financed by the Central government and international agencies like World Bank, Asian Infrastructure Investment Bank, etc. through project loans or grants. Under the NAFCC of MoEFCC, the Fisheries Department secured INR 25 Crore for the project to promote integrated farming system in the coastal wetlands of the State. In addition, a project proposal on the Participatory Ecosystem Action for Climate Resilience and Climate Change Mitigation in the Palakkad Gap has been submitted for Green Climate Fund with a total amount of USD 69.58 million, and is under the consideration of the MoEFCC.

There exists other few climate finance mechanisms in the State, for instance, KIIFB's masala bonds, subsidy schemes from Central and State governments, tax, cesses, and schemes to increase private investments such as KSEBL's business models for RTPV, feed-in-tariff schemes for solar projects, etc. In 2021, the World Bank approved a USD 125 million program – the Rebuild Kerala Initiative, to support the State's preparedness against natural disasters, climate change impacts, disease outbreaks, and pandemics. However, more funds need to be mobilised for climate action projects, especially for adaptation projects.

The State Planning Board plays an important role in the formulation of the Five-Year Plans and Annual Plans in the State. The objectives of the Annual Plan are to protect and extend social services and social infrastructure, promote production, and strengthen regional development. The Approach Paper to 14th Five Year Plan (2022-2027) recognized climate change as a significant issue to be addressed for the sustainable development of the State. The paper emphasises the efforts that must be made in different spheres to develop local climate resilience. These include developing sustainable infrastructure, creating local early warning systems to deal with extreme climatic events and their impacts, regulating construction, and protecting key local ecosystem resources. However, the frameworks for identifying the climate relevance of public expenditure need to be in place in the State. In view of the climate extremes projected under the AR6 of the UN IPCC, climate tagging of public expenditure has become an imperative for generating adaptive capacity in various sectors.

1 *Guidelines for funding State Action Plan on Climate Change under the CCAP, MoEFCC, Govt. of India.*

7.6. Proposed Strategies for Mitigation and Financing Requirements

The proposed mitigation strategies require a total requirement of INR 52,238 Crore (See Section 5). Out of this, the State's share is estimated at 5%, and the Central government's share is at 23%. The remaining investment will be the consumer's share. Manufacturing and implementation of solar panels, RTPV, biofuels, EVs, EV infrastructure, energy-efficient lamps, fans, etc. could be taken up through different schemes of the government. The investments for the existing and proposed Central and State mitigation schemes are presented in **Table 7.1**. The State should also leverage the possibility of private funding (for example, Corporate Social Responsibility (CSR) and Corporate Environment Responsibility (CER) programmes) in a systematic way for high-impact sectors such as transport, energy, waste management, afforestation and buildings through suitable policies and regulations. There are various financial windows to avail additional climate finance in the form of loans, grants, equity, result based payments, guarantees or co-financing, which the State can explore, such as:

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- International Climate Funds (GCF, IKI, etc.)
- Bilateral Cooperation (additional financial and technical support for climate change outcomes) from the Swiss Agency for Development and Cooperation (SDC), German International Cooperation (GIZ), Japan International Cooperation Agency (JICA), and the Department of International Development UK (DFID), etc.
- Multilateral facility [loan and grant projects through World Bank (WB), Asian Development Bank (ADB), United Nations Development Programme (UNDP), etc.]

In addition to the above-mentioned financing options, there are some State-specific examples of financial instruments, which may be replicable in Kerala. Maharashtra is a good example of incentivizing wind energy by providing zonal tariffs for wind energy to account for regional variations in the plant load factors. Gujarat invested INR 1,404 Crore towards feeder separation, primarily to make farm power rationing effective and tamper-proof. Dedicated feeders for irrigation purposes and separate 'Jyotigram' feeders cater 24 hours power supply to residential, industrial, and commercial consumers. The scheme implemented in 2004-05

Table 7.1: **Investment break up for mitigation activities based on subsidy schemes till 2019**

Mitigation actions	Target	Total investment (INR Crore)		Break up of investment cost (INR Crore)			Assumption
				Consumer share	State share	Central share	
Rooftop Solar PV-based electricity generation	1.1 GW by 2030	5,712		2,856	1142	1,714	MNRE is providing ~30% capital cost as a subsidy for residential, and government buildings. 100% of the installation will be in these building categories. MNRE subsidy is for meeting the 2022 national target and is assumed to continue till 2030. 20% of the total investment is considered to be subsidised by State government and is assumed to continue till 2030.
RE-based electricity generation	2.36 GW by 2030	15951		15951	0	0	The developer is making 100% of the investment. The State government would also be installing RE plants. This was not estimated, as the data on the targeted installed capacity of government-owned projects were not available.
Improving T&D loss infrastructure	T&D loss% is 8.8% by 2030	600		0	420	180	Assuming that the State will receive Central funds (30% of the total investment) till 2030 via IPDS or DDUGJY scheme.
Improving the energy efficiency of TPPs	Heat rate within 5%–7.5% of design heat rate	529		179	0	350	Cost for R&M activities in NTPC Kayamkulam is accounted for as a Central share. The R&M expenses till INR 1 Crore/ MW can be passed on to consumers as per the CERC tariff guidelines.
Energy efficiency improvements in two major Industries	Improvement in specific energy consumption as per IESS level 3 in fertilizer and at a CAGR of 0.2% in refinery between 2022 and 2030	311		311	0	0	Assuming that implementation of the PAT scheme is through 2030. The industry needs to make investments. By improving energy efficiency, there will be fuel cost savings, which are not accounted for.
Solar pumps	58,000 solar pumps by 2030	2,385		955	715	715	KUSUM scheme subsidy structure assumed to continue till 2030, accounting for 30% Centre and State each.

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Mitigation actions	Target	Total investment (INR Crore)		Break up of investment cost (INR Crore)			Assumption
				Consumer share	State share	Central share	
Solar feeder connected to EE pumps	1.5 lakh EE pumps	584		370	214	0	Assuming EE pumps will be bought by the consumers; and the PV plant will be installed by the State (like the case of Maharashtra), considering the subsidy savings for the State.
Efficient lighting	53% of lighting points in the residential sector	18		7.2	0.0	10.8	Centre provides 60% of the LED cost
Efficient appliances	Penetration of efficient appliances	785		785	0	0	No incentives from the government's side. Public awareness has to be created to prompt people to use energy-efficient appliances.
Adoption of ECBC	10% of commercial floor area by 2030	1828		1828	0	0	
Adoption of EV	Adoption of about 4.75 lakh vehicles by 2030	23,021		13,813	0	9,208	FAME provides 40% of the purchase price of vehicles
	51000 charging stations by 2030	514		386	128	0	Kerala EV policy provides for a 25% capital subsidy for charging stations
	Total	**52,238**					

led to reliable power supply, particularly in rural areas, and several associated socio-economic benefits (IFMR, 2013).

Another key component of climate finance funds from the Central government is in the form of subsidies and incentives. The major share of funds from the Central government were subsidies for RTPV installation and EV subsidies under the FAME policy. However, some Central financial assistance schemes had not been successfully taken up in the State. Also, some of the Central funds were allocated to projects unsuitable to the State/local context. A provision to allocate some funds for state-specific, high-impact, high-priority projects, rather than a general fund pool for a few activities, would help in utilizing the Central funds effectively. Devising the procedural mechanisms to aid the allocation of funds to these high-priority projects needs to be carried out with a mutual understanding of Central and State governments.

In addition, extensive cooperation between public and private finance is required to make interventions financially viable. Public-Private Partnership (PPP) model, CSR, CER or corporate citizenship model, Startup India scheme, etc. are a few platforms that can facilitate this financial mechanism. For interventions and projects that require high upfront costs, private investments should be encouraged. The PPP model enables private investment and involvement, which leads to state-of-the-art infrastructure development and its maintenance. It reduces the burden on local authorities, both financially and technically.

Climate change actions can be made part of CSR and CER projects - a self-regulatory model in which companies try to improve society, either economically or environmentally.

Improvising non-motorized and public transport infrastructure, installing solar street lights, and so on, are some of the activities that could be taken up under CSR and CER.

Another way of raising funds for clean energy and low-emission practices is levying taxes on their conventional counterparts. The cess levied on petrol, diesel, and conventional vehicles should be utilized for clean mobility. Congestion pricing and a share from toll can be used to improve public transport infrastructure, railways, waterways, and Non-Motorized Transport (NMT) infrastructure. Taxes on the manufacturing and trading of conventional appliances shall be used to incentivize the manufacturing, trading, and purchasing of energy-efficient appliances.

7.7. Proposed Strategies for Adaptation and Financing Requirements

A prerequisite for adaptation planning and implementation is adequate adaptation finance. Building resilience and climate-proofing actions need to be taken up by all stakeholders of the economy - governments, development organizations, financial institutes, and the private sector, to build a sustainable future. The proposed adaptation projects require a total investment of INR 38406.80 Crore over the next eight years to be implemented in prioritized regions. The State may face challenges to finance adaptation, particularly due to limited access and availability of financial resources and competing uses for available finance. The investment needs have been linked to existing national and State policies and schemes. Section 7.6 explains how additional funds may be leveraged for mitigation and the same applies to adaptation. Some specific financing options available particularly for adaptation (through loans, grants, or co-financing) include:

1. The National Adaptation Fund for Climate Change
2. Private sector investment (CSR and CER programmes)
3. International Adaptation Funds:
   - Green Climate Fund
   - Adaptation Fund (UNFCCC)
   - Global Fund for Ecosystem-based Adaptation (IUCN)
4. Bilateral and multilateral cooperation.

The stocktake of adaptation strategies (Section 6.4) implemented in the State highlights primarily the implementation of developmental programmes in different sectors that also produce adaptation benefits. There is no fixed percentage of assured finance allocated or earmarked in these programme budgets for adaptation. However, these may be leveraged for the implementation of the proposed adaptation projects and have been mapped in **Table 7.2**.

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Table 7.2: **Investment options for proposed adaptation projects based on State and Central schemes**

Sector	Adaptation Projects	Total investment Across Plan Period (INR Crore)		Potential Sources of Adaptation Finance
Agriculture	Sustainably Enhancing Agriculture Productivity	1895.90		With a 60-40 split between Centre and State, all schemes under the umbrella scheme, Krishi Unnathi Yojana may be leveraged to implement the various components of the project. Support through Primary Agricultural Credit Societies (PACS) for financing some of the components of the project.
	Enhanced storage / processing infrastructure	220.50		Agricultural Marketing Infrastructure (AMI), a sub-scheme of the Integrated Scheme for Agricultural Marketing (ISAM) may be leveraged for financing this project. A subsidy at the rate of 25% to 33.33% on the capital cost of the construction of storage facilities is provided. NABARD's Rural Infrastructure Development Fund may also be tapped to fill any financial gaps.
	Access to agricultural credit	115.60		Leveraging State schemes for the rehabilitation of weak but potentially viable PACS - 65% of the project cost: subsidy 20%, share capital 20%, loan 25%.
	Weather induced risk management	1172.30		Restructured Weather-Based Crop Insurance Scheme (RWBCIS) to be leveraged in project areas, to cut project costs.
	Strengthened institutional framework	682.50		Integrated Scheme for Agricultural Marketing (ISAM) to provide support to PACS and other cooperatives through loans with interest subvention of 3% per annum up to a limit of Rs.2 Crore, for 7 years for the creation of market infrastructure.
Livestock	Climate resilient livestock production	710.98		Funding under Rashtriya Gokul Mission (100% central funding) to be leveraged to develop and propagate improved, high-yielding indigenous breeds in the State. Subhiksha Keralam Scheme may be leveraged to assist farmers in procuring climate-resilient milch animals and to insure the animal for 3 years. Under the Milk Shed Development Programme, cattle sheds may be improved to lower heat stress on livestock. Woman Cattle Care Worker Scheme – enroll women within project areas to gain skill and income. Leverage Comprehensive Dairy Insurance Scheme. Currently, the scheme charges premiums ranging from 3.6% for heifers to 7% for milch cows/buffaloes. Attempts must be made to lower this for project beneficiaries, depending on their current per capita incomes. Gau Samridhi Plus scheme may also be leveraged, where general category farmers receive a 50% subsidy on premiums and SC/ST farmers receive 75% subsidy.
	Push for poultry performance	160.12		Leveraging Rashtriya Krishi Vikas Yojana (RKVY) for revamping existing commercial poultry farms. Swarna Jayanthi Gram Swarosgar Yojna (SGSY) for the promotion of backyard poultry, with 68% Central funding, 23% State, 8% loan and 1% beneficiary contribution. It is targeted at BPL women.
	Animal disease control and prevention programme	410.10		The Livestock Health & Disease Control scheme may be leveraged for the implementation of various project components. Animal Disease Monitoring and Surveillance System (ICAR) to be downscaled and mainstreamed for use in the State.
Coastal Fisheries	Improving aquaculture production and management	521.00		Leveraging the Central and State fisheries schemes, such as Pradhan Mantri Matsya Sampada Yojana; National Scheme of Welfare of Fishermen; Integrated Development and Management of Fisheries. Collaboration with Kerala State Coastal Area Development Corporation Ltd. and State Wetland Authority may be considered for the implementation of infrastructure and NbS adaptation components.
	Resilient coastal villages	423.00		
	Enhancing fisheries based income	1331.00		
	Improving the safety and energy efficiency of fishing	347.00		
	Post-harvest management	200.00		
	Feasibility studies	12.25		
	Innovative interventions	800.00		
	Training	96.00		

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Sector	Adaptation Projects	Total investment Across Plan Period (INR Crore)		Potential Sources of Adaptation Finance
Forests & Biodiversity	Improving green cover and forest protection	39.00		The National Adaptation Fund, CAMPA, NAP, GIM, IFMS, IDWH, Climate Change Action Programme (CCAP), and funding under other State-sponsored schemes for protected areas may be considered for funding. The budget allocated to MoEFCC for the Decision Support System for Environmental Awareness, Policy, Planning and Outcome Evaluation and Environmental Knowledge and Capacity Building (such as Eco-Task Force) should be leveraged for the implementation of various project components. CDM, REDD+ and other carbon market-based mechanisms provide ample scope for project implementation and management.
	Improving biodiversity	151.80		
	Enhancing the hydrological process of the forests	2206.90		
	Integrated forest fire management	44.20		
	Management of human-wildlife conflict	1454.00		
	Modernization and integration of various technological systems	8.00		
	Strengthening of participatory forest management and livelihood	3.50		
	Research-based information and studies on the impact of climate change on forests and biodiversity	4.95		
Health	Targeted healthcare for sensitive populations	13.52		A substantial portion of budgetary outlays towards the Ministry of Health and Family Welfare (MoHFW), Ministry of Drinking Water and Sanitation (MoDWS), and Ministry of Rural Department (MoRD) facilitate climate adaptation and should be leveraged to achieve project outcomes. NAFCC and bilateral cooperation may be leveraged for the implementation. Private sector investment through private hospital CSR/CER programmes may be leveraged.
	Healthcare service delivery to other vulnerable communities	2.40		
	Increasing access to functional healthcare	31.45		
	Safe drinking water	30.00		
	Safe and scientific sanitation	180.00		
	Solid waste management	436.00		
	Liquid waste management	668.00		
	Decentralized biomedical waste treatment and management	512.00		
	Mainstream the use of the digital mode of functional healthcare	7.06		
	Hub and spoke model for lab services	13.70		
	Insurance for sustainable healthcare	10.52		
	Addressing mental health issues in the context of frequent occurrences of extreme events	0.45		
	Capacity building for climate action	6.30		
	Air quality management and monitoring of climate-sensitive diseases	26.40		
Water	Sustainable access to safe drinking water in the priority districts	9042.5		Leveraging National Water Mission, Rajiv Gandhi National Drinking Water Mission, and Jal Jeevan Mission to achieve project outcomes. The National Bank for Financing Infrastructure and Development (NaBFID) and multilateral agencies may be engaged for funding. PMKSY may be leveraged for funding in convergence with MGNREGS.
	Community based sustainable drinking water interventions	1116.40		
	Availing and dissemination of water resources information of the State	40.90		
	Integrated water resources management	835.80		
	Water Conservation – sensitization and capacity building	2.80		

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Sector	Adaptation Projects	Total investment Across Plan Period (INR Crore)		Potential Sources of Adaptation Finance
Priority adaptation Interventions	Land use planning and zoning	74.00		Fund from State Disaster Response Fund and Dam Rehabilitation and Improvement Programme (DRIP) may be leveraged. The National Bank for Financing Infrastructure and Development (NaBFID) may be approached for funding. Multilateral engagement may be sought for funding.
	Sustainable protection and stabilization of shores and river banks	2844.40		
	Rehabilitation and Resettlement of vulnerable communities	8570.00		
	Sustainable drainage systems to reduce flood impact	716.50		
	Integrated and planned coastal zone management	23.70		
	Climate change monitoring and database management mechanism	67.30		
	Climate responsive local governance	120.00		
	Climate change education and awareness	4.10		
	Total	**38406.80**		

7.8. Summary

The departments of Agriculture, Animal Husbandry and Dairy Development, Environment, Fisheries, Health, Water Resources, Forests, Local Self Government, Revenue and Disaster Management, have great scope for implementing climate change adaptation schemes. Therefore, the magnitude of the budget allocated for these sectors may be increased, along with specific earmarking of funds for adaptation projects.

Climate risks disrupt societal business continuity, which is why it makes financial sense for the private sector to invest in adaptation not only as an imperative but as an opportunity. With the recent flooding in Kerala, the private sector can appreciate the loss and damages that amounted to thousands of Crore, affecting agro-based industries, mining, tourism, small business including FMCG companies, healthcare, financial services, road transport and real estate, etc. across the State. The private sector needs to assist the State in closing the financial gap. It can play a dual role in providing not only necessary finance and technical services for managing climate risk, but also in ensuring future investments prioritize climate resilience.

Extensive public-private co-financing of adaptation projects can ensure the financial viability of projects and also improve the potential for project scalability, which is essential for holistic resilience development in the State. The models to facilitate public-private investment has been briefly discussed in the previous section and includes the CSR, CER, etc., which is also applicable for adaptation. For the implementation of project components that focus on infrastructure development, be it agriculture storage facilities, medical institutions, safe homes for coastal fishing communities, or even green infrastructure and nature based solutions, the National Bank for Financing Infrastructure and Development (NaBFID) may be approached, as it has both financial and developmental objectives.

Besides these, the following strategies may also be used to increase climate resilience in the State:

- Build capacity of departments to diversify climate change finance – GEF, GCF, bilateral and multilateral sources, carbon market-based mechanisms, etc.
- The circular economy principles of reduce, reuse and recycle should be prioritised. Concepts of 'Regeneration' are trending and adaptation projects may be financed through crowdfunded investments. Digital platforms need to be established to tap these financial resources.
- Climate change adaptation programmes should be prioritised over other department schemes and programmes. Robust monitoring and evaluation frameworks must be put in place to map progress and efficacy of adaptation actions and to verify the consequent savings. Information must be readily available to the public.
- Climate Budget Tagging is an important tool for governments to monitor and track what they spend on climate-related activities and communicate them to all stakeholders. It also raises awareness and showcases efforts to tackle climate challenges, fosters better cooperation between departments, and mobilizes domestic and international finance by enabling the tracking of the allocation of resources. This will increase the attractiveness of investment in future adaptation actions.
- As an initial intervention, the State Government has already initiated climate tagging of the State Budget. Followed by the climate tagging, a comprehensive Climate Budgeting can be done under the Environment Budget as envisaged by the State Planning Board in the 14th Five Year Plan. The proposed interventions and actions in the SAPCC should be aligned to these budgets.
- There should be a separate chapter on 'Sustainable Development and Climate Change' in Economic Review of Kerala as is in the case of Economic Survey of India to review policies and budgetary allocations for climate mitigation and adaptation.

> Investing in no-regret adaptation actions today can save billions in avoiding loss and damages due to climate change in the future.

8. Institutional Mechanisms

8.1 Overview

State-wide implementation of the proposed climate change action plan would need planning and mainstreaming of climate actions, enhancing technology transfer and financing, and ensuring adequate capacity on all technical and managerial fronts. This would be possible only through enriched coordination and collaboration at all levels of planning, operationalization, and monitoring. According to UNFCCC, the institutional arrangements should identify clear roles and responsibilities of stakeholders at all levels. This includes streamlining resource use by having a lead institute at the regional level, establishing local champions to lead the work, and engaging with experts of similar experiences who offer opportunities for learning and supporting proposed actions (UNFCCC, 2014).

As outlined in the national and State action plans, the Centre and the States will have to implement sector-wise action plans through their respective ministries and departments. In the earlier phase, the SAPCCs were stand-alone documents, and as a result, there was a lack of coordination, absence of reliable information on the adverse impacts of climate change in a consolidated manner that was disseminated across various levels, lack of capacity that enabled coordination between State departments, academic and research institutions, and lack of an overarching monitoring and evaluation plan.

8.2 Current Institutional Mechanism

Kerala's State Climate Change Cell (SCCC) constituted vide G.O. (Rt) No. 27/2018/Envt dated 24-02-2018 functions as the pivotal point in the current institutional framework for the effective management, implementation, coordination, and monitoring of climate change activities in the State. Currently, the SCCC is functioning in the Directorate of Environment and Climate Change (DoECC), with the Director of DoECC as the Head of the Cell. The Directorate is responsible for the coordination and preparation of annual programmes as well as the assignment of responsibilities for the implementation of SAPCC. The SCCC also function as the Secretariat of the State Level Steering Committee (SLSC) for climate change. The State Level Steering Committee (SLSC) chaired by the Chief Secretary, acts as an apex body in scrutinizing and recommending climate change adaptation and mitigation interventions following NAPCC & SAPCC and ensures effective implementation, monitoring, and evaluation of the activities in the State.

With the inclusion of SLSC to the institutional framework, the current institutional mechanism accounted for leadership arrangements to some extent. This committee has the presence of high-level executives and bureaucrats in the State government system that aids in high-level monitoring, which encourages cross-sector convergence. However, there is a necessity of minister level governing body in the State to improve the climate change governance, formulation of policies and legislations. Further, the SLSC should be strengthened by 'domain experts/visionaries' who can contribute to overcoming barriers, inspire and motivate concerned line departments for achieving the goals set. The current institutional mechanism also lacks a framework to include adequate technical expertise in monitoring and evaluation. Even though the role of Local Self-Governments (LSGs) for implementing climate action plans were accounted for, some of the key concerns such as the capacity constraints to implement, operate, and maintain climate action projects/programmes were not addressed. The focus of the mechanism was more towards health, fisheries, and coastal areas and lacked proper institutional arrangements for other adaptation actions and mitigation projects. The lack of sectoral and district climate cells had also decelerated the implementation of projects set forth in SAPCC 1.0.

8.3 Proposed Institutional Mechanism

After thorough evaluation of the existing institutional framework, it is evident that their revision is required to overcome the identified drawbacks and the successful implementation of proposed climate action plans. In this section, some changes are suggested in the current institutional mechanism, addressing the gaps explained in the earlier section. The **Figure 8.1** depicts the proposed institutional mechanism for the State.

The Chief Minister's Governing Council on Climate Change shall act as the apex body supported by the State Level Steering Committee (SLSC). The SLSC will continue to function as the executive body supported by the State Climate Change Cell (SCCC) and the working groups. In addition to these functional bodies, it is proposed to constitute a high-level advisory committee with members from the State Planning Board, reputed academic and research institutions, and international & national sectoral experts. Regular convening of the SLSC along with the independent advisory committee, focusing on the monitoring and evaluation of the various strategies is inevitable for any course correction required for further implementation.

The State Climate Change Cell (SCCC) at DoECC, as the nodal agency, is the central unit of the proposed institutional framework. SCCC shall be responsible for communication and coordination with the SLSC at the top, the three Working Groups (WGs), State level Sectoral Climate Change Cells' (SeCCC) and District Climate Change Cells' (DCCC) at the bottom. The DCCCs as well as the SeCCCs will function as the nodal agencies at the respective level reporting to the SCCC. This will help in effectively addressing the cross-sectoral and local level aspects of the climate action strategies. The local self-governance institutions play a significant role in the effective implementation of the mitigation, and in particular, adaptation strategies at the 'grassroot' level. It is proposed to have a separate wing at the Local Self Governments (LSGs) level (the already existing working groups for environment, biodiversity, climate change and disaster management can perform this role) to interface with the District-Level Climate Change Cell (DCCC) that can act as a key link in the proposed implementation framework. The roles and functions of the various levels of governance structures are described below.

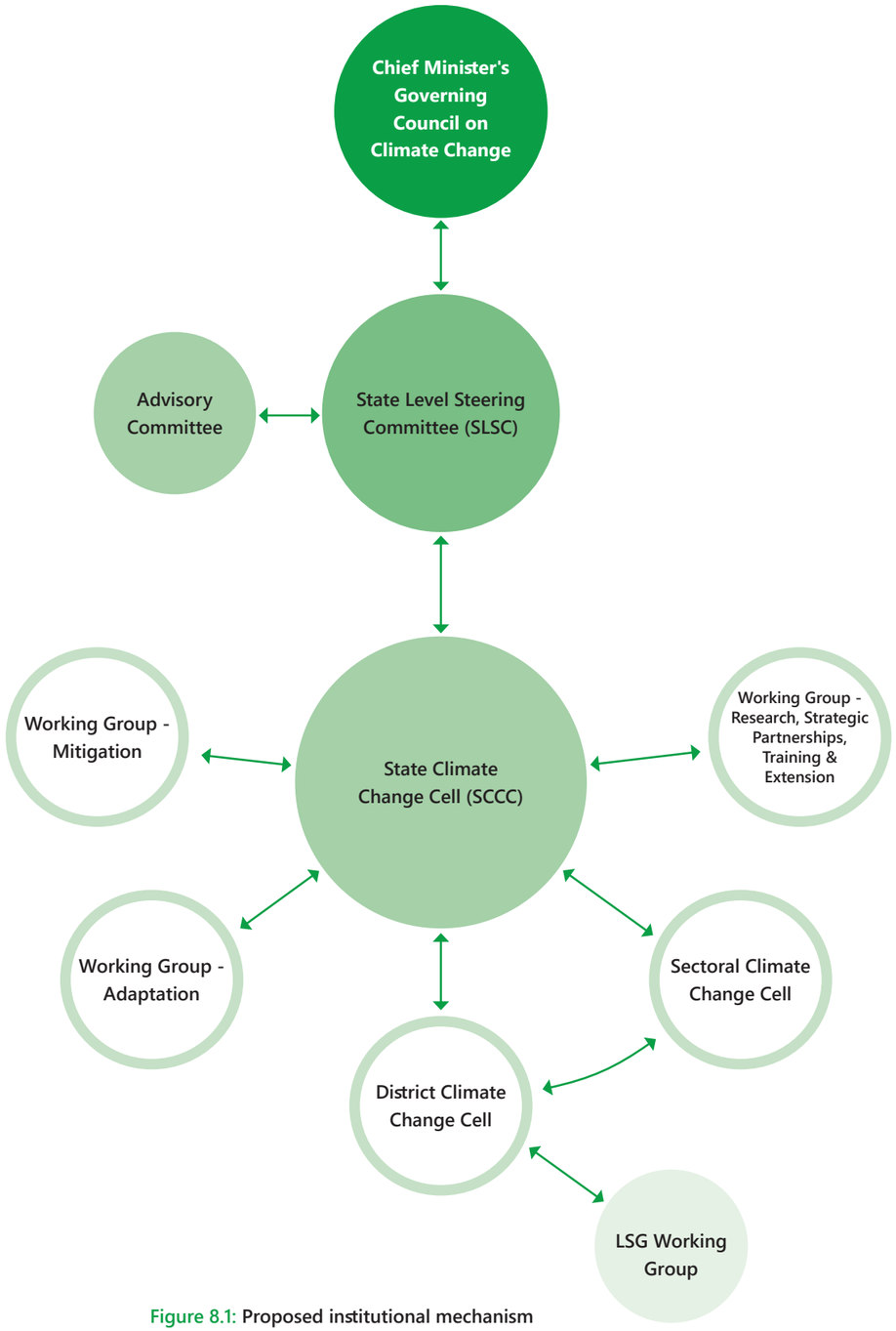

Figure 8.1: **Proposed institutional mechanism**

8.3.1 Chief Minister's Governing Council on Climate Change

The council shall be headed by the Chief Minister as its Chair and comprising the ministers of climate change priority sectors (Environment and Climate Change, Agriculture, Animal Husbandry, Fisheries, Forest, Health, Irrigation, Energy, Transport, Revenue and Disaster Management, Finance, LSGD and any other minister to be included by the Chief Minister), the Vice-Chairperson of Planning Board, the Chief Secretary and the Secretary to Environment and Climate Change. The Chief Secretary shall serve as Secretary to the Council. The council shall issue policy guidance, take stock of the climate change interventions in the State and act to induce any necessary changes required, including re-appropriation of funds. The council shall review the adequacy of existing legislation in addressing the climate change impacts and take appropriate actions to address the shortcomings if any. The council shall also guide on the issues of strategy, conflict resolution and the exemptions. The Council shall meet at its discretion as many times as deemed necessary, but at least once a year.

8.3.2 State Level Steering Committee (SLSC)

The State Level Steering Committee (SLSC) will be the top level executive body for the State level approval and driving the implementation of the approved SAPCC. It will steer and guide the various institutions and activities and prepare a roadmap with a clear vision, mission, and direction for action in consultation with the Advisory Committee. The Advisory Committee will have members from the State Planning Board, reputed academic and research institutions, international and national sectoral experts and representatives from the civil society and business community. The Steering Committee will also perform the functions of coordination and reporting to the Government of India and ensuring alignment of climate actions with NDCs and SDGs.

The SLSC will perform the following functions:

i) Policies: Frame policies and issue guidelines;

ii) Approves Action Plans and Projects: By perusing the Action Plans / Projects submitted by the SCCC, the Steering Committee will review and sanction projects. It may also commission consultants to carry out an appraisal of an action plan;

iii) Review the progress of the implementation of State Climate Change Action Plan and Programmes;

iv) Issue administrative directions and instructions for compliance.

8.3.3 State Climate Change Cell (SCCC)

The Kerala State Climate Change Cell established in the Directorate of Environment and Climate Change shall continue as the nodal entity in coordinating the climate change-related activities in the State. The Secretary (Environment) shall head the State Climate Change Cell and the Director, DoECC shall be the Secretary. The cell has to be strengthened with members from other key stakeholder departments/agencies including industry, NGOs, etc. The cell also has to be empowered with more regular technical staff at various levels in its cadre to enable the effective and efficient delivery of the duties. Apart from this, the virtual cadre of nodal officers from the sectoral departments/agencies will support the SCCC. The duties include:

a) constitute Working Groups for the preparation of action plans and projects;

b) coordinate with the three working groups to prepare State-level innovative and feasible plans and projects and get the approval of the SLSC;

c) review the plans and project proposals received from the SeCCCs and DCCCs and submit them to the SLSC for final approval;

d) monitor the implementation of State Climate Change Action Plan and submit the Annual Report to SLSC for review;

e) help networking among research institutions, experts, and consultants and act as the

conduit between the State and Central agencies and other organizations or agencies or institutions;

f) formulate and maintain the climate change database for the State;

g) periodic revision of the SAPCC;

h) take necessary actions in all matters related to the planning and management in addressing the effects of climate change in the State.

8.3.4 Climate Change Working Groups

It is proposed to formulate three Working Groups (WGs) which will act as think tanks for the preparation of State level action plans and projects. The WGs should carry out their activities under the aegis of the SCCC at DoECC. The composition of these WGs would be determined by the SCCC. The SCCC may brief the WGs on the process and understanding involved in the making of the SAPCC so that the WGs do not deviate from the central theme of SAPCC. The WGs will remain in constant dialogue with the SeCCCs of the respective departments responsible for programme implementation. The WGs should also be collating emerging information at the global level and initiate steps to fill the gap. All the three WGs will submit their programmes and reports to the SCCC for further approval and action. The three WGs and their functions is as follows:

i) ***Mitigation Working Group:*** This working group will address all issues related to climate mitigation and also work towards development of policies and programmes as enablers. Additionally, this working group will also examine ongoing programmes for their contribution and synergy with overall climate change mitigation goals of the State.

ii) ***Adaptation Working Group:*** This working group will address issues related to adaptation and contribute to priority programmes and projects development for promoting adaptation. The State level climate change adaptation programmes which have cross-sectoral/pan sectoral implications are to be formulated by this working group in tune with the sectoral adaptation projects & programmes conceived in the approved SAPCC.

iii) ***Research, Strategic Partnerships, Training & Extension Working Group:*** This working group will develop programmes to address the research, training and extension needs, in coordination with other research and training institutes and international bodies. They shall also formulate projects and programmes in consultation with the mitigation and adaptation working groups and guide the SCCC for funding from bilateral and multilateral organisations for implementation of the SAPCC.

8.3.5 Sectoral Climate Change Cells (SeCCCs)

The State level Sectoral Climate Change Cells are proposed to be constituted at every sectoral organisation/departments involved in implementation, with the existing manpower. The existing department level climate change cells need to be restructured as Sectoral Climate Change Cells. The climate change nodal officers designated from each sectoral department to the DoECC will invariably be the members of the SeCCC in their respective department. The SeCCCs should have representations from all the sectoral stakeholder departments and a nominated member from the State Climate Change Cell. These cells will ensure implementation of approved sectoral action plans and programmes, and periodical amendments, if any developed by the sectors or by the working groups.

The SeCCCs will need to collate all the climate change specific activities across the various departments in the sector and consolidate them for submission to the SCCC. The proposed climate change activities should be in alignment with the projects / objectives envisaged in the approved SAPCC. The SeCCCs should ensure that the activities being implemented in the sectors are not aggravating the climate change scene. The SeCCCs shall also decide on the necessary budget and the source of finance for the proposed activities. Additionally, those projects, which are envisaged to be externally funded, shall be supplemented by suitable proposals and duly submitted to the SCCC.

8.3.6 District Climate Change Cells (DCCCs)

Many of the climate action programmes, particularly the adaptation programmes, are implemented at the district level and local self-government level. Therefore, it is important to have an institutional structure that supports the activities of every department /sector at the district level. The existing District Planning Committee (DPC) may restructure or entrust to function as the District Climate Change Cells. The functions of this cell include:

a) Preparation of annual action programmes for the district, with clear quarterly milestones identified for monitoring and evaluation.

b) The DCCCs will remain in constant dialogue with the SeCCCs of the respective departments responsible for sector level programme implementation. The District Collector can resolve any issues requiring inter-departmental coordination and render support from the district administration for cross sector actions /programmes.

c) The annual programme with milestones and the annual progress report are to be communicated to SCCC by the District Collectors for review and approval.

d) The District Climate Change Cell can organise a workshop at the beginning of every year to brief people's representatives at various levels and the district level officers on the proposed measures, the plans, and milestones. The involvement of the elected representatives of the 3-Tier Panchayat Raj institutions such as District Panchayat, Block Panchayat and Grama Panchayat and the urban local bodies will systematically ensure the implementation of measures at the grass-root level. The DCCCs may avail the support of officers and experts for training and sensitisation.

e) Review and approval of Local Action Plan on Climate Change (LAPCC) prepared by the LSG Working Groups.

8.3.7 LSG Working Groups

The LSG level working groups already constituted by the LSGD, Government of Kerala for the 'Environment, Biodiversity, Climate Change and Disaster Management' should prepare the Local Action Plan on Climate Change (LAPCC) for the approval of the respective LSG and DCCC. The Working group should also monitor and evaluate the implementation progress of actions envisaged in LAPCC.

The proposed multi-tiered governance structure will ensure appropriate planning and implementation at different levels and also ensure that concerns and issues voiced by various representatives of the State, District, and Local Governments are taken into consideration and appropriately addressed.

9. Monitoring and Evaluation

9.1 Overview

The Monitoring and Evaluation (M&E) process could play a critical role in increasing the success of climate change mitigation and adaptation activities through evidence-based thorough assessment and efficient project management. Monitoring of a project is the process of keeping a close eye on the entire project management life cycle and ensuring project activities are on the right track. Evaluation of the executed projects is very critical in aiding decision makers to come up with practical solutions in addressing management problems or any barriers periodically. M&E is also needed to understand how the allocated funds are being utilized and to plan the disbursement of remaining funds effectively. The evidence-based evaluations of past experiences and ongoing projects help to evaluate the performance of an intervention, identify measures that can improve project quality, and thereby, aid in making the intervention more cost-effective.

Development of indicators into a workable monitoring framework is a huge task and has not come under the scope of this plan. The immediate steps after the approval of the plan should be to work on indicators and to develop the M&E Framework for the SAPCC. This is necessary for the implementing system to make any realignments or additions in the proposed activities so as to achieve the desired objectives. Specialised agencies may be brought in for the evaluation task. Evaluation exercises can be undertaken by implementing agencies under the guidance of State Climate Change Cell (SCCC). The SCCC would act as the nodal body for evaluation exercises by providing support for capacity building, training, evaluation framework development, etc. As an outcome of the evaluation exercise, a gap analysis will be conducted wherein progress against the proposed plan is mapped. This would then be used to make informed decisions to plan the remaining proposed activities.

In this section, M&E mechanisms for mitigation and adaptation activities that will be undertaken under SAPCC 2.0 is presented.

9.2 Mitigation

Monitoring of climate change mitigation projects refers to the measurement of carbon stocks, GHG emissions, costs, and socio-economic and environmental benefits that occur as a result of the project (Lawrence Berkeley National Laboratory, 2000). However, monitoring does not involve any GHG reduction calculations or comparisons with baseline measurements. For example, in the case of mitigation of GHG emissions via forest cover, monitoring would involve measurement of the number of hectares preserved by an afforestation project (Lawrence Berkeley National Laboratory, 2000). However, evaluation refers to a deeper analysis of the project(s) compared to monitoring. The calculation of GHG emission reductions is conducted at this stage. The focus of the evaluation is on projects that have been implemented and not quoted in the proposals. The analysis in the evaluation phase would be based on the actual data.

In this section, we elaborate on the indicators that can be monitored to assess the progress of an implemented project/programme in the sectors – power, transport, industry, buildings, and agriculture. This section also covers the scale and frequency of monitoring these indicators.

9.2.1 Power

The key indicators for mitigation strategies in the power sector include electricity generation from renewable sources, T&D losses, and energy efficiency of thermal power plants. At present, the key implementation/nodal agencies such as KSEBL, ANERT, EMC, NTPC, and Central ministerial departments monitor these indicators as part of existing policies and programmes. However, most of these data are not available at a single source to evaluate the progress of climate change mitigation actions at State level. These data at the district level need to be made available quarterly to the SCCC to conduct evaluation assessments. The disbursement of finance for the power sector mitigation projects also has to be documented regularly. Progress reporting on climate change action plans undertaken by each implementation agency needs to be mandated. Also, resource potential assessments and primary feasibility analysis for RTPV in all cities, floating solar in major irrigation canals, agrovoltaics, and micro/pico hydro projects need to be initiated soon.

Based on the reported data of RE-based electricity generation, T&D losses, and energy efficiency of thermal power plants, the actual emission mitigated to the base case will be estimated. The analysis of the utilization of finance disbursed by State and Central governments is also needed at regular intervals. Further, the co-benefits—such as reduced air, water, and land pollution, increased revenue of DISCOMs, and reduced fossil-fuel purchases—also need to be quantified during evaluation exercises.

9.2.2 Industry

The major industrial units in Kerala are covered under the PAT scheme and are monitored/audited for energy efficiency regularly. Further, the State has passed a resolution to make energy audits mandatory once in three years for all high-tension (HT) and extra high-tension (EHT) installations, which includes most of the industrial sector. The EMC is responsible for arranging energy audit firms with the requisite expertise for these mandatory audits. In the case of the MSME sector, the EMC is currently providing support (including finance) for energy audits in enterprises owned by women, energy efficiency capacity-building programmes, and awareness programmes, to some extent (EMC, 2021; MSME, 2021b). Regular documentation and reporting of fuel usage and specific energy consumption (SEC) to the EMC would help in evaluating the efficacy of any energy efficiency measures undertaken in this sector.

Based on the collated information on fuel usage and SEC, the actual emission mitigated to the base case will be calculated. Any co-benefits, and efficacy of finance utilized will be assessed in the evaluation exercise. A gap analysis of actual project achievement and the proposed plan will be done along with the other listed assessments.

9.2.3 Transport

The climate change action plans in the transport sector include a shift from private to public transport (including water transport) and the adoption of electric vehicles (EVs). To monitor the shift to public transport, departments need to keep track of public transport ridership for buses, metros, and ferries. This has to be at a city level and local authorities can take up the monitoring work. Increase in the ridership in any of these segments better than the historic trend is the easiest way to estimate success. For rigorous monitoring, a survey would be required to understand if there was a shift from private vehicles, which segments experienced the shift, and what the increased share of public transport is. A sample survey can be conducted at major transport hubs, bus stops, metro stations, and ferry stations, targeting the public transport users to understand how many of them have shifted from private vehicles to public transport, and when. For monitoring the shift to EVs, the Motor Vehicles department needs to track the sales trend of EVs and conventional vehicles. The negative growth rate of conventional vehicles is one indicator of successful EV policy.

To evaluate the impact of the shift to public transport, the mode-wise share in the base year and current year share is required. Based on the movement of vehicles and mileage, the mode-wise emissions would be calculated, and hence, the difference in emissions before and after the implementation of action plans could be compared to evaluate the impact. Similarly, the impact of electrification can be estimated by calculating the emissions that could have been on the road due to conventional vehicles, which are now replaced by EVs. Though EVs have zero tail-pipe emissions, the emission at the source shall be accounted for, based on the source of electricity generation for the electricity required to run the current EVs on road. The difference between the emissions from EVs and the same number of conventional vehicles is essentially the impact of an EV policy.

9.2.4 Buildings

For monitoring mitigation activities in the building sector, the Energy Management Centre may keep track of sales of energy-efficient appliances Vs conventional appliances year on year. Similarly, the distribution of LED lights and the sale of conventional lights need to be tracked. The decreasing percentage share of conventional appliances/lighting is proof of increasing energy efficiency. Also, climate-friendly building design and the use of local materials and construction techniques can further mitigate emissions (ECBC compliance). Proper guidelines need to be developed on using the traditional techniques to suit new age requirements. Orientation of building, standards on opening sizes, shading devices, and air circulation in the usable space (fresh air in-let and used air out-let) are a few easy and traditional building design techniques that can be incorporated into building bye-laws. Local authorities can monitor the number of such buildings being constructed and the interventions used by such buildings.

To evaluate the impact of replacing the conventional lights and appliances with energy-efficient ones, the wattage difference between the two and grid emission are the major parameters that would estimate the reduction. Using the methodology suggested by BEE, the emission due to LEDs and energy-efficient appliances and emissions due to another lighting such as CFL, incandescent light, etc. and conventional (non-energy efficient) appliances need to be calculated.

9.2.5 Agriculture

For monitoring the mitigation activities in the agriculture sector, a comprehensive database of agricultural pump sets, including parameters such as pump size, operational hours, water and energy consumption, geographical deployment, etc., needs to be created. Currently, proper documentation of agricultural pump sets is not available (EMC, 2018). This can be done on an annual basis by Krishi Bhavans and KSEBL with a pre-designed format. This level of monitoring can ensure that new pump sets purchased will be star-labeled and through proper channels. This will also help avoid unnecessary power consumption by old inefficient pumps, which are utilized beyond their design lifetime by rewinding the motors in the local markets. The data on finance allocated and disbursed for solar pump subsidy also needs to be documented and reported by ANERT at regular intervals. The PM KUSUM scheme has envisaged real-time monitoring and maintenance of solar pumps by the vendors as well.

The impact of the policies can be evaluated by estimating the electricity saved, and consequently, the emissions mitigated in the agriculture sector. Further, co-benefits for KSEBL in terms of savings in subsidies provided for agricultural consumers can also be estimated. The co-benefits of the solar pump policy can be estimated in terms of the impact on farmer income by saving the electricity.

9.3 Adaptation

For the monitoring and evaluation of adaptation actions in all sectors, a results-based M&E system to measure progress towards achieving the project development objectives is proposed. Three interrelated activities constitute the primary mechanism for assessing whether the adaptation investment is effective: a baseline survey at the beginning, a midterm assessment of any correction needs, and a comprehensive review when the project is finished. First and foremost, for each project, implementing agencies should identify and define key result indicators or indicators representing the project development objectives based on the expected outcomes of the project. Then, intermediate result indicators can be defined for each project component or activity.

A robust baseline assessment for each project must capture the climate risks, which incorporates:

a) Assessment of the probability of occurrence of current and future climate hazards,

b) Current and future exposure of systems to potential hazards, and

c) Inherent vulnerability (sensitivity and lack of adaptive capacity) of the system.

Baseline surveys will need to be conducted for each of the districts, or specific project locations within prioritized districts. Against this, projects can establish an M&E system to monitor and assess project progress, the effectiveness of implementation, and the level of achievement of expected results. Baseline surveys will quantify the various indicators defined and the same indicators will need to be quantified in the mid-term impact evaluation survey as well as at the end of project evaluation survey. All project evaluation exercises should be undertaken by implementing agencies under the guidance of the SCCC.

These surveys will be backed by smaller surveys to track seasonal and periodic changes in key result indicators. The seasonal surveys should be implemented by the relevant departments, while the impact evaluation surveys could be contracted to a third-party M&E agency with expertise in climate change as related to the various sectors. Appropriate sampling methods and a clear understanding of climate change issues will guide these assessments.

With the lack of baseline information for the proposed adaptation project, this section aims to only propose potential indicators for the measurement of project outcomes. Actual targets and indicators will be project- and location-specific and dependent on the output of baseline surveys. The overall effectiveness of adaptation projects should be measured as their ability to lower existing and projected climate risks to the system. Thus, impact evaluation studies must be conducted with this in mind. As projects are linked to both SDGs and NDCs, the M&E framework capturing project outputs should also reflect the level of project contribution to achieving these goals.

An illustrative results framework for monitoring and evaluation of adaptation projects, with an example of a project conceived for Sustainably Enhancing Agricultural Productivity, is provided in **Table 9.1**.

Table 9.1. **Illustrative Results Framework - Sustainably Enhancing Agricultural Productivity**

Indicator	Baseline (2023)	Intermediate Target (2026)	End Target (2030)
Project development objective Indicators			
Farmers provided with agricultural assets or services (SDG 1, 2, 3, 5, 10, 11, 12, 13 and 15; NDC 1, 2, 3, 4, 5 and 6)			
Farmers provided with agricultural assets or services (number)	0	50,000	100,000
Farmers provided with agricultural assets or services – women (number)	0	15,000	40,000
Productivity of specific crops increased (tonne/ha)			
a) Paddy	2.5	2.80	3.2
b) ...	--	--	--
c) ...	--	--	--
Farmer's income increased (INR)	₹ 50,782	₹55,860	₹63,477
Intermediate results Indicators by activity			
Crop area provided with irrigation services (ha)	1000	12,154	18,230
The area under integrated farming increased (ha)	500	2,430	3,646
Percentage of emission intensity of crop and livestock production lowered	1%	5%	10%
Percentage area brought under agroforestry	20%	30%	40%
Carbon sink created and emissions mitigated (tCO_{2eq}/ha/yr)	0	-10	-15
Percentage of farmers covered under short term crop advisory	5%	50%	70%
Percentage of farmers using services provisioned by Krishi Bhavans	15%	50%	70%
Percentage of farmers using services provisioned by Krishi Bhavans – women	10%	50%	100%
Percentage of farmers provided with soil health card	10%	50%	100%
Number of farmers provided with soil health card – women	5%	50%	100%
Percentage of farmers having access to market infrastructure	20%	50%	70%
Percentage of farmers having access to market infrastructure – women	10%	50%	100%

The project assumed is to be implemented in the least productive areas of prioritized districts.

As part of the M&E process, a detailed financial and economic analysis may be conducted to assess the potential annual and incremental benefits and returns of project activities even after project completion. Furthermore, for natural resource-based adaptation projects, particularly for agriculture, livestock, fisheries, and forestry sectors, GHG accounting of proposed project interventions may be assessed using tools such as Ex-Ante Carbon Balance Tool (EX-ACT v9, FAO), to add mitigation co-benefit value to proposed adaptation projects.

9.4 Summary

The M&E framework should reflect the decentralized nature of the project structure, and thus, the process for assessing progress should be participatory. Stakeholders should be engaged to prepare a plan for measuring results, evaluating achievements, and learning from the project experience. The process will help build local capacity to reflect, analyze, propose solutions, and act. It will encompass social audit and quality control, monitoring how the interventions undertaken are progressing, and capturing how climate-resilient activities are enhancing the profitability of systems managed by project beneficiaries. Where ever possible, data should be disaggregated by gender.

A robust GIS-based Management Information System (MIS) should be established for each project to track implementation progress, including disbursement, procurement, and the implementation of planned activities, highlighting physical results in real-time, and giving the implementation agencies an external perspective on the work of the project. The MIS should have separate but interlinked modules for all implementing agencies. The existing PlanSpace dashboard of the Kerala State Planning Board may also be restructured to cater the above mentioned management information system.

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Annexures

Annexure 1.1: Guiding Principles

Principle 1

SAPCC is a policy document of the States/UTs outlining the major initiatives and strategies, and reflecting the commitments and proposed actions in the State to tackle vulnerabilities and impacts of climate change across socio-economic sectors.

Principle 2

SAPCCs envisage inclusive, sustainable and climate resilient low carbon development pathways with a focus on climate change adaptation and mitigation within the key sectors in the States/UTs and are aimed to protect the poor and vulnerable sections of society from adverse effects of climate change.

Principle 3

SAPCCs consider recent scientific assessments and projections on global warming vulnerability and impacts.

Principle 4

SAPCCs are aligned with the NDC goals under the Paris Agreement, and they also contribute toward the achievement of the Sustainable Development Goals.

Principle 5

SAPCCs highlight the links with National Missions related to climate change.

Principle 6

SAPCCs are built on the evolving socio-economic development context and priorities of the State.

Principle 7

States/UTs strengthen existing climate action measures as well as launch new initiatives in their priority sectors. Some of the initiatives can be introduced in the areas of efficient and cleaner technologies, promoting renewable energy generation, reducing emissions from the transport sector, afforestation and greening activities, and standardizing knowledge management system for adaptation and mitigation.

Principle 8

The period of the implementation of SAPCCs should be brought out starting with the implementation cycle of NDCs i.e. 2021-2030 and beyond.

Principle 9

Financial resources required for the implementation of the SAPCC are primarily leveraged from the existing budget of the State Governments and through convergence with relevant schemes and programmes.

Principle 10

SAPCCs set out the institutional mechanism for implementation including stakeholder engagement ensuring inclusiveness along with the mechanism for capacity building and monitoring and evaluation with clear indicators for reporting.

Annexure 1.2: Core Group for the Revision of Kerala SAPCC

A	**SAPCC Revision Team - Department of Environment** Sri. Suneel Pamidi IFS, Director, Directorate of Environment and Climate Change Dr Jude Emmanuel – Environmental Scientist & State Climate Change Nodal Officer Dr John C Mathew – Environment Programme Manager Er. Kalaiarasan – Environmental Engineer Dr Lakshmi P.M. – Environmental Scientist Smt. Sreeja Raj S. R. – Environmental Officer Dr Jissy Jyothy S. – Environmental Officer Sri. Toms Augustine – Assistant Environmental Officer Sri. Rahul Ramesh – Assistant Environmental Officer Dr Shiju Chacko – GIS Specialist Dr Kannan Narayanan – Research Associate Dr Jikku Kurien – State Expert Consultant & Scientific Coordinator
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E	**Stakeholder Partners - Departments/Institutions/Agencies**

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Annexure 3.1: Changes in projected temperature under the given climate scenarios

Districts	Change in temperature (°C) during the 2030s (2021–2050) compared to the historical period (1990–2019)			
	Summer maximum temperature		Winter minimum temperature	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Thiruvananthapuram	1.3	2.0	1.4	1.3
Kollam	1.3	1.7	1.7	1.6
Pathanamthitta	1.4	1.7	1.3	1.7
Alappuzha	1.3	1.7	1.1	1.5
Kottayam	1.4	1.5	1.5	1.8
Idukki	1.1	1.9	1.4	2.0
Ernakulam	1.4	1.8	1.3	1.8
Thrissur	1.2	1.9	1.2	1.8
Palakkad	1.2	1.9	1.4	1.8
Malappuram	1.3	1.6	1.4	1.7
Kozhikode	1.3	1.7	1.3	1.7
Wayanad	1.4	2.0	1.7	2.0
Kannur	1.3	1.6	1.5	1.8
Kasaragod	1.2	1.5	1.7	1.9

ANNEXURES

Annexure 3.2: Changes in projected rainfall under the given climate scenarios

Districts		Thiruvananthapuram	Kollam	Pathanamthitta	Alappuzha	Kottayam		Idukki	Ernakulam	Thrissur	Palakkad	Malappuram	Kozhikode	Wayanad	Kannur	Kasaragod
Annual Rainfall																
Near-term (2021-2050)	RCP 4.5	87	69	70	74	47		28	80	96	73	96	77	110	74	25
	RCP 8.5	117	88	85	95	61		34	95	115	87	116	95	124	92	32
Mid-term (2051-2080)	RCP 4.5	102	74	72	80	42		24	79	97	67	91	70	91	71	25
	RCP 8.5	117	74	69	90	48		20	77	97	63	89	69	93	72	28
Winter																
Near-term (2021-2050)	RCP 4.5	95	61	57	93	114		111	159	178	237	280	309	266	272	77
	RCP 8.5	69	22	21	24	49		56	82	85	94	134	163	99	222	112
Mid-term (2051-2080)	RCP 4.5	80	34	32	44	75		94	132	134	198	207	235	181	222	74
	RCP 8.5	3	-23	-14	9	39		33	89	113	99	182	260	207	293	193
Pre-monsoon																
Near-term (2021-2050)	RCP 4.5	40	20	14	29	17		20	70	63	62	83	50	53	41	-1
	RCP 8.5	142	106	79	133	101		61	177	191	172	224	173	139	184	104
Mid-term (2051-2080)	RCP 4.5	71	41	27	56	27		20	80	83	73	99	66	49	70	21
	RCP 8.5	65	31	13	64	32		1	83	89	62	102	66	42	73	29
Monsoon																
Near-term (2021-2050)	RCP 4.5	184	137	162	118	69		51	99	125	91	117	86	133	83	32
	RCP 8.5	201	146	171	128	75		54	104	132	93	126	96	138	92	33
Mid-term (2051-2080)	RCP 4.5	197	139	161	121	62		50	97	123	81	109	77	112	77	30
	RCP 8.5	237	143	162	135	67		46	92	121	78	106	77	118	79	34
Post-monsoon																
Near-term (2021-2050)	RCP 4.5	-12	-18	-18	-12	-10		-18	6	0	13	9	34	64	32	-16
	RCP 8.5	-3	-19	-21	-16	-18		-21	-1	-3	13	7	28	55	19	-28
Mid-term (2051-2080)	RCP 4.5	0	-14	-17	-11	-19		-27	1	4	8	7	26	40	23	-17
	RCP 8.5	5	-11	-14	-5	-10		-18	10	9	10	3	17	38	16	-23

ANNEXURES

Annexure 3.3: Extreme rainfall events under historical and projected periods

Districts		Thiruvananthapuram	Kollam	Pathanamthitta	Alappuzha	Kottayam		Idukki	Ernakulam	Thrissur	Palakkad	Malappuram	Kozhikode	Wayanad	Kannur	Kasaragod
Heavy rainfall																
Historical		48	97	22	131	182		21	160	151	37	100	136	23	218	363
Near-term (2021-2050)	RCP 4.5	284	348	188	453	502		98	547	515	217	475	465	196	530	489
	RCP 8.5	294	434	198	501	554		89	608	597	254	515	450	189	537	530
Mid-term (2051-2080)	RCP 4.5	277	370	168	468	437		87	539	592	184	455	410	143	492	478
	RCP 8.5	336	374	183	456	495		79	519	494	204	457	422	171	482	466
Very heavy rainfall																
Historical		4	14	3	6	32		2	13	19	3	11	36	2	30	59
Near-term (2021-2050)	RCP 4.5	80	137	45	179	185		13	239	278	55	211	187	47	279	258
	RCP 8.5	116	145	44	221	213		15	277	319	55	241	244	59	328	276
Mid-term (2051-2080)	RCP 4.5	108	138	45	190	179		23	222	252	43	201	177	38	254	241
	RCP 8.5	133	140	52	251	191		25	233	289	47	187	184	43	286	288
Extremely heavy rainfall																
Historical		0	2	0	0	2		0	2	1	1	1	1	0	2	0
Near-term (2021-2050)	RCP 4.5	6	15	3	32	25		5	23	41	4	29	27	5	53	34
	RCP 8.5	22	25	7	45	32		4	29	46	5	46	44	11	76	52
Mid-term (2051-2080)	RCP 4.5	18	26	9	47	27		3	32	48	8	32	32	6	63	54
	RCP 8.5	23	28	10	50	28		3	35	54	3	41	26	3	61	61
Rainfall deficient years																
Historical		6	5	6	5	5		7	6	7	8	7	6	13	6	5
Near-term (2021-2050)	RCP 4.5	6	7	6	6	4		6	4	4	5	4	5	4	4	4
	RCP 8.5	7	7	8	7	7		7	6	7	6	5	7	8	7	7
Mid-term (2051-2080)	RCP 4.5	10	7	6	7	7		7	7	8	7	7	7	9	6	8
	RCP 8.5	10	8	9	6	5		8	5	7	7	7	7	7	6	6

Annexure 3.4: Total number of rainy days (>2.5 cm/day) during the historical and projected periods

Districts	Historical (1990-2019)	Near-term (2021-2050)		Mid-term (2051-2080)	
		RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Thiruvananthapuram	3869	4103	4351	4084	4017
Kollam	4275	4489	4725	4447	4351
Pathanamthitta	4154	4448	4697	4421	4328
Alappuzha	4659	4647	4872	4572	4526
Kottayam	4956	4923	5135	4819	4777
Idukki	4410	4192	4426	4121	4001
Ernakulam	4916	4962	5166	4833	4809
Thrissur	4144	4522	4728	4396	4444
Palakkad	3764	4537	4733	4330	4309
Malappuram	4315	4585	4789	4443	4422
Kozhikode	4212	4484	4637	4323	4253
Wayanad	3497	4139	4321	3956	3845
Kannur	4607	4342	4525	4217	4174
Kasaragod	4882	4111	4157	3972	3849

Annexure 4.1: Sectoral Vulnerability Assessments

Seven sectoral vulnerability assessments were conducted covering the agriculture, livestock, coastal fisheries, forests, health, tourism, and water sectors. Sectoral experts assisted in the selection of indicators and recommended the inclusion of 20–27 indicators for the assessment of different sectoral vulnerabilities. As there may be autocorrelation among indicators selected, post quantification of indicators, correlation matrices were constructed to assist with exclusion of highly correlated indicators ($r^2 \geq 0.7$) for each sector.

Sector: Agriculture

Indicators selected for Agriculture Vulnerability Assessment

A total of 20 indicators were suggested by sectoral experts. Six of these indicators were found to have very significant correlation with other indicators, and as such, were excluded. Details are provided below:

1. The indicators' percentage area under small and marginal holdings (r^2= -0.865); percentage share of agricultural sector to the total GDVA (r^2= 0.793) and drainage density (km/sq.km) (r^2= 0.716) were found to have very significant negative and positive correlation with the indicator percentage of population dependent on agriculture, respectively. This means districts that have a higher population dependent on agriculture also observe large landholding sizes, which is the case in Kerala, and obviously, agriculture in these districts contribute more to the GDVA. These districts also appear to have a higher drainage density aiding agricultural productivity. As such, all three indicators were excluded as they are represented by the indicator percentage of population dependent on agriculture.
2. Districts with a higher percentage area under integrated farming system were found to also have a higher percentage area under collective farming (positively correlated, r^2= 0.765), and as such, only the latter was retained.
3. Similarly, districts with many agriculture markets also had many Krishi Bhavans (positively correlated, r^2= 0.749), and as such, only the latter was retained.
4. Finally, districts with more insurance coverage of cultivators also observed better access to primary agricultural credit societies (positively correlated, r^2= 0.765) and as such only the latter was retained.

Thus, a total of 14 indicators (5 sensitivity and 9 adaptive capacity indicators) were finalised for vulnerability assessment. The final list of indicators, the function of vulnerability they represent, and the source of data used to quantify them are provided in **Table A-4.1**.

Agriculture Vulnerability Index

Normalised indicator values of each district were aggregated to form an Agriculture Vulnerability Index value, which were then arranged in ascending order to rank the 14 districts on a three-point scale of low, medium, and high vulnerability. Results are presented as a graph **(Figure A-4.1)** and map (**Figure A-4.2**). Palakkad, Wayanad, Kasaragod, Idukki, Kozhikode, Malappuram, Kottayam, Kannur and Thiruvananthapuram were ranked as being highly vulnerable, with Palakkad being most vulnerable.

Table A4.1: **Indicators selected for the computation of Agriculture Vulnerability**

SN	Indicators	Function of Vulnerability	Source
1.	Percentage of population dependent on agriculture	Sensitivity	Census (2011)
2.	Variation in food grain crop yield (5 years)	Sensitivity	Agriculture Department (2019)
3.	Percentage net irrigated area to net sown area	Adaptive Capacity	
4.	Number of Krishi Bhavans per 1,000 ha of net cropped area	Adaptive Capacity	
5.	Number of storage facilities per 1,000 ha gross cropped area	Adaptive Capacity	
6.	Percentage of operational holdings issued with soil health card	Adaptive Capacity	
7.	Percentage area of potential cultivable area to the total district area (excluding forest)	Adaptive Capacity	Directorate of Soil Survey & Soil Conservation (2019)
8.	Variation in productivity of principal agricultural crops (except paddy, cardamom, coffee, and tea) (5 years)	Sensitivity	Department of Economics and Statistics, Kerala (2018–19)
9.	Percentage area under collective farming to net sown area	Adaptive Capacity	Agriculture Department (2019) & Economic Review (2020)
10.	Variation in soil moisture (10 years)	Sensitivity	NRSC (2020)
11.	Groundwater level trend for 10 years (pre-monsoon)	Sensitivity	CGWB (2010–20)
12.	Crop Diversity Index	Adaptive Capacity	KAU (2020)
13.	Road density	Adaptive Capacity	LSG, PWD, NHAI (2020)
14.	Number of primary agricultural credit societies per 1,000 farmers	Adaptive Capacity	Registrar of Co-op. Societies (2020)
	Indicators excluded after correlation analysis		
15.	Percentage of cultivators covered under insurance	Adaptive Capacity	Agriculture Department (2019)
16.	Percentage area under integrated farming systems to net sown area	Adaptive Capacity	
17.	Number of agriculture markets per 1,000 ha of gross cropped area	Adaptive Capacity	
18.	Drainage density (km/sq.km)	Adaptive Capacity	Land Use Board (2020)
19.	Percentage share of agricultural sector to the total GDVA	Sensitivity	Economic Review (2020)
20.	Percentage area under small and marginal holdings	Sensitivity	Agriculture Census (2015-16)

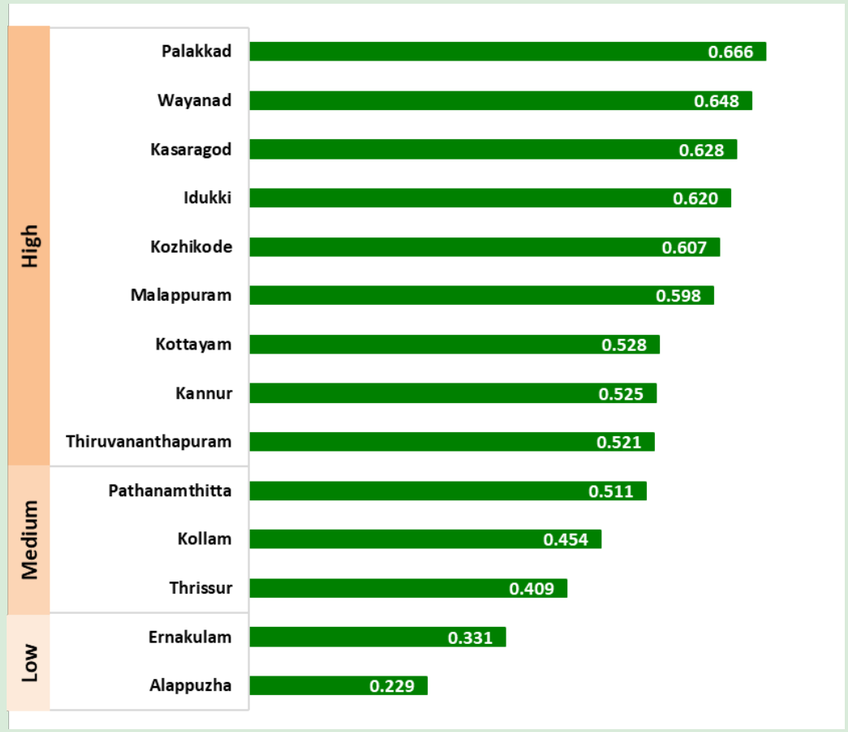


Figure A-4.1: **Ranking of districts based on Agriculture Vulnerability Index**

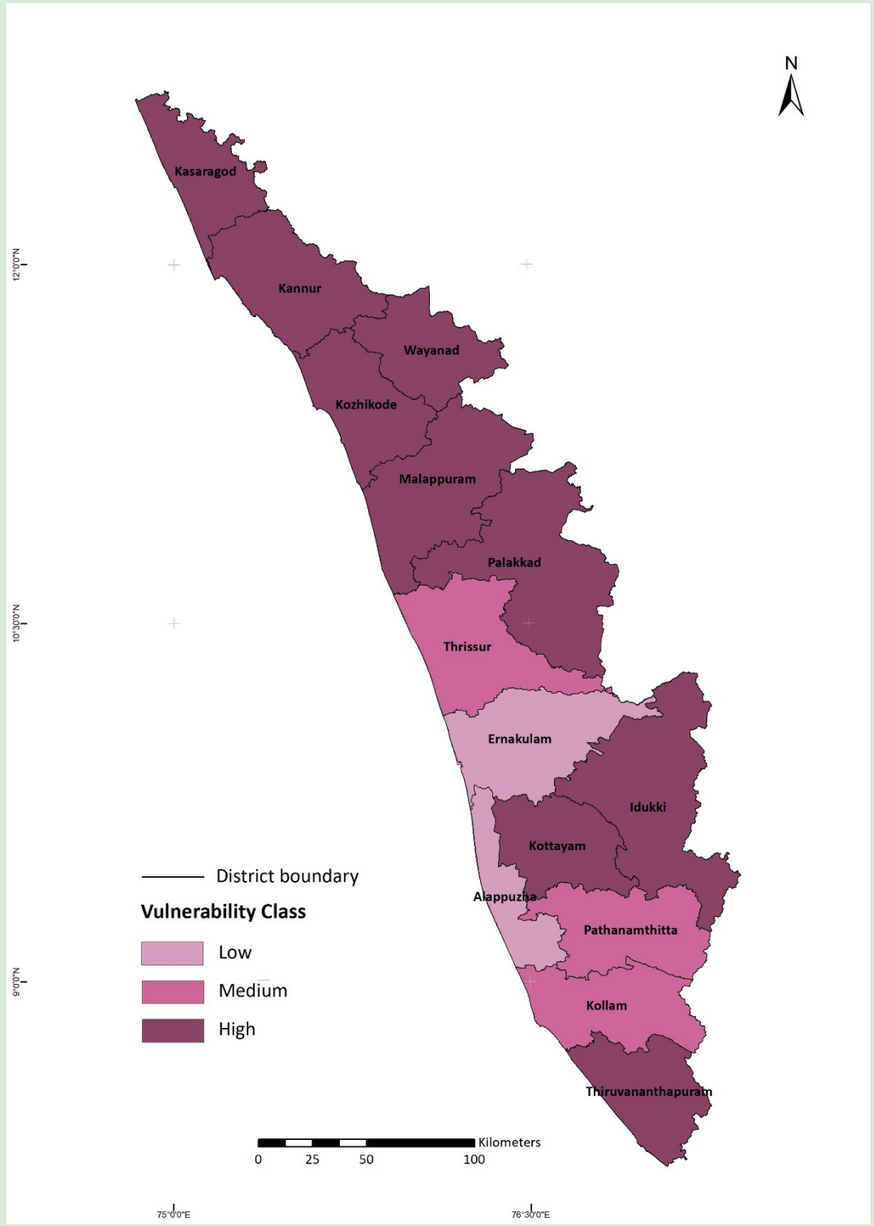


Figure A4.2: District wise Agriculture Vulnerability Index

Drivers of Agriculture Vulnerability

The average normalised values of indicators were computed for each vulnerability class (high, medium, and low) to represent the drivers of vulnerability (**Table A-4.2**). Significant drivers are those with average normalised scores over 0.5 and priority drivers are those with values over 0.75 and have been highlighted in **bold**.

In order to lower agriculture vulnerability and to develop no-regret adaptation strategies, these drivers can be addressed. However, vulnerability is context specific and drivers of vulnerability vary from district to district. As such, major drivers of agriculture vulnerability for the highly vulnerable districts are also provided (**Table A-4.3**).

Table A4.2: Drivers of Agriculture Vulnerability

Vulnerability class	Districts	Drivers of Vulnerability
High	Palakkad, Wayanad, Kasaragod, Idukki, Kozhikode, Malappuram, Kottayam, Kannur, Thiruvananthapuram	1. **Low percentage area under collective and integrated farming systems** 2. **Fewer storage facilities** 3. **Fewer primary agricultural credit societies and crop insurance coverage** 4. Poor irrigation coverage 5. Low potential for expansion of agriculture land 6. Fewer Krishi Bhavans and agriculture markets 7. High variation in soil moisture 8. Low road density 9. High variation in groundwater level trend during pre-monsoon periods
Medium	Pathanamthitta; Kollam and Thrissur	1. Fewer primary agricultural credit societies and crop insurance coverage 2. Fewer storage facilities 3. Poor irrigation coverage 4. Low road density 5. High variation in foodgrain crop yield 6. High variation in groundwater level trends during pre-monsoon periods 7. Prevalence of monocrop systems
Low	Ernakulam and Alappuzha	1. High variation in the productivity of principal agriculture crops (except paddy, cardamom, tea, and coffee)

Table A4.3: **Drivers of Agriculture Vulnerability in highly vulnerable districts**

Districts	Driving Indicators
Palakkad	High variation in the groundwater level trend during pre-monsoon period Poor storage facilities High variation in the productivity of principal agricultural crops (except paddy, cardamom, coffee, and tea) Low road density Low percentage of operational holdings issued with soil health card Low number of primary agricultural credit societies.
Wayanad	Low number of Krishi Bhavans per 1000 ha Low number of primary agricultural credit societies per 1000 farmers Low road density High percentage of agricultural dependent population Low percentage of net irrigated area to net sown area.
Kasaragod	Low percentage of area capable for cultivation to the total district area High variation in the productivity of principal agricultural crops (except paddy, cardamom, coffee, and tea) Low number of Krishi Bhavans per 1000 ha High variation in the groundwater level trend during pre-monsoon Low percentage of area under collective farming to net cropped area.
Idukki	High variation in soil moisture High percentage of agricultural dependent population Low number of primary agricultural credit societies Poor storage facilities Low number of Krishi Bhavans Low percentage of area under collective farming Low percentage of cultivable land Low road density.
Kozhikode	Low percentage of net irrigated area to net sown area Low crop diversification Low percentage of area under collective farming to net cropped area Low percentage of area capable for cultivation to the total district area.
Malappuram	Low percentage of operational holdings issued with soil health card High variation in food grain crop yield Low percentage of area under collective farming to net cropped area Low number of primary agricultural credit societies per 1000 farmers.
Kottayam	Low percentage of net irrigated area Low percentage of area under collective farming to net cropped area Low crop diversification Low percentage of area capable for cultivation Poor storage facilities.

Districts	Driving Indicators
Kannur	Low number of storage facilities per 1000 ha Low percentage of net irrigated area to net sown area Low percentage of area capable for cultivation to the total district area Low road density.
Thiruvananthapuram	Very low percentage of area under collective farming to net cropped area Low percentage of net irrigated area High variation in soil moisture Poor storage facilities Low number of primary agriculture credit societies.

Sector: Livestock

Indicators selected for Livestock Vulnerability Assessment

A total of 27 indicators were suggested by sectoral experts. Nine of these indicators were found to have very significant correlation with other indicators, and as such, were excluded. Details are provided below:

1. Four indicators – livestock to human ratio (r^2= 0.866); per capita milk availability (r^2= 0.814); percentage area under pasture (r^2= 0.802), and percentage of livestock farmers (r^2= 0.760) showed significant positive correlation with the indicator percentage share of livestock to GDVA. This means districts that have more livestock obviously have more livestock farmers, a larger area under pastures and also more milk production, and thus, also contribute a larger share to the GDVA. As such, all four indicators were excluded.
2. Two indicators - number of dairy cooperative societies per 1,000 dairy livestock population (r^2= 0.816) and percentage enrolment in the Kerala Dairy Farmers Welfare Fund (r^2= 0.746) showed significant positive correlation with the indicator percentage coverage of dairy cooperative societies to total dairy livestock farmers, and thus, were excluded.
3. Similarly, two indicators – number of ICDP/ insemination centres per 1,000 livestock population (r^2= 0.807) and number of veterinary hospitals per 1,000 livestock population (r^2= 0.776) showed significant positive correlation with the indicator number of veterinary doctors and livestock inspectors per 1,000 livestock population. They were both excluded.
4. Finally, districts with higher per capita availability of chicken meat also observed higher per capita availability of eggs (positively correlated, r^2= 0.813), and as such, only the latter was retained.

Thus, a total of 18 indicators (5 sensitivity and 13 adaptive capacity indicators) were finalised for vulnerability assessment. The final list of indicators, the function of vulnerability they represent, and the sources of data used to quantify them are provided in **Table B-4.1.**

Livestock Vulnerability Index

Normalised indicator values of each district were aggregated to form the Livestock Vulnerability Index value, which were then arranged in ascending order to rank districts on a three-point scale of low, medium, and high vulnerability. Results are presented as a graph (**Figure B-4.1**) and map (**Figure B-4.2**). Palakkad, Kasaragod, Idukki and Kollam were ranked as being highly vulnerable, with Palakkad being most vulnerable.

Table B4.1: **Indicators selected for the computation of Livestock Vulnerability**

SN	Indicators	Function of Vulnerability	Source
1.	Percentage of female dairy farmers to the total number of dairy farmers	Adaptive capacity	19th Livestock Census 2012
2.	Percentage share of livestock to GDVA	Sensitivity	Department of Economics and Statistics, Kerala (2017–18)
3.	Number of co-operative societies/SHGs in the dairy sector per 1,000 dairy farmers	Adaptive capacity	Dairy Development Department (2019)
4.	Percentage coverage of dairy cooperative societies to total dairy livestock farmers	Adaptive capacity	
5.	Average milk yield (kg/day)	Adaptive capacity	
6.	Variation in dairy productivity over the last 3 years	Sensitivity	
7.	Variation in dairy production over the last 5 years	Sensitivity	
8.	Total water requirement (KL/day)	Sensitivity	
9.	Percentage capacity of dairy processing units or chilling units to total diary production	Adaptive capacity	
10.	Average compensation disbursed to livestock farmers (3 years)	Sensitivity	Department of Animal Husbandry (2019)
11.	Average reproduction rate over 8 years	Adaptive capacity	
12.	Percentage local breeds to cross-breed	Adaptive capacity	
13.	Percentage coverage of vaccination	Adaptive capacity	
14.	Per capita annual egg availability	Adaptive capacity	
15.	Number of veterinary doctors and livestock inspectors per 1,000 livestock population	Adaptive capacity	
16.	Number of mobile farm aid or vet hospital or clinic facilities per 1,000 livestock population	Adaptive capacity	
17.	Percentage insurance coverage	Adaptive capacity	
18.	Net Groundwater Availability (MCM)	Adaptive capacity	GWB (2019)
	Indicators excluded after correlation analysis		
19.	Percentage of livestock farmers to the total population	Sensitivity	19th Livestock Census 2012
20.	Livestock to human ratio (2019)	Adaptive capacity	
21.	Percentage enrolment in the Kerala Dairy Farmers Welfare Fund	Adaptive capacity	KDFWF Board, 2019
22.	Number of dairy cooperative societies per 1,000 dairy livestock population	Adaptive capacity	Dairy Development Department (2019)
23.	Percentage area under pasture	Adaptive capacity	Department of Animal Husbandry (2019)
24.	Per Capita annual chicken meat availability	Adaptive capacity	
25.	Per Capita milk availability	Adaptive capacity	
26.	Number of veterinary hospitals per 1,000 livestock population	Adaptive capacity	
27.	Number of ICDP/insemination centres per 1,000 livestock population	Adaptive capacity	

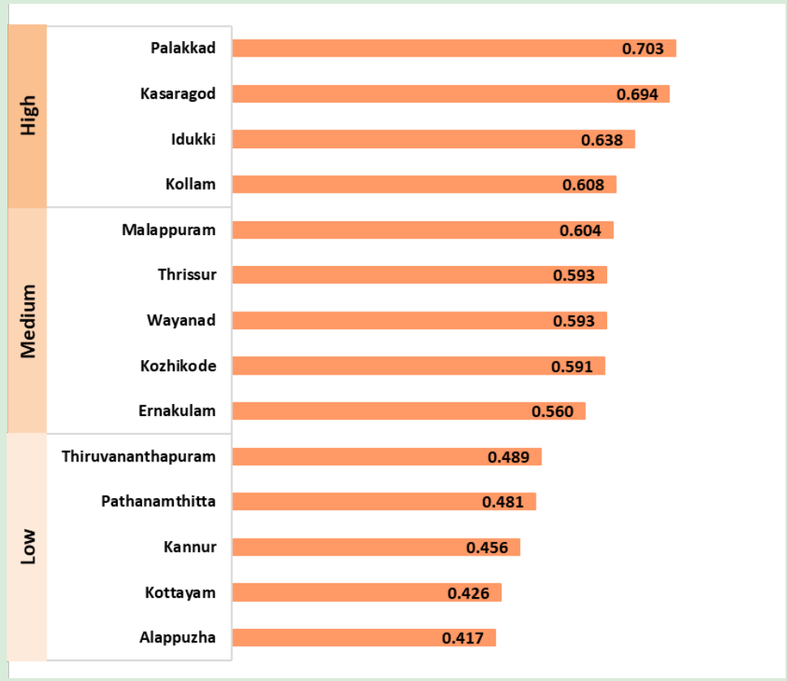


Figure B-4.1 Ranking of districts based on Livestock Vulnerability Index

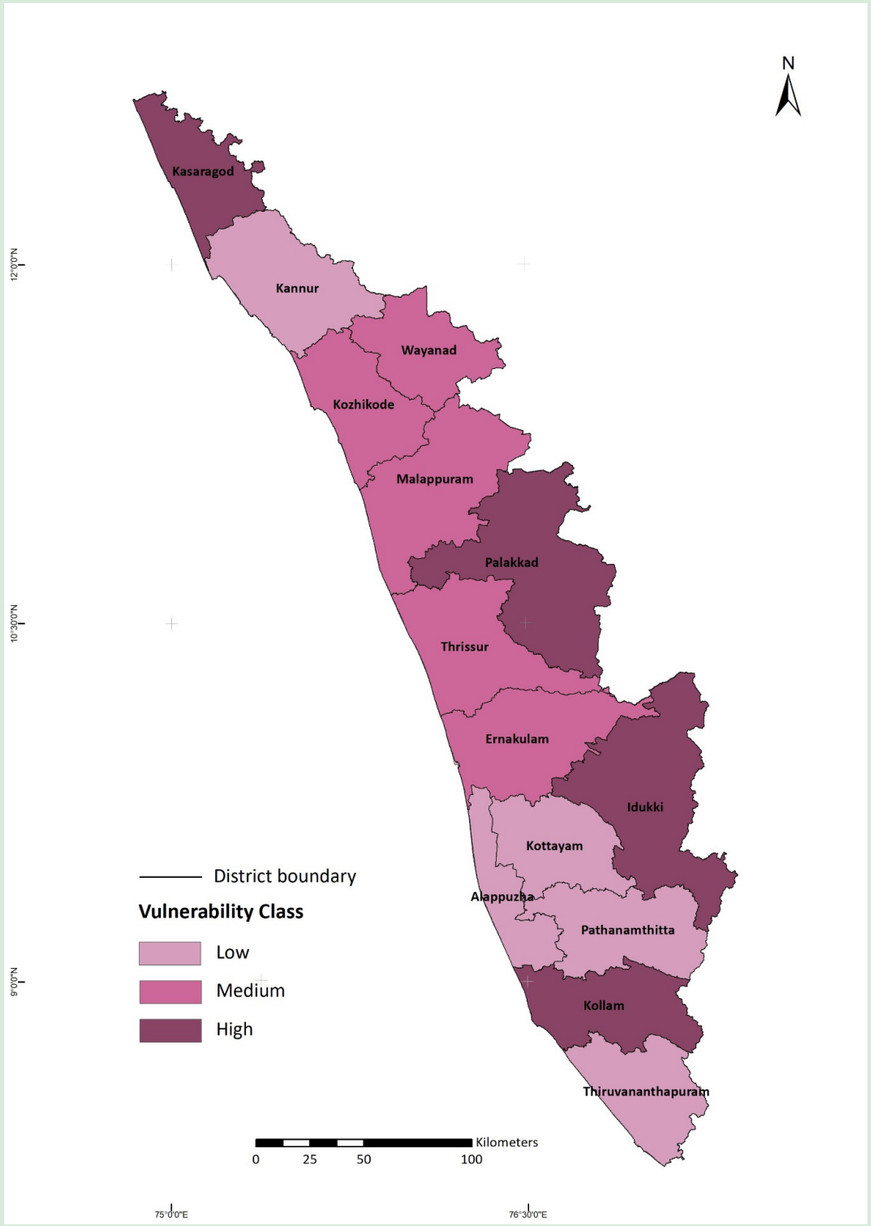


Figure B-4.2: District wise Livestock Vulnerability Index

Drivers of Livestock Vulnerability

The average normalised values of indicators were computed for each vulnerability class (high, medium, and low) to represent the drivers of vulnerability (**Table B-4.2**). As there are 18 indicators to consider, significant drivers here are those with average normalised scores over 0.7, which may be prioritised for development of adaptation strategies.

As the most significant driver in all vulnerability classes is the low ratio of local breeds to cross-breeds, efforts need to be taken to preserve indigenous livestock biodiversity and to promote these breeds along with strategies to enhance their productivity. Sector-specific adaptation strategies have been spelled out in Chapter 6. As vulnerability is context-specific and the drivers of vulnerability vary from district to district, the major drivers of animal husbandry vulnerability for the highly vulnerable districts are provided in **Table B-4.3**.

Table B4.2: Drivers of Livestock Vulnerability

Vulnerability class	Districts	Drivers of Vulnerability
High	Palakkad, Kasaragod, Idukki, Kollam	1. Low ratio of local breeds to cross breeds 2. Low per capita annual egg availability 3. Low average milk yield per day 4. Fewer veterinary doctors and livestock inspectors per 1,000 livestock population 5. High variation in dairy productivity over the last 3 years 6. Low percentage of insurance coverage 7. Fewer mobile farm-aid or vet-hospital/clinic facilities per 1,000 livestock population
Medium	Malappuram, Wayanad, Thrissur, Kozhikode, Ernakulam	1. Low ratio of local breeds to cross breeds 2. Low percentage vaccination coverage 3. Low per capita annual egg availability 4. Low percentage coverage of dairy cooperative societies to total dairy livestock farmers 5. Low number of veterinary doctors and livestock inspectors per 1,000 livestock population 6. Low average reproduction rate 7. Low percentage of female dairy farmers to the total dairy farmers
Low	Thiruvananthapuram, Pathanamthitta, Kannur, Kottayam, Alappuzha	1. Low ratio of local breeds to cross breeds 2. Low percentage coverage of dairy cooperative societies to total dairy livestock farmers 3. Low average reproduction rate

Table B4.3: **Drivers of Livestock Vulnerability in highly vulnerable districts**

Districts	Driving Indicators
Palakkad	High water requirement per day Fewer veterinary doctors and livestock inspectors Fewer dairy farmers who are women Low average milk yield per day Low ratio of local breeds to cross-breeds
Kasaragod	Low average milk yield per day High compensation disbursed due to calamities Low percentage of vaccination coverage High variation in dairy productivity Fewer mobile farm-aid or vet-hospital/clinic facilities High variation in dairy production
Idukki	Low net groundwater availability Low ratio of local breeds to cross-breeds Fewer veterinary doctors and livestock inspectors High percentage share of livestock to gross district value addition High variation in dairy productivity Fewer dairy farmers who are women
Kollam	Low ratio of local breeds to cross breeds High variation in dairy productivity High compensation disbursed due to calamities Low percentage coverage of dairy cooperative societies Low average reproduction rate

Sector: Coastal Fisheries

Indicators selected for Coastal Fisheries Vulnerability Assessment

A total of 23 indicators were suggested by sectoral experts to assess the coastal fisheries vulnerability of the 9 coastal districts of Kerala. Only one indicator—percentage inland fisherfolk to total fisherfolk population—was found to have a very significant negative correlation (r^2= -0.867) with another indicator—percentage active fisherfolk to the total population. It implies that districts with more active fisherfolk have a higher proportion of marine fisherfolk, and as such, only the latter indicator was retained.

Thus, a total of 22 indicators (6 sensitivity and 16 adaptive capacity indicators) were finalised for vulnerability assessment. The list of indicators, the function of vulnerability they represent, and the source of data used to quantify them are provided in **Table C4.1**.

Table C4.1: **Indicators selected for the computation of Coastal Fisheries Vulnerability**

SN	Indicators	Function of Vulnerability	Source
1.	Percentage of active fisherfolk to the total population	Sensitivity	Fisheries Handbook (2020)
2.	Number of fishermen co-operative societies affiliated to Matsyafed per 1,000 fisherfolk	Adaptive Capacity	
3.	Per capita income of fisherfolk	Adaptive Capacity	
4.	Percentage share of GDVA from fisheries sector	Sensitivity	
5.	Percentage of fisherfolk registered in KFWF Board	Adaptive Capacity	
6.	Percentage change in total fish production (marine and inland)	Sensitivity	
7.	Aquaculture production	Adaptive Capacity	
8.	Literacy rate of the fisherfolk	Adaptive Capacity	CMFRI (2019)
9.	Percentage change in fish species in annual landings	Sensitivity	
10.	Number of freeze storage facility	Adaptive Capacity	
11.	Capacity of shelter camps per 1,000 population	Adaptive Capacity	KSDMA (2020)
12.	Percentage of fisherfolk living within 50 m from high tide level (HTL)	Sensitivity	Directorate of Fisheries (2017-18)
13.	Percentage of landless population among fisherfolk	Sensitivity	Directorate of Fisheries (2020)
14.	Percentage of fisher folk having own crafts to total active fisherfolk population	Adaptive Capacity	
15.	Percentage of motorised vessels to total vessels	Adaptive Capacity	
16.	Percentage of pucca houses to the total houses	Adaptive Capacity	
17.	Percentage of vessels with EWS to total vessels	Adaptive Capacity	
18.	Number of fishing harbours/fish landing centres	Adaptive Capacity	
19.	Percentage of coverage of life saving equipment	Adaptive Capacity	
20.	Percentage of fisherfolk households with sufficient drinking water supply	Adaptive Capacity	
21.	Percentage of women fishers who are members of the Society for Assistance to Fisher women (SAF)	Adaptive Capacity	Society for Assistance to Fisher women (SAF)
22.	Percentage extent of mangrove vegetation to the total tidal influenced waterbody	Adaptive Capacity	CZMP (2011)
	Indicators excluded after correlation analysis		
23.	Percentage inland fisherfolk to total fisherfolk population	Adaptive Capacity	Fisheries Handbook (2020)

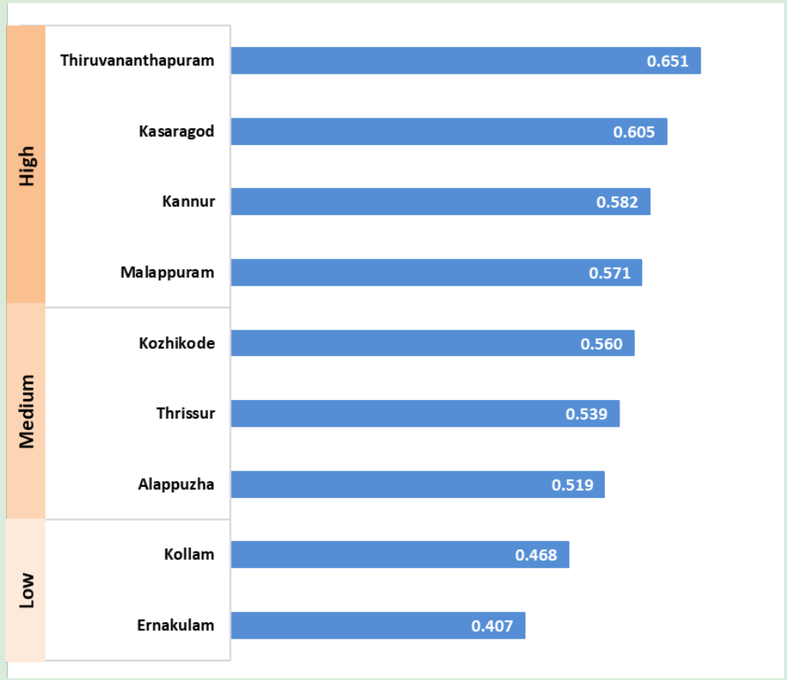


Figure C4.1: Ranking of districts based on Coastal Fisheries Vulnerability Index

Coastal Fisheries Vulnerability Index

Normalised indicator values of each district were aggregated to form a Coastal Fisheries Vulnerability Index value, which were then arranged in ascending order to rank the 9 coastal districts on a three-point scale of low, medium, and high vulnerability. Results are presented as a graph (**Figure C-4.1**) and map (**Figure C-4.2**). Thiruvananthapuram, Kasaragod, Kannur, and Malappuram were ranked as being highly vulnerable, with Thiruvananthapuram being most vulnerable.

Drivers of Coastal Fisheries Vulnerability

The average normalised values of indicators were computed for each vulnerability class (high, medium, and low) to represent the drivers of vulnerability (**Table C-4.2**). As there are 22 indicators to consider, significant drivers here are those with average normalised scores over 0.7, which may be prioritised for development of adaptation strategies.

In order to lower vulnerability in the coastal districts identified as having high vulnerability, the above-mentioned drivers may be prioritised and addressed. As vulnerability is context-specific

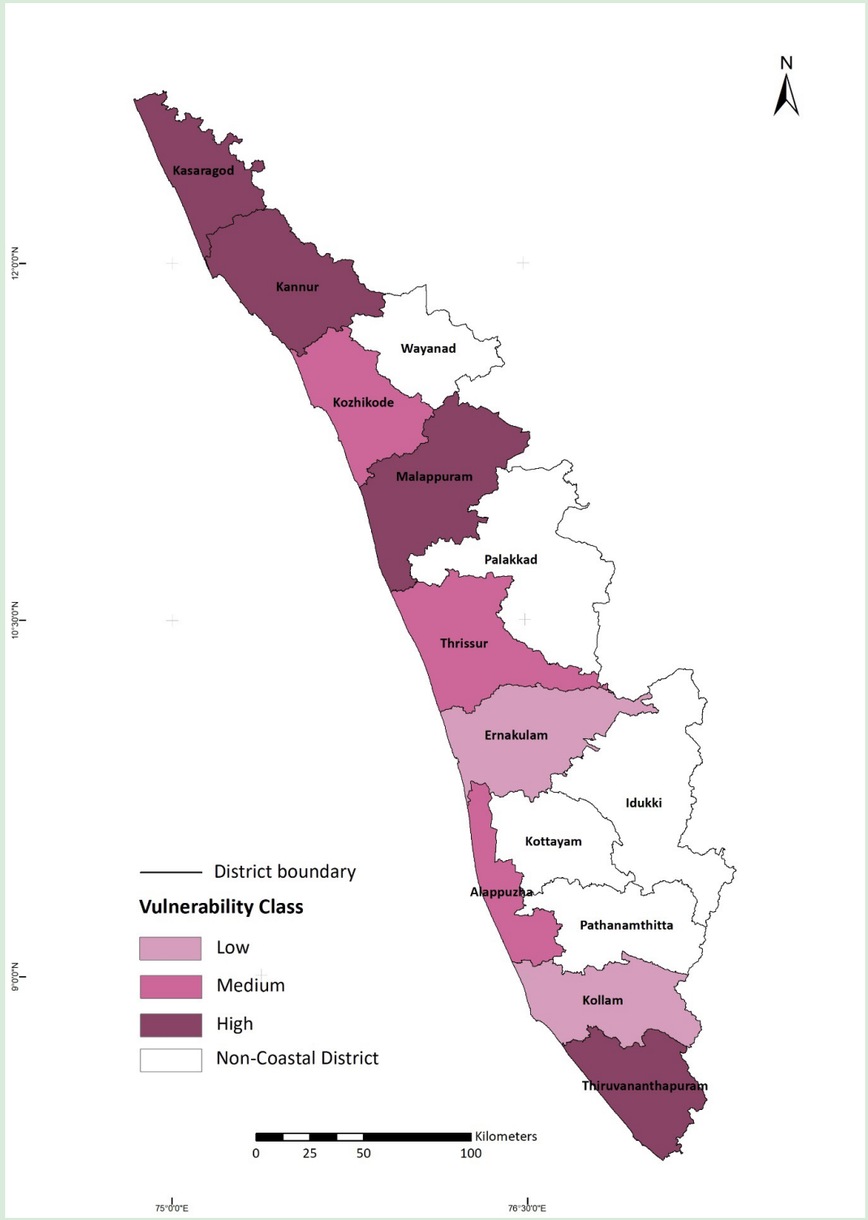


Figure C4.2: District wise Coastal Fisheries Vulnerability Index

Table C4.2: **Drivers of Coastal Fisheries Vulnerability**

Vulnerability class	Districts	Drivers of Vulnerability
High	Thiruvananthapuram, Kasaragod, Kannur, and Malappuram	1. Limited aquaculture production 2. Low per capita income of fisherfolk 3. Fewer freeze storage facility 4. High percentage of landless population among fisherfolk 5. Inadequate capacity of shelter camps per 1,000 population 6. High percentage of fisherfolk living within 50 m from HTL
Medium	Kozhikode, Thrissur, and Alappuzha	1. Low per capita income of fisherfolk 2. Poor mangrove vegetation coverage 3. Fewer vessels with EWS 4. Fewer freeze storage facility 5. Fewer fishing harbours/fish landing centres
Low	Kollam and Ernakulam	1. Fewer fisherfolk have their own crafts 2. Limited aquaculture production 3. Poor mangrove vegetation coverage

and the drivers of vulnerability vary from district to district, the major drivers of coastal fisheries vulnerability for the highly vulnerable districts are provided in **Table C-4.3**.

Sector: Forests and Biodiversity

Indicators selected for Forest & Biodiversity Vulnerability Assessment

A total of 21 indicators were suggested by sectoral experts. Four of these indicators were found to have very significant correlation with other indicators, and as such, were excluded. Details are provided below:

1. Three indicators – percentage share of forest resource-based income (r^2= 0.864); average Net Primary Productivity (r^2= 0.756); and percentage of total forest area with very dense forest cover (r^2= 0.738) showed significant positive correlation with the indicator percentage forest area to the total district area. This means districts that have more forest coverage also have dense forest cover with high NPP and obviously have a higher share of forest resource-based income. As such, all three indicators were excluded.
2. Districts with high drainage density also observed higher forest coverage (positively correlated, r^2= 0.820), and as such, only the latter was retained.

Thus, a total of 17 indicators (10 sensitivity and 7 adaptive capacity indicators) were finalised for vulnerability assessment. The list of indicators, the function of vulnerability they represent, and the source of data used to quantify them are provided in **Table D4.1.**

Forest & Biodiversity Vulnerability Index

Normalised indicator values of each district were aggregated to form a forest & biodiversity vulnerability index value, which were then arranged in ascending order to rank districts on a three-point scale of low, medium, and high vulnerability. Results are presented as a graph (**Figure D-4.1**) and map (**Figure D-4.2**). Kottayam, Kollam, Kasaragod, and Wayanad were ranked as being highly vulnerable, with Kottayam being most vulnerable.

Table C4.3: **Drivers of Coastal Fisheries Vulnerability in highly vulnerable districts**

Districts	Driving Indicators
Thiruvananthapuram	Fewer fishermen co-operative societies affiliated to Matsyafed Poor literacy among fisherfolk Poor mangrove vegetation coverage High percentage change in fish species in annual landings Fewer motorised vessels Inadequate capacity of shelter camps per 1,000 population Limited aquaculture production
Kasaragod	Fewer fisherfolk own land Limited aquaculture production High percentage share of GDVA from fisheries Fewer households have adequate drinking water supply Inadequate capacity of shelter camps per 1,000 population
Kannur	Fewer fishing harbours/fish landing centres High percentage of fisherfolk living within 50 m from HTL High percentage change in total fish production Fewer fisherfolk own land Fewer households have adequate drinking water supply Low per capita income of fisherfolk Limited aquaculture production
Malappuram	Fewer freeze storage facility Low per capita income of fisherfolk Fewer vessels with EWS Fewer fishing harbours/fish landing centres Fewer fisherfolk have their own craft High percentage change in total fish production

Table D4.1: **Indicators selected for the computation of Forest and Biodiversity Vulnerability**

SN	Indicators	Function of Vulnerability	Source
1.	Number of forest dependent families per 100 sq.km forest area	Sensitivity	Kerala Forest Department (2020)
2.	Average per capita wildlife conflict compensation (2016 -21)	Sensitivity	
3.	Percentage of total forest area encroached	Sensitivity	
4.	Percentage of total forest area enclosed	Sensitivity	
5.	Percentage of forest area to district area	Adaptive capacity	
6.	Percentage of total forest area protected	Adaptive capacity	
7.	Average fire density (counts/sq.km/time period)	Sensitivity	
8.	Percentage of monoculture plantations inside forest area to the total forest area	Sensitivity	

SN	Indicators	Function of Vulnerability	Source
9.	Number of establishments per 100 sq. km area for conservation	Adaptive capacity	Kerala Forest Department (2020)
10.	Number of staff per 100 sq.km forest area	Adaptive capacity	
11.	Percentage of forest cover to district area	Adaptive capacity	Forest Survey of India (2019)
12.	Decrease in the percentage forest cover to district area	Sensitivity	
13.	Percentage change in very dense forest cover (2003–2019)	Sensitivity	
14.	Percentage of total forest area having very high biological richness	Adaptive capacity	Indian Institute of Remote Sensing (2012)
15.	Percentage of total forest area having very high disturbance index	Sensitivity	
16.	Variation in soil moisture over a period of 10 years	Sensitivity	National Remote Sensing Centre - Bhuvan portal
17.	Percentage of waterbody to the total forest area	Adaptive capacity	Kerala State Land Use Board (2020)
	Indicators excluded after correlation analysis		
18.	Average Net Primary Productivity (NPP) (mg C/ha/yr)	Adaptive capacity	National Remote Sensing Centre - Bhuvan portal
19.	Drainage density	Adaptive capacity	Kerala State Land Use Board (2020)
20.	Percentage of very dense forest cover to total forest area	Adaptive capacity	Forest Survey of India (2019)
21.	Percentage share of forest resource based income	Sensitivity	Department of Economics and Statistics, Kerala (2017)

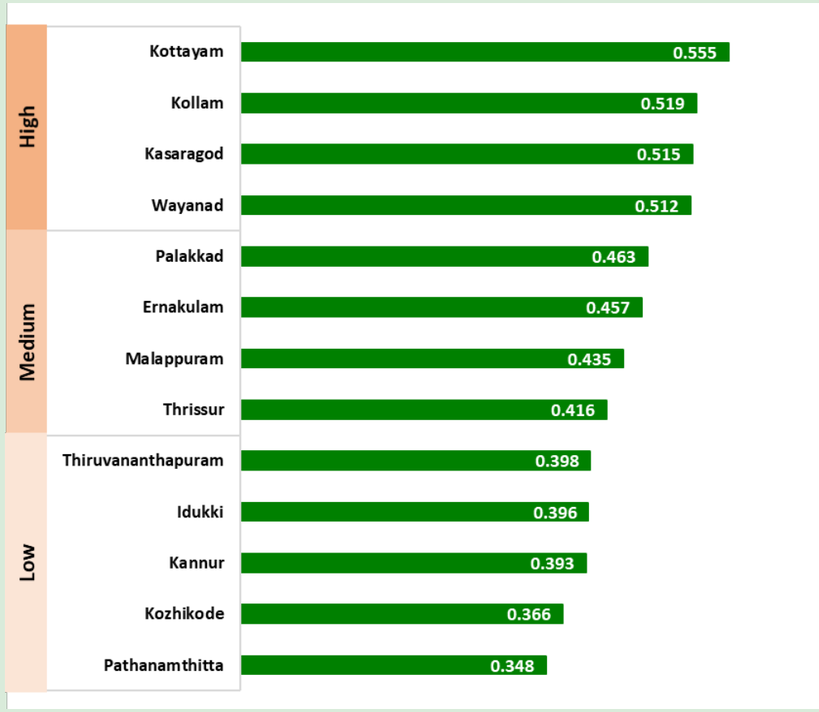


Figure D4.1: **Ranking of districts based on Forest and Biodiversity Vulnerability Index**

Drivers of Forest & Biodiversity Vulnerability

The average normalised values of indicators were computed for each vulnerability class (high, medium, and low) to represent the drivers of vulnerability (**Table D-4.2**). Significant drivers here are those with average normalised scores over 0.5, which may be prioritised for development of adaptation strategies.

Repetitive significant drivers in all vulnerability classes are less area under forests and a lack of establishments and human resources required for efficient forest management and conservation. These drivers may be prioritised for planning and development of strategies to lower forest vulnerability across the State of Kerala. More sector-specific adaptation strategies have been spelled out in Chapter 6. As vulnerability is context-specific and the drivers of vulnerability vary from district to district, the major drivers of forest vulnerability for the highly vulnerable districts are provided in **Table D-4.3**.

Sector: Health

Indicators selected for Health Vulnerability Assessment

A total of 22 indicators were suggested by sectoral experts. Four of these indicators were found to have very significant correlation with other indicators, and as such, were excluded. Details are provided below:

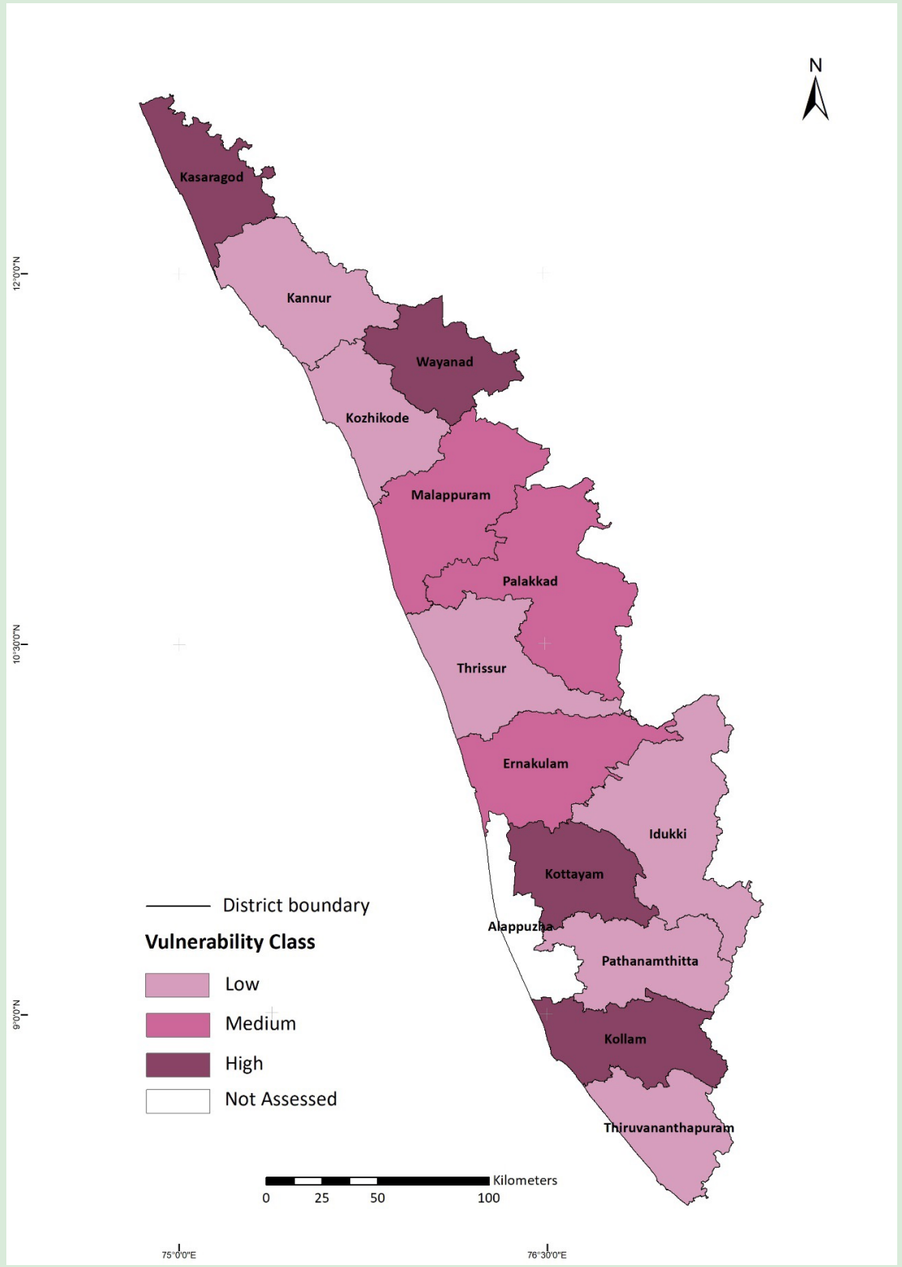


Figure D4.2: District wise Forest and Biodiversity Vulnerability Index

Table D4-2: Drivers of Forest and Biodiversity Vulnerability

Vulnerability class	Districts	Drivers of Vulnerability
High	Kottayam, Kollam, Kasaragod, and Wayanad	1. Low biological richness in forests 2. Fewer waterbodies in forests 3. Less area under forests 4. Fewer protected forest areas 5. Fewer establishments for forest conservation 6. Inadequate human resources for forest conservation 7. High occurrence of forest fire 8. Decrease in forest coverage
Medium	Palakkad, Ernakulam, and Malappuram	1. Inadequate human resources for forest conservation 2. Poor forest cover 3. High occurrence of forest fire 4. Fewer protected forest areas 5. Fewer establishments for forest conservation 6. Less area under forest
Low	Thrissur, Thiruvananthapuram, Idukki, Kannur, Kozhikode, and Pathanamthitta	1. Inadequate human resources for forest conservation 2. High variation in soil moisture 3. Fewer waterbodies in forests 4. Fewer establishments for forest conservation 5. Less area under forests

Table D4.3: Drivers of Forest and Biodiversity Vulnerability in highly vulnerable districts

Districts	Driving Indicators
Kottayam	Fewer establishments for forest conservation Fewer protected forest areas Less area under forests Prevalence of monoculture inside forested areas Fewer waterbodies in forests Low biological richness in forests
Kollam	High occurrence of forest fire High percentage of forested area enclosed Fewer establishments for forest conservation Inadequate human resources for forest conservation Low biological richness in forests
Kasaragod	High human dependence forests Fewer protected forest areas Less area under forests Low biological richness in forests Inadequate human resources for forest conservation

Districts	Driving Indicators
Wayanad	Decrease in forest cover High incidence of human-wildlife conflict Excessive encroachment of forest areas Frequent occurrence of forest fire Fewer waterbodies in forests

1. The indicators – Insurance coverage (r^2= 0.651) and average IMR (r^2= 0.608) showed significant positive correlation with the indicator percentage population below the poverty line. This means districts that have a higher population below the poverty line also observed a higher infant mortality rate and a higher rate of insurance coverage. As such, the indicator representing poverty was excluded.
2. Districts with higher IMR also had higher maternal mortality rate (r^2= 0.693) and as such MMR was excluded.
3. Districts with higher number of recorded in-patient and out-patients also have a higher number of taluk/district/general/medical hospitals (r^2= 0.685) and a higher number of hospital beds available (r^2= 0.643). Here, the latter two indicators were retained.
4. Similarly, districts with a greater number of blood banks also have higher number of hospital beds available (r^2= 0.909), and as such, only the latter was retained.

A total of 18 indicators (9 sensitivity and 9 adaptive capacity indicators) were finalised for vulnerability assessment. The list of indicators, the function of vulnerability they represent, and the source of data used to quantify them are provided in **Table E-4.1.**

Table E4.1: **Indicators selected for the computation of Health Vulnerability**

SN	Indicators	Function of Vulnerability	Source
1.	Percentage of sensitive population (below 6 and over 65 years of age and people living with disabilities)	Sensitivity	Census (2011); Disability Census Report (2015)
2.	Average Infant Mortality Rate (5 Years)	Sensitivity	Directorate of Health Services (DHS) (2019)
3.	Vector-borne disease incidence per 1,000 population	Sensitivity	
4.	Water-borne disease incidence per 1,000 population	Sensitivity	
5.	Average morbidity due to heat-related illness (5 years)	Sensitivity	
6.	Average mortality due to respiratory diseases (5 years)	Sensitivity	
7.	Number of primary healthcare centres (PHCs/FHCs/CHCs) per 1,000 population	Adaptive Capacity	DHS (2020)
8.	Number of Taluk/District/General/Medical hospitals per 100,000 population	Adaptive Capacity	DHS & DME (2020)
9.	Number of beds per 1,000 population (Public/Private/ISM)	Adaptive Capacity	
10.	Number of doctors per 1,000 Population	Adaptive Capacity	
11.	Number of healthcare professionals per 1,000 population	Adaptive Capacity	
12.	Number of health emergency management facilities per 1,000 population	Adaptive Capacity	
13.	Number of frontline workers per 1,000 population	Adaptive Capacity	
14.	Percentage of households with insurance coverage	Adaptive Capacity	RSBY CHIS (2018–19)
15.	Percentage of households with treated water supply	Adaptive Capacity	KWA & Jalanidhi (2019)
16.	Groundwater Quality Index	Sensitivity	CGWB (2019)
17.	Surface Water Quality Index	Sensitivity	CWRDM (2016)
18.	Air Quality Index	Sensitivity	KSPCB (2010–2019)
	Indicators excluded after correlation analysis		
19.	Average Maternal Mortality Rate (5 Years)	Sensitivity	DHS (2019)
20.	Average In-Patient and Out-Patient over 10 years per 1,000 population	Sensitivity	
21.	Number of blood bank units per 1,000 population	Adaptive Capacity	DHS & DME (2020)
22.	Percentage of population living below the poverty line	Sensitivity	WFP (2014)

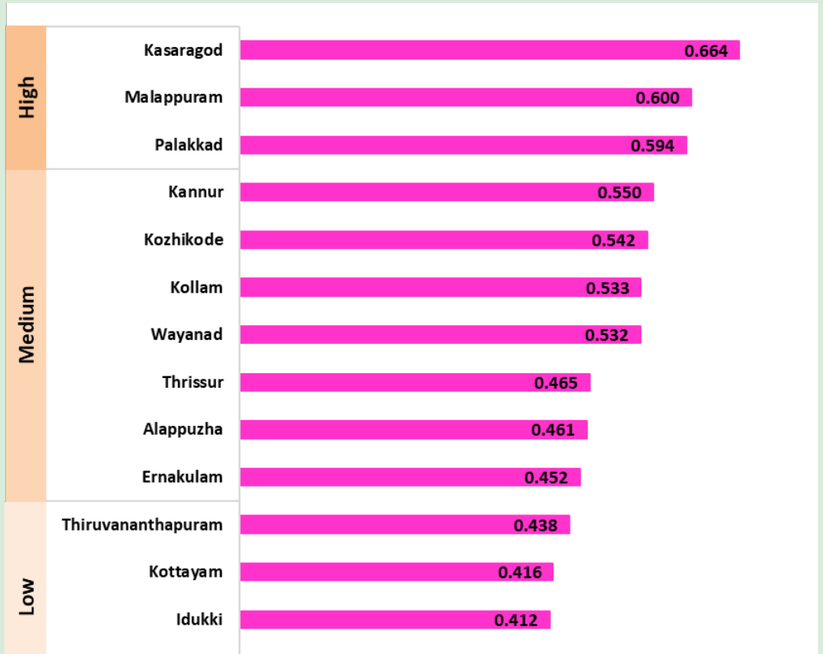


Figure E4.1: Ranking of districts based on Health Vulnerability Index

Health Vulnerability Index

Normalised indicator values of each district were aggregated to form a Health Vulnerability Index value, which were then arranged in ascending order to rank districts on a three-point scale of low, medium, and high vulnerability. Results are presented as a graph (**Figure E-4.1**) and map (**Figure E-4.2**). Kasaragod, Malappuram, and Palakkad were ranked as being highly vulnerable, with Kasaragod being most vulnerable.

Drivers of Health Vulnerability

The average normalised values of indicators were computed for each vulnerability class (high, medium, and low) to represent the drivers of vulnerability (**Table E-4.2**). Significant drivers here are those with average normalised scores over 0.5, which may be prioritised for development of adaptation strategies.

Repetitive significant drivers in all vulnerability classes are the presence of a large inherently sensitive population (below 6 and over 65 years of age and people living with disabilities), inadequate number of healthcare professionals including doctors and frontline workers, unsatisfactory number of households provisioned with treated water supply, and either poor ground or surface water quality. These drivers may be

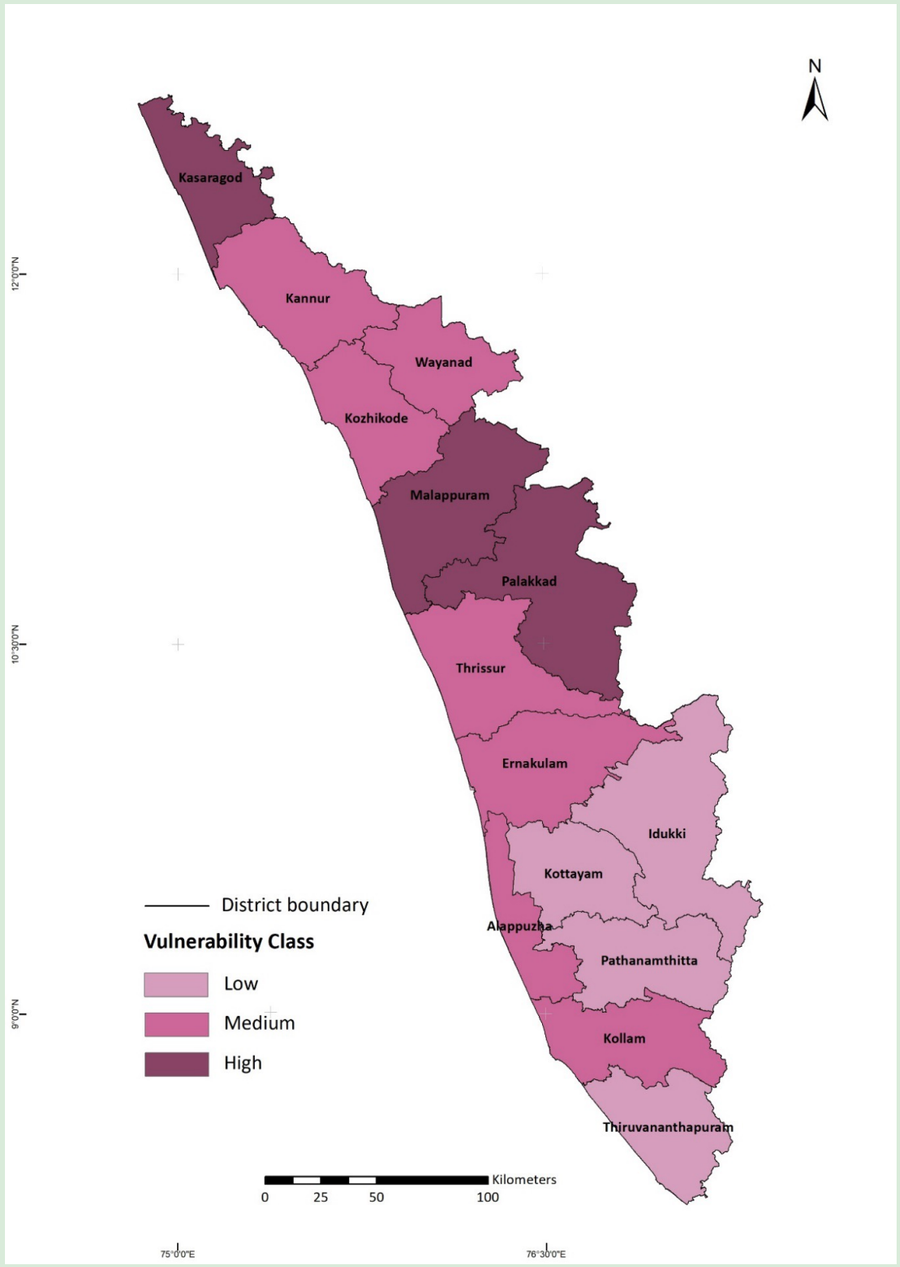


Figure E4.2: District wise Health Vulnerability Index

Table E4.2: Drivers of Health Vulnerability

Vulnerability class	Districts	Drivers of Vulnerability
High	Kasaragod, Malappuram, and Palakkad	1. Fewer healthcare professionals 2. Fewer doctors 3. Fewer Taluk/District/General/Medical hospitals 4. Insufficient beds in healthcare facilities 5. More inherently sensitive population 6. Fewer households with treated water supply 7. Fewer health emergency management facilities 8. Insufficient primary healthcare facilities (PHCs/FHCs/CHCs) 9. Fewer frontline workers 10. High infant mortality rate 11. High prevalence of water borne diseases 12. Low insurance coverage 13. Poor groundwater quality
Medium	Kannur, Kozhikode, Kollam, Wayanad, Thrissur, Alappuzha, and Ernakulam	1. More inherently sensitive population 2. Fewer health emergency management facilities 3. Insufficient PHCs/FHCs/CHCs 4. Inadequate number of healthcare professionals 5. Fewer households with treated water supply 6. Insufficient number of doctors 7. Fewer frontline workers 8. Poor surface water quality 9. Poor air quality
Low	Thiruvananthapuram, Kottayam, Idukki, and Pathanamthitta	1. Presence of more inherently sensitive population 2. Fewer households with treated water supply 3. Poor surface water quality 4. Fewer frontline workers

prioritised for planning and development of strategies to lower health vulnerability across the State of Kerala. More sector-specific adaptation strategies have been provided in Chapter 6. As vulnerability is context-specific and the drivers of vulnerability vary from district to district, the major drivers of health vulnerability for the highly vulnerable districts are provided in **Table E4.3.**

Sector: Tourism

Indicators selected for Tourism Vulnerability Assessment

A total of 21 indicators were suggested by sectoral experts. Three of these indicators were found to have very significant correlation with other indicators, and as such, were excluded:

1. The indicator – population density (r^2= 0.799) showed significant positive correlation with the indicator road network density. This means that densely populated districts also have better road connectivity. As such, only the latter was retained.
2. Highly forested districts also had a lot more ecotourism destinations (r^2= 0.753) and as such forest area was excluded.
3. Similarly, districts that have a higher number of beds in tourism accommodation establishments also have a higher percentage share from tourism to the GDVA (r^2= 0.835). Here, the latter indicators were retained.

Table E4.3: Drivers of Health Vulnerability in highly vulnerable districts

Districts	Driving Indicators
Kasaragod	Fewer households with treated water supply Insufficient number healthcare professionals Inadequate number of beds in healthcare facilities High infant mortality rate Few doctors and far between High prevalence of water-borne diseases
Malappuram	Insufficient number of PHCs/FHCs/CHCs High population burden on Taluk/District/General/Medical hospitals Fewer health emergency management facilities High percentage of inherently sensitive population Inadequate number of healthcare professionals
Palakkad	Insufficient number of doctors High population burden on Taluk/District/General/Medical hospitals Poor groundwater quality Inadequate number of healthcare professionals High percentage of inherently sensitive population

A total of 18 indicators (8 sensitivity and 10 adaptive capacity indicators) were finalised for vulnerability assessment. The list of indicators, the function of vulnerability they represent, and the source of data used to quantify them are provided in **Table F4.1.**

Tourism Vulnerability Index

Normalised indicator values of each district were aggregated to form a Tourism Vulnerability Index value, which were then arranged in ascending order to rank districts on a three-point scale of low, medium, and high vulnerability. Results are presented as a graph (**Figure F-4.1**) and map (**Figure F-4.2**). Idukki, Wayanad, and Kasaragod were ranked as being highly vulnerable, with Idukki being most vulnerable.

Drivers of Tourism Vulnerability

The average normalised values of indicators were computed for each vulnerability class (high, medium, and low) to represent the drivers of vulnerability (**Table F-4.2).** Significant drivers here are those with average normalised scores over 0.5, which may be prioritised for development of adaptation strategies.

Recurring significant drivers in all vulnerability classes are a lack of tourism-centered human resources, organisations, and programmes, such as community tour leaders/tour operators, responsible tourism units, ecotourism units, and cultural/village tourism programmes. These drivers may be prioritised for planning and development of strategies to lower tourism vulnerability across the State of Kerala. More sector-specific adaptation strategies have been provided in Chapter 6. As vulnerability is context-specific and the drivers of vulnerability vary from district to district, the major drivers of tourism vulnerability for the highly vulnerable districts are provided in **Table F-4.3**.

Sector: Water Resources

Indicators selected for Water Resources Vulnerability Assessment

A total of 21 indicators were suggested by sectoral experts. Three of these indicators were found to have very significant correlation with other indicators, and as such, were excluded:

Table F4.1: **Indicators selected for the computation of Tourism Vulnerability**

SN	Indicators	Function of Vulnerability	Source
1.	Percentage of villages covered under treated water supply	Adaptive Capacity	Census (2011)
2.	Percentage of population dependent on tourism	Sensitivity	Tourism Statistics (2019)
3.	Variation in foreign tourists arrival (2010–19)	Sensitivity	
4.	Variation in domestic tourists arrival (2010–19)	Sensitivity	
5.	Percentage of tourism-based income to the total GDVA	Sensitivity	Tourism Statistics, 2019 & Department of Economics and Statistics, Kerala (2019)
6.	Number of responsible tourism units	Adaptive Capacity	Department of Tourism (2021)
7.	Number of cultural/village tourism programmes	Adaptive Capacity	
8.	Number of community tour leaders/tour operators	Adaptive Capacity	
9.	Number of Tourist Information Centres	Adaptive Capacity	
10.	Percentage of ecotourism destinations	Adaptive Capacity	Directorate of Ecotourism (2021)
11.	Road network density	Adaptive Capacity	LSG, PWD, NHAI
12.	Communicable diseases per 1,000 population	Sensitivity	DHS (2019)
13.	Number of healthcare facilities	Adaptive Capacity	
14.	Percentage of local administrations with functional waste collection system	Adaptive Capacity	Suchitwa Mission Progress Report (2018-19)
15.	Net groundwater availability per 1,000 population	Adaptive Capacity	CGWB (2019)
16.	Air Quality Index	Sensitivity	KSPCB (2010 - 2019)
17.	Surface Water Quality Index	Sensitivity	CWRDM (2016)
18.	Groundwater Quality Index	Sensitivity	CGWB (2019)
	Indicators excluded after correlation analysis		
19.	Population density	Sensitivity	Census (2011)
20.	Number of beds in tourism accommodation establishments (Government & Private)	Adaptive Capacity	Department of Tourism (2021)
21.	Percentage of district area under forests	Adaptive Capacity	FSI (2019)

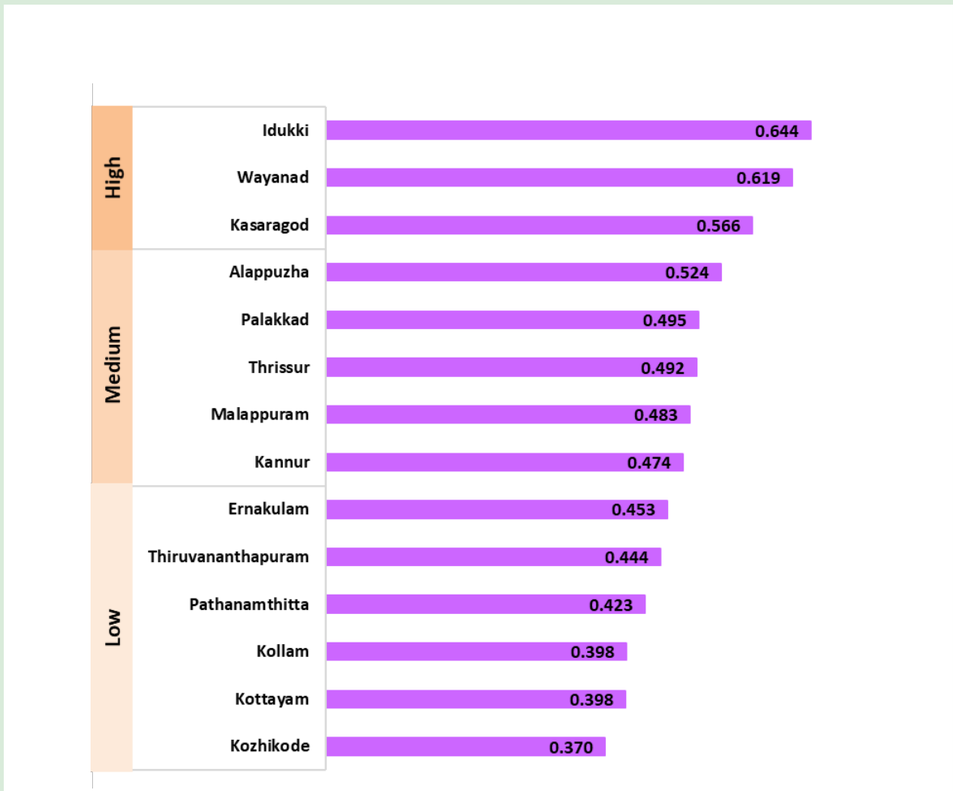


Figure F4.1: **Ranking of districts based on Tourism Vulnerability Index**

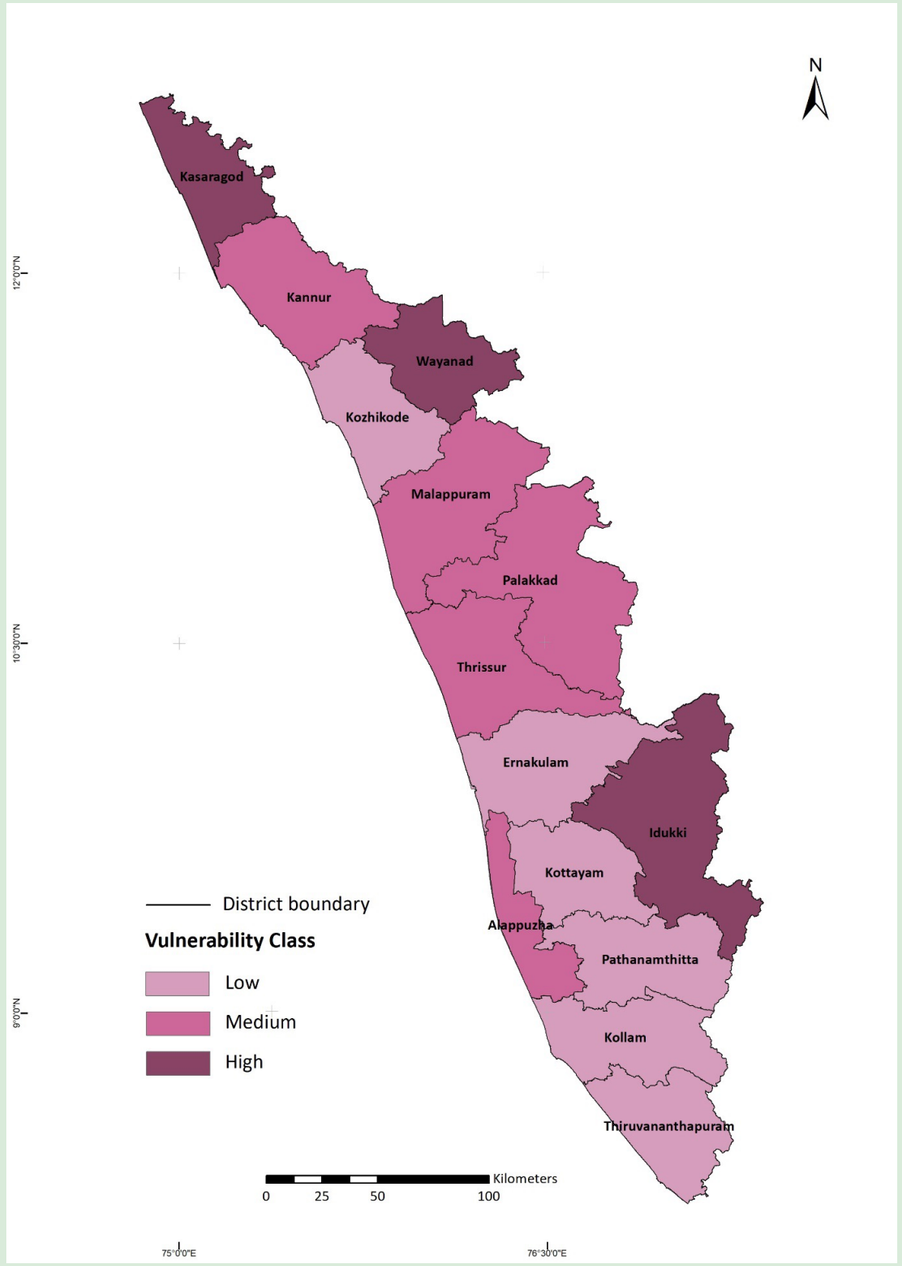


Figure F4.2: **District wise Tourism Vulnerability Index**

Table F-4.2: **Drivers of Tourism Vulnerability**

Vulnerability class	Districts	Drivers of Vulnerability
High	Idukki, Wayanad, and Kasaragod	1. Inadequate number of local administrations with functional waste collection system 2. High population burden on healthcare facilities 3. Poor road connectivity 4. Fewer community tour leaders/tour operators 5. Poor surface water quality 6. Insufficient number of responsible tourism units 7. High prevalence of communicable diseases 8. Few tourist information/facilitation centres 9. High variation in domestic tourists arrival 10. High dependence on tourism-based income 11. High percentage share of tourism to GDVA 12. Few cultural/village tourism programmes 13. Limited number of ecotourism units
Medium	Alappuzha, Palakkad, Thrissur, Malappuram, and Kannur	1. Limited number of tourist information/facilitation centres 2. Fewer responsible tourism units 3. Inadequate number of local administrations with functional waste collection system 4. Insufficient number of community tour leaders/tour operators 5. Poor road connectivity 6. Limited number of ecotourism units 7. Poor groundwater availability 8. Fewer villages with treated water supply 9. Inadequate number of cultural/village tourism programmes
Low	Ernakulam, Thiruvananthapuram, Pathanamthitta, Kottayam, Kollam, and Kozhikode	1. Poor groundwater availability 2. Limited number of responsible tourism units 3. Poor surface water quality 4. Insufficient number of ecotourism units 5. Poor air quality 6. Fewer community tour leaders/tour operators 7. Inadequate number of cultural/village tourism programmes

Table F-4.3: **Drivers of Tourism Vulnerability in highly vulnerable districts**

Districts	Driving Indicators
Idukki	High dependence of population on tourism as a source of income High variation in domestic tourists arrival Fewer community tour leaders/tour operators Inadequate number of local administrations with functional waste collection systems Poor road connectivity
Wayanad	High prevalence of communicable diseases Poor surface water quality High population burden on healthcare facilities Poor road connectivity High percentage share of tourism to the GDVA
Kasaragod	High variation in foreign tourists arrival Fewer local administrations with functional waste collection systems High prevalence of communicable diseases High population burden on healthcare facilities Insufficient number of community tour leaders/tour operators

1. The indicators – Percentage district area under forests (r^2= 0.785) and percentage increase in urbanisation (r^2= -0.721) showed significant positive and negative correlation with the indicator drainage density, respectively. This means that districts with high drainage density also have more area under forests and less area that has observed an increase in urbanisation. As such, only drainage density was retained.
2. Similarly, districts that have a higher number of groundwater quality monitoring wells also have a higher number of groundwater table monitoring wells (r^2= 0.913). Here, the latter indicators were retained.

A total of 18 indicators (7 sensitivity and 11 adaptive capacity indicators) were finalised for vulnerability assessment. The list of indicators, the function of vulnerability they represent, and the source of data used to quantify them are provided in **Table G4.1.**

Table G4.1: **Indicators selected for the computation of Water Resources Vulnerability**

SN	Indicators	Function of Vulnerability	Source
1.	Population density	Sensitivity	Census (2011)
2.	Percentage of households with bore/tube/other wells	Adaptive Capacity	
3.	Percentage of villages with access to water sources throughout the year	Adaptive Capacity	
4.	Percentage of households with sanitary facilities	Adaptive Capacity	
5.	Percentage of population below the poverty line (BPL)	Sensitivity	WFP (2014)
6.	Net groundwater availability per 1,000 population	Adaptive Capacity	GWD (2019)
7.	Variation in groundwater level trend (pre-monsoon) (10 years)	Sensitivity	CGWB (2011–20)
8.	Number of Groundwater table monitoring wells per 100 sq.km	Adaptive Capacity	CGWB (2016–17)
9.	Groundwater Quality Index	Sensitivity	
10.	Surface Water Quality Index	Sensitivity	CWRDM (2016)
11.	Drainage density	Adaptive Capacity	KSLUB (2020)
12.	Percentage of district area that is built-up	Sensitivity	
13.	Evapotranspiration rates (ET) (mm/day)	Sensitivity	WRIS (2019)
14.	Surface water monitoring stations	Adaptive Capacity	
15.	Percentage of households with treated water supply	Adaptive Capacity	Jalanidhi & KWA (2020)
16.	Gross storage capacity of reservoirs (in '000 cum)	Adaptive Capacity	CWC (2019)
17.	Percentage Net irrigated area to the total geographic area	Adaptive Capacity	Economic Review (2020)
18.	Meteorological monitoring stations	Adaptive Capacity	IMD, KSDMA, IDRB (2020)
	Indicators excluded after correlation analysis		
19.	Number of Groundwater quality monitoring wells per 100 sq.km	Adaptive Capacity	GWD (2019)
20.	Percentage increase in urbanization (between 2005-06 and 2015-16)	Sensitivity	KSLUB (2020)
21.	Percentage of district area covered by forests	Adaptive Capacity	FSI (2019)

Water Resources Vulnerability Index

Normalised indicator values of each district were aggregated to form a Water Vulnerability Index value, which were then arranged in ascending order to rank districts on a three-point scale of low, medium, and high vulnerability. Results are presented as a graph (**Figure G-4.1**) and map (**Figure G-4.2**). Wayanad, Alappuzha, Kottayam and Kozhikode were ranked as being highly vulnerable, with Wayanad being most vulnerable.

Drivers of Water Resources Vulnerability

The average normalised values of indicators were computed for each vulnerability class (high, medium, and low) to represent the drivers of vulnerability (**Table G4.2**). Significant drivers here are those with average normalised scores over 0.5, which may be prioritised for development of adaptation strategies.

Recurring significant drivers in all vulnerability classes are poor drainage density and irrigation

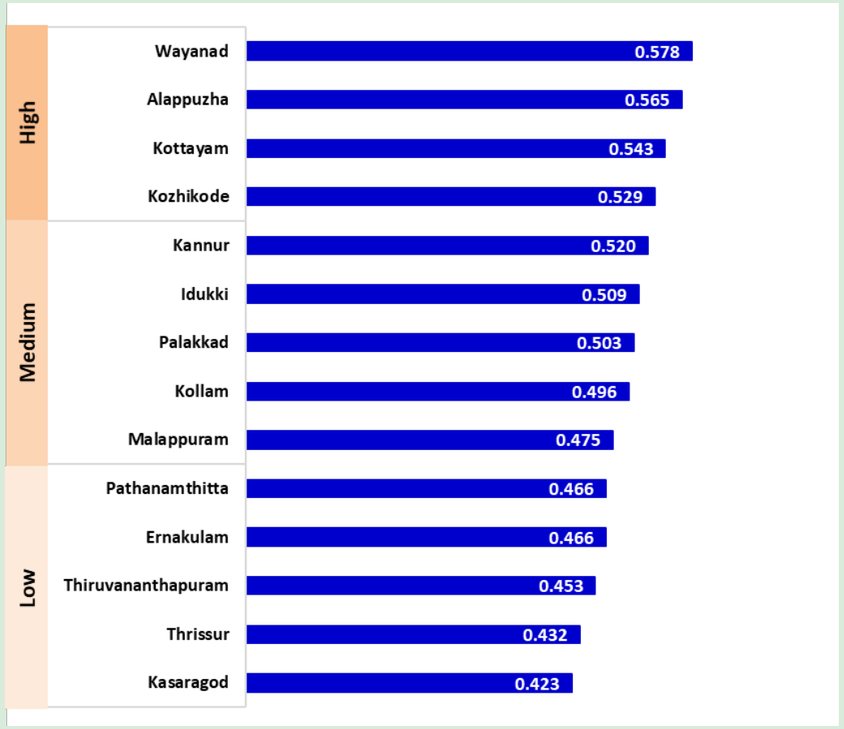


Figure G4.1: Ranking of districts based on Water Resources Vulnerability Index

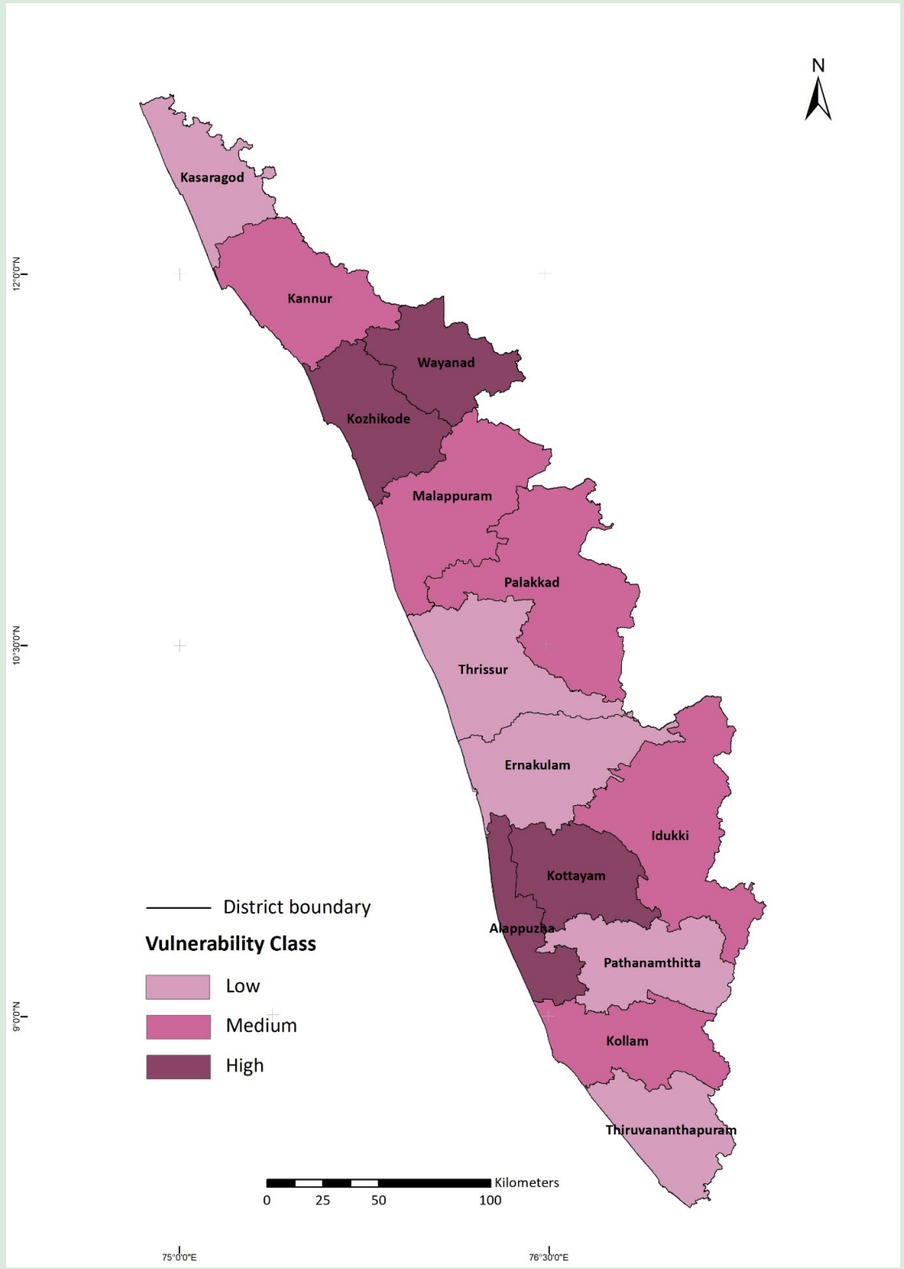


Figure G4.2: District wise Water Resources Vulnerability Index

Table G4.2: Drivers of Water Resources Vulnerability

Vulnerability class	Districts	Drivers of Vulnerability
High	Wayanad, Alappuzha, Kottayam, and Kozhikode	1. Insufficient storage capacity of reservoirs 2. Poor surface water quality 3. Few surface water monitoring stations 4. Limited number meteorological monitoring stations 5. Poor irrigation coverage 6. High percentage of population living below the poverty line 7. Fewer households with treated water supply 8. Low drainage density 9. High population density 10. Fewer villages with access to water sources throughout the year
Medium	Kannur, Idukki, Palakkad, Kollam, and Malappuram	1. Poor irrigation coverage 2. Fewer households with treated water supply 3. Insufficient storage capacity of reservoirs 4. Insufficient number of groundwater table monitoring wells 5. Poor per capita groundwater availability 6. Fewer villages with access to water sources throughout the year 7. Low drainage density 8. High variation in groundwater levels pre-monsoon
Low	Ernakulam, Pathanamthitta, Thiruvananthapuram, Thrissur, and Kasaragod	1. Insufficient storage capacity of reservoirs 2. Low drainage density 3. Poor per capita groundwater availability 4. Inadequate irrigation coverage 5. High population density 6. High percentage of district area is built-up 7. Fewer households with treated water supply

Table G4.3: Drivers of Water Resources Vulnerability in highly vulnerable districts

Districts	Driving Indicators
Wayanad	Poor surface water quality Limited meteorological monitoring stations High percentage of BPL population Insufficient storage capacity of reservoirs Low irrigated coverage
Alappuzha	Insufficient storage capacity of reservoirs Limited surface water monitoring stations High population density Low drainage density Limited meteorological monitoring stations
Kottayam	Insufficient storage capacity of reservoirs High evapotranspiration rates Low irrigation coverage Fewer villages with access to water sources throughout the year Poor surface water quality
Kozhikode	Poor irrigation coverage Low per capita groundwater availability High population density Insufficient storage capacity of reservoirs Fewer households with treated water supply

coverage, as well as insufficient storage capacity of reservoirs and households connected with treated water supply. These drivers may be prioritised for planning and development of strategies to lower water vulnerability across the State of Kerala. More sector-specific adaptation strategies have been provided in Chapter 6. As vulnerability is context-specific and the drivers of vulnerability vary from district to district, the major drivers of water vulnerability for the highly vulnerable districts are provided in **Table G4.3**.

Annexure 5.1: Data and methodology used for energy sector emission-mitigation analysis

Input Data and Methodology

A. Power

Planned upcoming waste-to-energy projects:

Project Name	Installed Capacity (MW)	Assumed Commissioning year	Status
Munnar	5 MW	2023-24	Agreement executed.
Bhramapuram	6 MW	2023-24	Agreement executed.
Plants at 7 districts (Thiruvananthapuram, Thrissur, Palakkad, Kozhikode, Kannur, Kollam and Malappuram)	35 MW (5 MW each)	2026-2029	Sanctioned

Source: (LSGD, 2018)

Ongoing RE projects (>1MW)

Project Name	Installed Capacity (MW)	Assumed Commissioning year	Status
GM solar	1 MW	2022	Under construction
Nenmara solar	1.5 MW	2022	Under construction
Solar plants at 3 sites	1 MW (Agali) 3 MW (Kanjikode) 4 MW (Bhramapuram)	2021-2022	Under construction
West Kallada floating solar	50 MW	2024	Undergoing document verification
PMKUSUM	40 MW (Component A) 5.99 MW (Component C)	2023	Bidding process
Floating solar plant	8 reservoirs of KSEBL 2 reservoirs of Kerala Water Authority	2024	Bidding process
Wind	100 MW	2024	Bidding process

Source: Data from KSEBL (2020)

Input data for investment:

Activity	Cost	Unit
Install Solar PV plant	3.8	INR crore/MW
Install RTPV	4.5	
Install Wind power plant	5.25	
Install mini hydel power plant	8	
Install biomass power plant	5.76	
Install waste to energy plant	15	
Reduce T&D loss reduction	300	INR Crore/percent of T&D loss reduction
R&M activities in TPP	1	INR Crore/MW
Life extension with upgradation	1.75	
Energy efficiency improvement activities	0.2	

Methodology for power emission mitigation potential estimation:

(1) CO_2 avoided from RE-based electricity generation to meet demand

= $\sum_{\text{time period}}$ Annual RE-based electricity generation x grid[1] emission factor

(2) CO_2 avoided with T&D improvement

= $\sum_{\text{time period}}$ Annual electricity generation avoided with T&D loss improvement w.r.t 2015 x national grid emission factor[2] (kg/kWh)

Indian Average grid emission factor	2014-15	2017-18	2029-30
kgCO_2/kWh	0.726	0.705	0.511

Source: (CEA, 2019a)

(3) CO_2 avoided with efficiency improvement in fossil-based plants

= $\sum_{2012\text{-}2018}$ CO_2 emission $\text{factor}_{\text{fuel}}$ (tCO_2/TJ) * Annual energy savings (TJ) w.r.t 2012

Where, CO_2 $\text{emission factor}_{\text{coal}}$ = 96.7 tCO_2/TJ, CO_2 $\text{emission factor}_{\text{diesel}}$ = 56.1 tCO_2/TJ, CO_2 $\text{emission factor}_{\text{diesel}}$ = 74.1 tCO_2/TJ (IPCC, n.d.)

(4) Emission mitigated with respect to base scenario

= Emission mitigated with policy or actual scenario – Emission mitigated with base scenario

Similar equations are used for projections as well. Instead of 2015 as base year, 2019 is used for T&D loss reduction and energy efficiency improvement lever.

1 *RE-based generating sources are assumed to be the replacement for fossil fuel powered plants. The demand cannot be met by high installations of large hydro projects due to environmental constraints.*
2 *Since Kerala's electricity demand is mainly met by imports, national grid emission factors were used.*

B. Transport

Assumptions made for electric vehicles emission savings estimation:

- The base scenario considers no increase in EVs after 2021 (as per data availability).
- Policy scenario considers growth rate for EV from 2016 to 2021 to be consistent till 2030.
- As number of electric buses in Kerala are very less, the growth rate has not been considered; instead, the EV policy target of 3000 e-buses is assumed to be achieved by 2030.
- Mode-wise number of electric vehicles registered in Kerala from VAHAN dashboard.
- Calculating number of annual kilometres run – mode-wise based on trip length and assuming 300 running days.
- Mode-wise trip length for Kochi was assumed to be common across the State as that was the most relevant number available from Kochi Metro DPR.
- Annual energy consumption by electric vehicles was calculated based on mode-wise energy efficiency and annual kilometres run.
- Based on Indian average grid emissions from CEA 2019 and energy consumption by EVs, emissions for EVs were calculated.
- Same number of vehicles were considered to be ICE for the base scenario.
- Mode-wise emission factor from literature for Indian road vehicles was considered to estimate emissions from ICE.
- The difference between the emission from base case and policy case is the emission savings due to EV introduction.

EV investment estimation:

- Bus - Cost of 12m low floor electric bus is considered.
- 2-wheeler – cost of e-2-wheeler ranges from INR 70k to 1.3 lakh; hence, an average price of INR 1 lakh is considered.
- 3-wheeler – for 3-wheeler (auto rickshaw), average price of 2 lakh has been considered.
- 4-wheeler – for car segment, price of electric Tata Nexon has been considered as mid-segment car.
- Subsidy from centre – 40% of purchase price (based on FAME).

Type of EV	Cost (INR)
E-Bus	220,00,000
E-Two Wheelers	1,00,000
E-Auto	2,00,000
E-Car	15,00,000

Charging infrastructure cost estimation:

Type of charger	Share in Charging Infrastructure	Cost (INR)
Slow	60%	70,000
Level 1 AC	34%	1,20,000
DC fast	5%	2,40,000
Ultra-fast	1%	14,50,000

A subsidy of 25% from the State as per Kerala EV policy has been considered

C. Industries

- To estimate the emissions mitigation in industries, the following equation was used.
- For example, for fertiliser industry's ammonia production, Emissions due to RLNG consumption = Total Ammonia Production (tonnes) * SEC of Ammonia (Gcal/tonnes of product) * Emission Factor of RLNG (tCO_2/Gcal)

D. Buildings

For estimating building sector mitigation potential, the segments considered were efficient lighting (LED lights), energy-efficient fans, refrigerators and air conditioners for residential segment, and for commercial segment, implementation of ECBC for 10% of commercial floor space was considered. Looking at the Kerala GDP growth, a high growth rate scenario from IESS version 2.2 was considered while calculating commercial floor space, and looking at the energy efficient appliances penetration, a medium efficient scenario was considered.

Reduction in power consumption based on wattage was calculated to further estimate the emission reduction. For estimating emission savings from efficient lighting, IESS level 1 was considered as base scenario and level 3 was considered as policy scenario, looking at the current LED penetration. For efficient appliances, IESS level 1 was considered as base scenario and IESS level 2 was considered as policy scenario.

Data on UJALA scheme

Year	LED Bulb	LED tubelight	Energy-Efficient Fans
May 2018	1,51,50,200	19650	9100
May 2019	1,52,69,773	19650	9100
May 2020	1,53,95,580	19650	9100

Source: Indiastat, UJALA dashboard

Assumptions for efficient lighting:

Parameters					
Wattage of bulb	59 W	Wattage of fluorescent tube light	40 W	Wattage of conventional fan	75 W
Wattage of LED	9 W	Wattage of LED tube light	20 W	Wattage of star rated fan	50 W
Annual operating hours	990	Annual operating hours	1200	Annual operating hours	3000

Source: BEE, Kerala State Electricity Regulatory Commission

E. Agriculture

Annual hours of pump operation: Back-calculated based on actual data of average HP, number of pumps, and electricity consumption by irrigation pumps in the period 2013–17

Efficiency improvement lever:

Annual emissions = ((Number of electric pumps*Average capacity * Average annual hours of operation)/ Efficiency)*grid emission factor

Year-on-year emissions were calculated for base and policy scenarios, based on the respective efficiency trajectory

- Emissions mitigated for this lever = $\sum_{2023-2030}$ *(Base annual emissions – Policy annual emissions)*

Solar stand-alone pumps lever:

- Solar pump emissions = 0
- Year-on-year emissions were calculated for base scenario based on base-case efficiency trajectory. Policy case emissions for this lever =0
- Emissions mitigated for this lever = $\sum_{2023-2030}$ *(Base annual emissions)*

Solar-feeder lever:

- Emissions from pumps connected to solar feeder = 0
- Year-on-year emissions were calculated for base scenario based on base-case efficiency trajectory. Policy case emissions for this lever =0
- Emissions mitigated for this lever = $\sum_{2023-2030}$ *(Base annual emissions)*

For Investment calculations:

Efficiency lever:

- Motor efficiency (=Rated power/Input power) for regular electric pumps assumed to be 60%; energy-efficient (EE) pumps assumed to be 80% (Based on IESS average efficiency as per aggressive effort Trajectory 3 in 2030)
- Cost per 5 HP EE pump = INR 50,000; Cost per 5 HP conventional pump = INR 35,000
- Base scenario: EE pump share – 0% in 2012-20; and 16.7% in 2030; remaining pumps conventional
- Policy scenario: EE pump share – 0% in 2012-20; to 46% in 2030; remaining pumps conventional

Solar stand-alone pump lever:

- Cost per 5 HP solar pump = INR 4,85,000; EE pump = INR 50,000; conventional pumps = INR 35,000

Solar feeder lever:

- Solar power capacity required for dedicated feeders: Electricity generation required = (# of EE pumps connected*hours of operation*average capacity)/(1-feeder loss%)*(Efficiency) - where feeder loss is 4%
- Corresponding solar capacity = Electricity generation required/(CUF*8760)- where CUF = 19%

Cost per MW solar capacity = INR 3.4 crores; EE pump = INR 50,000; conventional pumps = INR 35,000

Scenario definitions

The scenario definitions of each lever for the existing policy analysis as well as for the projections are provided in the section below.

A. Power

Existing Policy Analysis:

Assumptions:

a. Actual CUF of renewable-based electricity generation in historic years is lower than the CUF mentioned in tariff orders

b. CUF is linearly increased from 2020 level to CUF mentioned in recent tariff guidelines from Central Electricity Regulatory Commission (CERC) by 2022 and were kept constant till 2030

c. Demand projections (2019–30) for key sectors (industries, agriculture, buildings, and transport) were taken from demand-side sectoral analysis. Electricity demand from other sectors was taken from CEA's 19th EPS report

d. Net Heat Rate (NHR) was back-calculated from ESCerts.

   a. Number of energy savings certificates= (heat rate notified for target year - heat rate as achieved in target year) x Production in baseline year in million kwh/10

Scenario Definitions:

Levers	Base	Actual
RE-based electricity generation	Imported from other States with marginal RE-based generation	Actual RE-based generation is considered
T&D loss reduction	Marginal reduction in T&D loss% (CAGR of –0.5%) **T&D loss%:** 2015: 14.42% 2019: 14.31% *PAT scheme targets (target for T&D loss –0.82% reduction (PAT-1), therefore a lower reduction trend is used for base case)*	Actual T&D loss% is considered (CAGR of –4.2%) **T&D loss%:** 2015: 14.42% 2019: 12.13% *Data on 2020-21 T&D loss% is not available. T&D loss% is extrapolated till 2020-21*
Energy efficiency of power plants	Slight improvement in plant efficiency considering the nominal annual degradation and nominal annual improvement with annual maintenance **Net annual reduction% of heat rate:** 0.01%	Actual improvement in plant efficiency is considered. *Actual data was available only for PAT-1 cycle assessment year (2014-15). Further, NHR is reduced by 0.02% annually, due to lack of data (NHR were in par with the design heat rate)*. NHR data for NTPC Kayamkulam were available for 2014–15 to 2016–17

Source: PAT-1 cycle data from EMC

Projections (2023-30):

Levers	Base	Policy
Renewable energy-based electricity generation	Imported from other States with marginal RE-based generation	· Solar capacity addition as per the State targets (1000 MW) by 2022. Further the State meets the current solar potential of 3.0 GW with ground-mounted and RTPV installations · Waste-to-energy plant of 46 MW by 2030 · Small hydro- data was inadequate. Currently projected using historic CAGR · Biomass/Cogen plants: Historic CAGR
T&D loss reduction	Marginal reduction in T&D loss% (CAGR of (-0.5%)) **T&D loss%:** 2030: 13.54%	Historic T&D loss% reduction till 2018 continues (Continuation of UDAY scheme) **T&D loss%:** 2030: 8.8%
Energy efficiency of power plants	Slight improvement in plant efficiency considering the nominal annual degradation and nominal annual improvement with annual maintenance **Net annual reduction% of heat rate:** 0.01%	Significant improvement in overall plant efficiency. Already, plant energy efficiency is on par with design heat rate. **Net annual reduction% of heat rate:** 0.02%

B. Transport

Existing Policy Analysis:

Scheme/Policies	Base	Actual
FAME	EV introduction started in 2015	5874 electric two-wheelers 1183 electric three-wheelers 1636 electric cars 10 electric buses *(Source: VAHAN Data)*
Kerala Electric Vehicle Policy	1st public charging station in 2019	~20 public charging stations in the State by 2021

Base Scenario – Existing registered EV have been accounted for till 2021 (latest available data) and we assume the number does not increase after 2021.

Projections:

Levers	Base	Policy
EV Penetration	5874 electric two-wheelers 1183 electric three-wheelers 1636 electric cars 10 electric buses By 2021	~3.2 lakh two-wheelers ~1.1 lakh three-wheelers ~75k cars 3000 buses
Kerala Electric Vehicle Policy	20 public charging stations in the State by 2021	~51k EV chargers

Policy Scenario – Understanding the growth trend of electric vehicles in different segments and the policy target, we assume growth trend continues and estimate the EV number for 2030. Wherever the number increases beyond the total vehicle number, we assume 100% electrification or we stick to policy target.

C. Buildings

Existing policy analysis:

Scheme/Policies	Base	Actual
UJALA	Lighting demand met by incandescent bulb and fluorescent tube lights	1.53 crore LED bulbs and 19.6 thousand LED tube lights (as on May 2020)
SLNP	Conventional streetlight	5.6 lakh LED streetlights (till 2020)

Projections:

Assumptions:

Number of appliances per household:

No of appliances per household	2012	2017	2022	2027	2032
Ceiling Fans	1.4	1.5	1.7	1.9	2.1
Televisions	0.5	0.6	0.7	0.9	1
Refrigerators	0.2	0.3	0.4	0.5	0.6
Room Air Conditioners	0	0.1	0.1	0.2	0.3

Source: IESS version 2.2

Lighting trajectory till 2030:

Trajectory	Type of appliance	2020	2025	2030
Base	Bulb	38%	35%	32%
	Tube light	37%	34%	32%
	CFL	19%	23%	27%
	LED	5%	7%	9%
Policy	Bulb	31%	23%	15%
	Tube light	35%	31%	27%
	CFL	10%	7%	5%
	LED	24%	38%	53%

Source: IESS Version 2.2

Appliance efficiency trajectory

Trajectory	Efficiency level	2017	2022	2027	2032
Base	Low	98%	98%	98%	98%
	Medium	1%	1%	1%	1%
	High	1%	1%	1%	1%
Policy	Low	89%	79%	70%	60%
	Medium	8%	16%	23%	30%
	High	3%	6%	8%	10%

Source: IESS Version 2.2

D. Agriculture

Scenario Definitions:

Levers	Base	Actual
EE pumps	3% in 2015 to 6% in 2019 of electric pumps EE; remaining conventional	7% in 2015 to 15% in 2019 of electric pumps EE; remaining conventional
Solar pumps	Actual number of installed solar pumps considered to be electric pumps requiring grid electricity	2019 solar pumps installed as per PM KUSUM Yojana (0 emission)

Projections:

Three levers, each where base scenario assumes existing high carbon-footprint technology and policy assumes a higher adoption of emission-mitigation technologies, based on State policies.

EE lever:

- Numbers of electric pumps are assumed to be growing at an annual growth rate of 0.05% (average based on data from 2013 to 2017 and stakeholder consultation). The number of electric pumps by 2030 will be ~5.3 lakh.

- Base case: Average motor efficiency of the pumps assumed to mildly improve from 58% in 2012 to 62% in 2030 (based on trajectory 1 of IESS)
- Policy case: Average efficiency of the pumps assumed to improve more aggressively from 58% in 2012 to 68% in 2030 (based on trajectory 2 of IESS)

Solarisation lever: This lever has two sub-levers: Stand-alone solar pumps and EE pumps connected to solar powered dedicated feeder.

a. Total number of pumps data was not available for taking a historical trend of solar fuel share. A proxy—fraction of solarised pumps out of total (solarised + electric) pumps—was used. Thus, we get an annual cumulative number of solarised pumps.
b. From 2020 onwards, we assume an increasing fraction of the annual new solarised pumps added (0% in 2020 to 70% in 2030) will be diverted to the solar feeder lever.
c. Solar stand-alone pumps:
   i. Base scenario: 58,000 electric pumps following base efficiency trajectory requiring grid electricity
   ii. Policy scenario: 58,000 stand-alone solar pumps
d. Solar feeder pumps:
   i. Base scenario: ~74,000 electric pumps following base efficiency trajectory requiring grid electricity
   ii. Policy scenario: 74,000 EE pumps connected to solar-powered grid

Scenario Definitions:

Levers	Base	Policy
Efficiency improvement	2022: • Total number of pumps: 5.3 lakh pumps • Electric pumps (with average efficiency of 60%): 5.3 lakh 2030: Total number of pumps: 6.6 lakh Number of electric pumps: 5.3 lakh 13% pumps with 80% motor efficiency 87% pumps with 60% motor efficiency	2022: • Total number of pumps: 5.3 lakh pumps • Electric pumps (with average efficiency of 60%): 5.3 lakhs 2030: Total number of pumps: 6.6 lakh Number of electric pumps: 5.3 lakh 38% pumps with 80% motor efficiency 42% pumps with 60% motor efficiency
Solar pumps and solar fed agricultural feeders	2022: • Total number of pumps: 5.3 lakh pumps • 0 solar pump (10,400 electric pumps assumed to be grid-connected instead) • 0 EE pumps with solar 2030: • Total number of pumps: 6.6 lakh pumps • 0 solar pumps (58,000 electric pumps assumed to be grid-connected instead) • 0 EE pumps with solar fed agricultural feeder (74,000 electric pumps assumed to be grid-connected instead)	2022: • Total number of pumps: 5.3 lakh pumps • 8,461 solar pumps • 0 EE pumps with solar-fed agricultural feeder 2030: • Total number of pumps: 6.6 lakh pumps • 58,000 solar pumps • 74,000 EE pumps with solar-fed agricultural feeder (with 26 MW solar installed capacity)

Annexure 6.1: Health Adaptation Plan for heat related illnesses[1]

Role of Department of Health and Family Welfare

Pre-Heat Season (February)

- Create a list of high-risk areas (heat-wise) of districts/blocks/cities.
- Update surveillance protocols and programs, including tracking daily heat-related data.
- Develop/revise and translate IEC in local language
- Make a communication plan for the dissemination of heat –related alerts or education materials.
- Capacity building of health care personnel to detect and treat heat-related illnesses.
- Issue health advisory to healthcare personnel based on IMD seasonal prediction or warning
- Promote practice of cool roofing.
- Reassess 'Occupational Health Standards' for various types of occupation.
- Ensure inter-sectoral convergence and coordination for improving architecture, design, energy-efficient cooling and heating facility, increase in plantation i.e. Climate Resilient Green Building Design.
- Train medical officers and paramedics to handle heat stress
- Coordinate outreach efforts with other community groups, non-profits, and higher education.

Heat Season (March to May)

- Ensure real-time surveillance and monitoring system in case of an extreme event.
- Equip health facilities with additional materials and manpower, if required at high risk areas.
- Distribute "Do's and Don'ts" to the community
- Ensure strict implementation of legislative/ regulatory actions as per Occupational Health Standards.
- Expedite recording of cause of death due to heat-related illnesses.

Post-Heat Season (June to October)

- Participate in the annual evaluation of Heat Action Plan.
- Review revised Heat Action Plan.

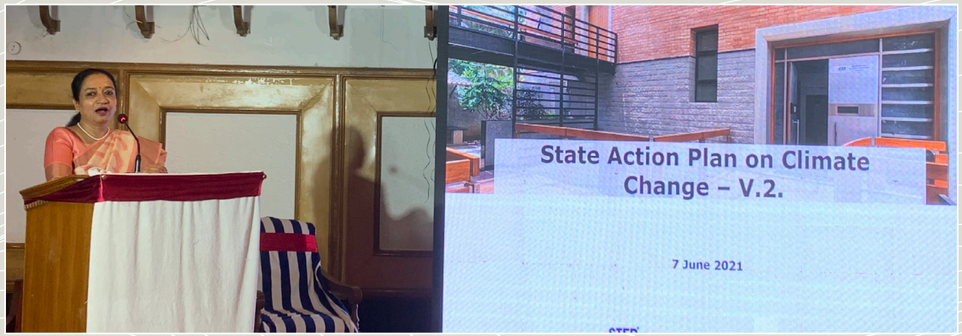
1 *Adapted from State Action Plan on Climate Change and Human Health, 2022 prepared by Department of Health and Family Welfare, Kerala*

Role of other Departments / Agencies

Department / Agencies	Season	Roles and Responsibilities
IMD / SDMA	Pre-Heat	• Issue weather forecasts on Short/Medium/Long range duration.
	Heat	• Issue Heat wave alerts • Coordination with the health department for analyzing cases and death data with meteorological variables like maximum temperature and relative humidity
	Post - Heat	• Participate in the annual evaluation of heat action plan • Review revised heat action plan
KWA, LSGD	Pre-Heat	• Identify vulnerable places
	Heat	• Provide drinking water points at identified places and worksites.
	Post-Heat	• Participate in the annual evaluation of heat action plan • Review revised heat action plan
LSGD, PWD	Pre-Heat	• Review the heat preparation measures • Construct cool shelters/sheds at public places, bus stands, etc.
	Heat	• Maintain shelters/sheds, bus stands
	Post-Heat	• Participate in the annual evaluation of heat action plan • Review revised heat action plan
Education	Pre-Heat	• Train and Sensitize teachers and students towards the health impact of extreme events and disseminate health ministry approved prevention and first-aid measures. • Proper seating and ventilation in classrooms.
	Heat	• Rescheduling school timing during summer • During extreme events, keep a check on outdoor activities • Close teaching institutes in case of issue of alert from Government
	Post-Heat	• Participate in the annual evaluation of heat action plan • Review revised heat action plan
Labour and Skills	Pre-Heat	• Reassess 'Occupational Health Standards' for various types of occupation • Utilize maps of construction sites to identify more high-risk outdoor workers • Heat illness orientation for factory medical officers and general practitioners • Sensitize the non-factory workers and other un-organized labourers.
Labour and Skills	Heat	• Encourage employers to shift outdoor worker's schedules away from peak afternoon hours during a heat alert or consider extended afternoon break or alternate working hours for workers • Provide water at work sites.
	Post-Heat	• Participate in the annual evaluation of heat action plan • Review revised heat action plan
Power	Pre-Heat	• Maintenance of electrical lines
	Heat	• Ensure uninterrupted supply of electricity
	Post - Heat	• Participate in the annual evaluation of heat action plan • Review revised heat action plan
Forest, Environment & Climate Change	Pre-Heat	• Develop/encourage projects to decrease the 'Urban Heat Island effect'.
	Heat	• Ensure implementation of guidelines of the heat action plan.
	Post-Heat	• Review the heat preparation measures and make a note of the lessons learned for the next season.
Transport	Pre-Heat	• Review the road map for preparation for the heat season.
	Heat	• Ensure implementation of guidelines of heat action plan
	Post-Heat	• Participate in the annual evaluation of heat action plan • Review revised heat action plan
I&PRD, SDMA & Media	Pre-Heat	• Secure commercial airtime slots for public service announcements • Identify areas to post warnings and information during heat season • Activate hotline to address the emergencies • Placing temperature forecasts in print and electronic media • Install LED screens with scrolling temperature.
	Heat	• Issue heat warnings in print and electronic media • Use SMS, text and WhatsApp mobile messaging and centralized mobile databases to send warnings • Co-ordinate with transport department to place warnings on buses
	Post-Heat	• Evaluate reach of advertising to target groups and other means of communication such as social media.

Kerala SAPCC Revision - Sectoral Consultations


DIRECTORATE OF ENVIRONMENT & CLIMATE CHANGE
Government of Kerala
REVISION
KERALA STATE ACTION PLAN ON CLIMATE CHANGE | KSAPCC
Consultation Meeting of Sectoral Nodal Officers


State Action Plan on Climate Change – V.2.
7 June 2021


State Action Plan on Climate Change
Tier-III Consultations
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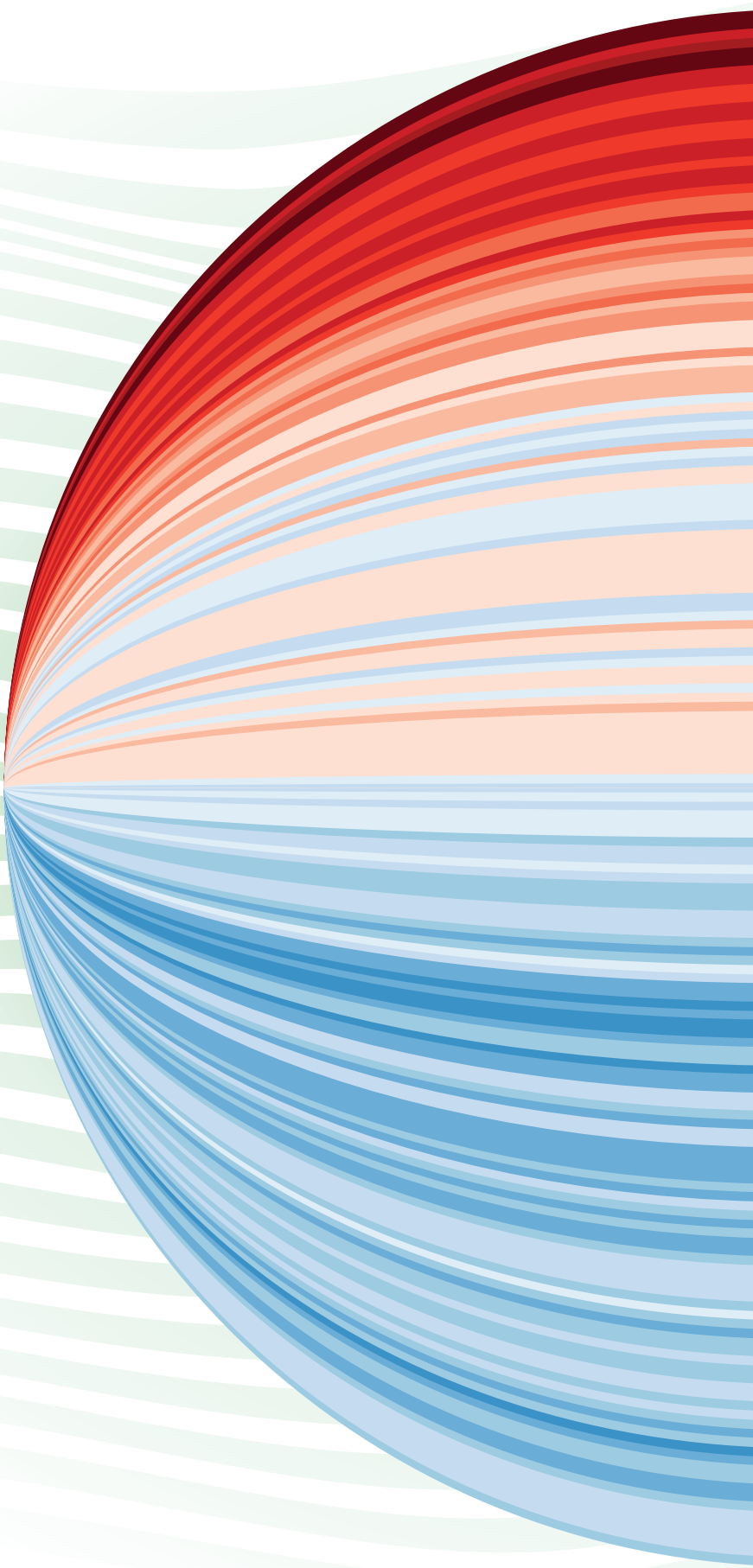

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