

FINAL REPORT

**ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR
THIRUVANANTHAPURAM - KASARAGOD
SEMI HIGH-SPEED RAIL (SILVERLINE) PROJECT**



Submitted to



**KERALA RAIL DEVELOPMENT CORPORATION LIMITED
THIRUVANANTHAPURAM**

By



**CENTRE FOR ENVIRONMENT AND DEVELOPMENT
THIRUVANANTHAPURAM**

JULY 2020

Contents

Sl. No	Content	Page No.
1.	Introduction	3
	1.1 Background	3
	1.2 The Present Project	5
	1.3 Applicable Policies, Legal and Institutional Framework	6
	1.4 Objectives of the EIA Study	12
	1.5 Approach and Methodology Adopted for EIA Study	13
	1.6 Structure of the Report	15
2.	Project Description	17
	2.1 Type of Project	17
	2.2 Need of the Project	18
	2.3 Location of the Project	19
	2.4 Magnitude of Operation	20
	2.5 Project Input	21
	2.6 Project Implementation Schedule	24
	2.7 Electrical Power Supply and Traction	25
	2.8 Signaling and Telecommunication	26
	2.9 Project Profile: Basic Design Parameters	27
	2.10 Rolling Stocks	33
3.	Environmental Baseline Data	34
	3.1 Study Area	34
	3.2 Regional Physical Settings	35
	3.3 Geology & Seismicity	38
	3.4 Soil	43
	3.5 Natural Hazards	44
	3.6 Climate and Meteorology	49
	3.7 Air Environment	55
	3.8 Water Environment	69
	3.9 Noise & Vibration Assessment	82
	3.10 Land Environment	92
	3.11 Biological Environment: Ecology and Biodiversity	100
	3.12 Human Environment: Socio-Economic Aspects	109
	3.13 Historical / Archaeological Importance	115
4.	Anticipated Environmental Impacts and Mitigation Measures	117
	4.1 Introduction	117
	4.2 Land Environment	119
	4.3 Water Environment	122
	4.4 Air Environment	126

4.5	Noise and Vibration	128
4.6	Biological Environment	134
4.7	Microclimate	136
4.8	Flood and Landslides	136
4.9	Impacts on Hydrology	137
4.10	Socio-economic Environment	145
5.	Analysis of Alternatives	147
5.1	Introduction	147
5.2	Alternative Scenarios for SilverLine	149
5.3	Comparison of Alternatives	149
6.	Additional Studies and Activities	151
6.1	Hydrological Environment Impact Assessment	151
6.2	Study on Socio-Economic Environment	162
6.3	Risk Assessment	169
6.4	Disaster Management Plan	173
6.5	Disaster Management Plan for SilverLine	175
6.6	Capacity Building to Handle Disaster	180
6.7	Communication for Disaster Management	181
7	Project Benefits	182
8	Environment Management Plan	185
8.1	Introduction	185
8.2	Environment Management Plan	185
8.3	Institutional Framework for Implementation of EMP	199
8.4	Grievance Redressal Mechanism and Reporting under EMP	200
8.5	Costs for Implementation of EMP	200
9	Environmental Monitoring Programme (EMoP)	202
9.1	Introduction	202
9.2	Environmental Monitoring Programme (EMoP)	202
9.3	Institutional Framework for Implementation of EMoP	205
9.4	Costs for Implementation of EMoP	205
10	Summary and Conclusion	208
11	Disclosure of Consultant Engaged in EIA Study	216
	Annexures	

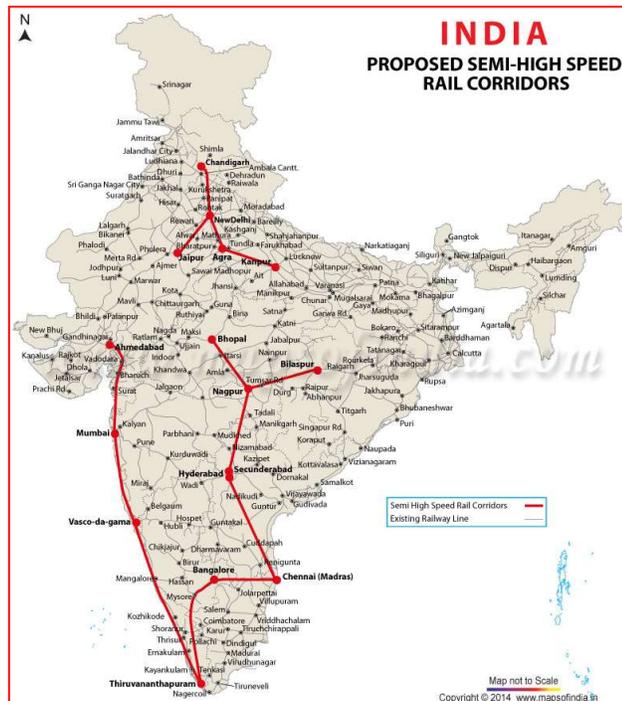
Chapter 1

INTRODUCTION

1.1 Background

Rapid economic growth in India in the recent decades has resulted in increase in the volume of people and goods being transported across the country. In order to meet the growing demand of goods transportation, Dedicated Freight Corridors (DFC) are being constructed to haul freight from Delhi to Mumbai and Kolkata. For better and improved passenger transport, Ministry of Railways, Government of India, has formulated the “Indian Railway Vision 2020” in December 2009, which aims to modernize existing conventional lines and enhance capacity as well as develop highspeed railway lines. At present, India does not have any high-speedrail (HSR) corridor of international standards. The current fastest train in India is the *Vande Bharat* Express, with an operational speed of 160 km/h and an average speed of 100 km/h, which runs between New Delhi and Varanasi. Another semi-high-speed train in India is the *Gatimaan* Express, runs at the top speed of 160 km/h from Delhi to Agra. However, the Government has approved the proposal of Japan to build India's first high-speed railway on December 2015, between Mumbai & Ahmedabad at a top speed of 320 km/h. The construction of HSR began in 2017 and is expected to be completed in the year 2022.

Kerala State, which has one of the highest densities of population in India, has 205545.62 km of roads (3.49% of India's total) which translates to about 615.5 km of road per lakh population. The road traffic has been growing at a rate of 10 to 11%, whereas Road length growth has been negligible. This has resulted in great increase in road congestion. Four international airports at Thiruvananthapuram, Kochi, Kozhikode and Kannur, link the state with the rest of the nation



and the world. A total of 1588 km rail line with nearly 200 Railway stations connects all major towns and cities of Kerala except in highland districts of Idukki and Wayanad. The

existing railway and road networks in the state are not amenable to faster travel. Average speed on road and by trains in the State is among the lowest of all regions of the country.

There is a widespread realization that the economic and social life in the state of Kerala suffers from slowspeed of travel on its existing highways and railways. The idea of high-speed rail corridor between Thiruvananthapuram and Kasaragod was first announced in the 2009-10 Kerala Budget. In 2009, the then government had set up a corporation named Kerala High Speed Rail Corporation Ltd (KHSRC) to implement the project. Following that, Delhi Metro Rail Corporation (DMRC) had conducted a feasibility study and submitted a report in 2012. The project which had an estimated cost of Rs 1.27 lakh crore, however, failed to be implemented due to various factors and the government had dissolved the KHSRC.

Augmenting the present Rail Infrastructure, Kerala Government has decided to build special railway corridor between Thiruvananthapuram and Kasaragod and in the 2019-20 Kerala budget, Finance Minister, Shri. Thomas Isaac had announced a 515km elevated corridor with an estimated cost of Rs 55,000 crore. But later it was decided to construct third and fourth railway lines considering the escalating cost of construction for elevated corridor. The 529.45 km long project, which is executed by Kerala Rail Development Corporation Limited (K-Rail), a joint venture of Government of Kerala and Ministry of Railways, for implementing the railway infrastructure in the state. K-Rail estimated the cost of project as Rs 63941 crores and according to K-Rail, the proposed third and fourth railway lines are planned to be in mostly straight alignment which is designed to run at a Semi-High Speed of 200 Km/h.



The Semi High-Speed Rail (SilverLine) Project is expected to complete by 2025, will reduce journey time from Thiruvananthapuram to Kasaragod from 12 hours to just 4 hours. This SilverLine will reduce congestion and pollution on the roads, improve safety and comforts.

The airport at Kochi will be connected in the SilverLine. This rail line will pass through eleven districts, and will stop at 11 stations namely Thiruvananthapuram, Kollam, Chengannur, Kottayam, Ernakulam, Kochi Airport, Thrissur, Tirur, Kozhikode, Kannur and Kasaragod. From Thiruvananthapuram to Tirur, the proposed rail line will pass by a stretch that is different from the existing railway line and from Tirur upward, the line will run parallel to the existing track up to Kasaragod. The rail corridor will also have roads parallel to it and there will be underpasses for road traffic at every 500 m.

The station buildings, depots, administrative building and other service structures will be designed based on the standards of Indian Green Building Council. K-Rail is set to adopt last-mile connectivity, with system-driven e-vehicle public transport system, multi-modal integration, charging and parking stations, which would take Kerala to next generation of urban mobility. The strategies proposed to be adopted during construction includes recycling steel and concrete, diversion of construction waste from landfills through reuse and recycling, use of new, low emission construction equipment, replacement of inefficient truck engines and urban forestry programme. The SilverLine project is estimated to reduce approximately 3,51,940 tons of carbon dioxide equivalent emission by 2029-30, and 5,94,636 tons by 2052-53.

Development of the proposed SilverLine makes significant contribution to the socio-economic development in the regions and urban growth. At the same time, it may also create adverse impacts on the surrounding environment. The SilverLine development may create a wide range of impacts on the environment during construction and operation phase. The potential adverse effects of rail development encompass air pollution, noise and vibration, ground water pollution, loss of biodiversity, damage to habitat, waste disposal, and other socio-cultural impacts. The SilverLine development and operation should, therefore, be planned with careful consideration of their environmental impacts. To minimize these adverse effects that may be created by the SilverLine development project, it is essential to identify the Environmental Impacts - both positive and negative and formulate Environment Management Plan based on the Environmental Impact Assessment.

1.2 Present Project

The K-Rail has selected the Centre for Environment and Development (CED), Thiruvananthapuram, to carry out the Rapid Environment Impact Assessment (EIA) study of the proposed SilverLine and issued the Letter of Award (LoA) on 30.09.2019. The assignment is to help the K-Rail in identifying environmental and social impacts; prepare environmental and social management plans to mitigate the identified issues and to ensure

that the proposed works are designed and constructed in line with the regulations and stipulations of MOEFCC, CPCB, SPCB, KRDC and international funding agencies like KfW, ADB, JICA, WB & AIIB. Since the proposed Project is a railway project, Environmental Clearance is not required from MoEFCC, Government of India, but K-Rail in its commitment to safeguard the environment and also to mitigate the social impact due to project is desirous of conducting the EIA. The EIA report is a prerequisite for various international funding agencies and it is also to be incorporated in the Detailed Project Report (DPR).

1.3 Applicable Policies, Legal and Institutional Framework

The legal framework of India consists of several acts, notifications, rules, and regulations to protect environment and wildlife. The environmental impact assessment requirement in India is based on the Environment (Protection) Act, 1986 and the Environmental Impact Assessment Notification, 2006 (amended 2009), all its related circulars. Review of Indian legal system has been carried out to identify its applicability to the project. The following rules, notifications and standards under the Environment (Protection) Act, 1986 are particularly relevant in this case:

- Environment (Protection) Act & Rules, 1986 and its amendments
- EIA Notification, 1994 and its amendments in 2006 & 2009
- Ash Utilization Notification, 1999 and its amendments
- The Forest (Conservation) Act 1980 (Amended 1988) and Rules 1981 (Amended 2003)
- The Wildlife (Protection) Act, 1972 (Amended 1993)
- The Water (Prevention & Control of Pollution) Act 1972 (Amended 1988) & Rules 1974
- The Air (Prevention & Control of Pollution) Act, 1981 (Amended 1987) & Rules 1982
- The Noise Pollution (Regulation and Control) Rules, 2000 (Amended 2010)
- Solid Waste Management Rules, 2016
- Plastic Waste Management Rules, 2016
- Construction and Demolition Waste Management Rules, 2016
- E- Waste Management Rules, 2016
- Biomedical Waste Management Rules, 2016
- Hazardous and Other Waste (Management and Trans-boundary Movement) Rules, 2016
- Ancient and Historical Monuments and Archaeological Sites and Remains (Declaration of National Importance) Act, 1951 (No. LXXI of 1951)
- Coastal Regulation Zones Rules 2011 and its amendment 18th January 2019
- The Biological Diversity Act 2002 and its Rules, 2007

- MoEF circular (1998) on linear Plantation on roadside, canals and railway lines modifying the applicability of provisions of Forest (Conservation) Act, to linear Plantation
- Public Liability and Insurance Act, 1991 and its Amendment, 1992
- The Explosives Act, 1884
- Central Motor Vehicle Act 1988 and Central Motor Vehicle Rules, 1989
- The Railway (Amendment) Act, 2008
- The Petroleum (Amendment) Rules, 2011
- Land Acquisition Act, 1984 and its Amendment
- National Rehabilitation and Resettlement Policy, 2007
- National Green Tribunal Act, 2010
- National Green Tribunal (Practices and Procedure) Rules, 2011
- The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013, (RTFCTLARRA, 2013)
- The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Kerala) Rules.

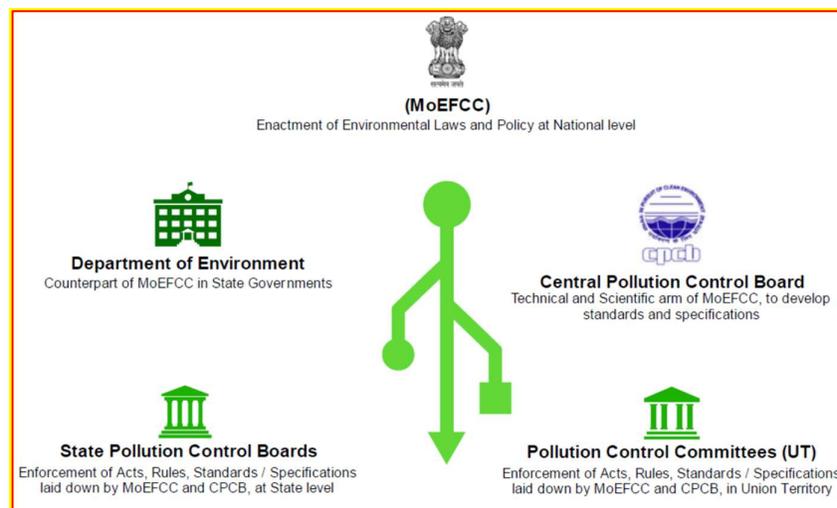
Other Applicable Cross-Sectoral Laws

- Minimum Wages Act, 1948; As per this act, the employer is supposed to pay not less than the minimum wages fixed by appropriate Government.
- Child Labor (Prohibition and Regulation) Act, 1986; This Act prohibits employment of children below 14 years of age in building and construction industry covering Railway.
- The Labors Act, 1988; The health and safety of workers employed in construction work, etc.
- The Factories Act, 1948; Health and safety considerations for workers
- Workmen's Compensation Act, 1923; This act provides for compensation in case of injury by accidents arising out of and during the course of employment.
- Contract Labor (Regulation and Abolition) Act, 1970; This act provides for certain welfare measures to be provided by the contractor to contract labor.
- The Building and other Construction Workers Act, 1996; All the establishments who carry on any building or other construction work and employ 10 or more workers are covered under this Act. The employer is required to provide safety measures at construction work site and other welfare measures such as canteens, first-aid facilities, ambulance, and housing accommodation for Workers near the workplace, etc.

Requirement of Environmental Clearance: As per provisions of the EIA Notification, 14 September 2006 as amended up to 1 December 2009, any person who desires to undertake any new project in any part of India or the expansion or modernization of any

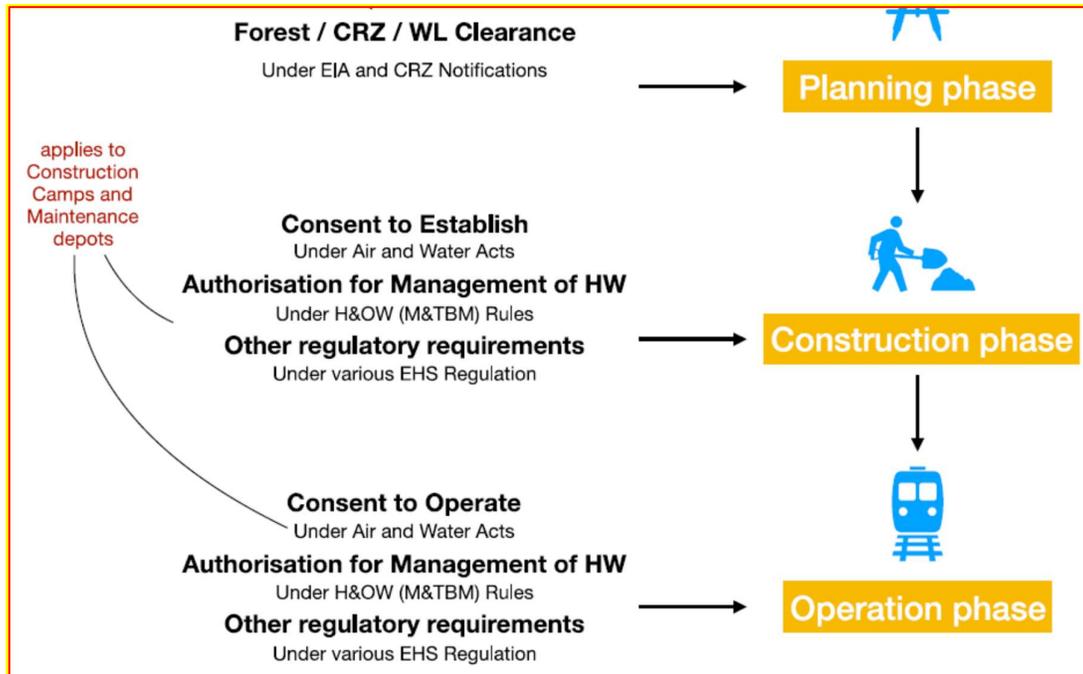
existing industry or project listed in Schedule of the said notification shall submit an application to the Ministry of Environment and Forests and Climate Change (MoEFCC), Government of India (GoI) in accordance with the guidelines issued by the MoEFCC, GoI, from time to time. The SilverLine project is not included in the Schedule of the EIA Notification, 2006. Thus, the project does not require an environmental clearance certificate from the MoEFCC, GoI. However, the client K-Rail, being environment conscious, proposed to undertake an Environmental Impact Assessment study for the proposed project so that the environmental impacts stemming from the project can be assessed and mitigated. The EIA study would enable K-Rail in dealing with careful planning and designing of the SilverLine rail alignment and structures from environmental point of view and for making adequate provision of environmental clauses in work contracts so as to eliminate or reduce significantly all possible adverse impacts on the environment.

The MoEFCC is vested with overall responsibility to set policy and standards for the protection of environment along with Central Pollution Control Board (CPCB) and State Pollution Control Boards (See Fig below). The air, noise and water quality need to be maintained as per respective standards. These standards are also of significance for the proposed project. More importantly, Consents under the Air Act and Water Act will have to be sought from the Kerala Pollution Control Board specially for establishing Batching plants, installation of DG sets and discharge of effluents from the Depot. Permission from relevant Government Authorities will be required for water requirements and access to public sewers both during construction and operation of the SilverLine project.



Forest Clearance: As per Indian “Forests Conservation Act (1980), every project requiring diversion of forest land for non-forestry purposes require forest clearance from MoEFCC. The forestry clearance is granted through two-stage process: Stage 1, in principle

agreement, refers to the project proposal in which usually the conditions relating to transfer, mutation and declaration as RF/PF under the Indian Forest Act, 1972, of equivalent non-forest land for compensatory afforestation and funds for raising compensatory afforestation there of are stipulated. Stage II involves formal approval under the Act after receipt of compliance report from the State Government in respect of the stipulated conditions. Since no diversion of forest land is involved in SilverLine Project, no forest clearance is required for this project.



In addition to rail construction work and rehabilitation including establishment of temporary workshops, construction camps, hot-mix plants, and opening of quarries for rail construction work require to comply with provisions of The Forest (Conservation) Act 1980 (Amended 1988) and Rules 1981 (Amended 2003); The Wildlife (Protection) Act, 1972 (Amended 1993); The Water (Prevention and Control of Pollution) Act 1972 (Amended 1988) and Rules 1974; The Air (Prevention and Control of Pollution) Act, 1981 (Amended 1987) and Rules 1982; The Noise Pollution (Regulation and Control) Rules, 2000 (Amended 2002) and Hazardous and Other Waste (Management and Trans-boundary Movement) Rules, 2016.

Social Regulatory Requirements: There are many rules and regulations framed by the Government of India for the protection of workers. Most of these legislations will be applicable to contractors in charge of construction. EA will ensure compliance to these social legislations through contractual obligation and regular checks & penalties. These

legislations include The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996; Child Labour (Prohibition and Regulation) Act, 1986; Minimum Wages Act, 1948; Workmen Compensation Act, 1923; Payment of Gratuity Act, 1972; Employee State Insurance Act; Employees P.F. and Miscellaneous Provision Act, 1952; Maternity Benefit Act, 1951; Payment of Wages Act, 1936; Equal Remuneration Act, 1979; Inter-State Migrant Workmen's (Regulation of Employment & Conditions of Service) Act, 1979; Equal Remuneration Act, 1979; etc.

JICA Guidelines for Environmental & Social Considerations, April 2010

JICA enforced the new guidelines on environmental and social considerations in April 2010. As per this guideline, JICA supports the recipient governments by offering cooperation projects into which JICA incorporates appropriate environmental and social considerations so as to avoid or minimize development projects' adverse impacts on the environment and local communities. JICA thus promotes sustainable development in developing countries. JICA classifies projects under four categories (A, B, C, and F1) according to the extent of environmental and social impacts similar to the funding agencies categorization like World Bank (WB), Asian Development Bank (ADB) and Japan Bank for International Cooperation.

Categorisation of the Project as per JICA

Category A: Project that is likely to have significant adverse impacts on environment and society. A largescale project that requires special attention such as energy development and infrastructure development, or a project in a sensitive area such as a nature reserve or a living sphere of indigenous people.

Category B: Project whose impacts on the environment and society are less adverse than that of category A.

Category C: Project that has a minimal or virtually no impact on the environment and society.

Category F1: Project in which JICA funds the financial intermediary or executing agency that selects its sub-projects after JICA's approval of the funding, and therefore JICA cannot assess the ESC of each sub-project prior to its approval. Such projects are classified as F1 if the sub-projects are likely to have a considerable impact on the environment and society.

Source: JICA Guidelines for Environmental and Social Consideration, 2010

World bank Safeguard Policies

There are 10 safeguard policies, comprising the World Bank's policy on Environmental Assessment (EA) and policies on: Cultural Property; Disputed Areas; Forestry; Indigenous Peoples; International Waterways; Involuntary Resettlement; Natural Habitats; Pest Management; and Safety of Dams. The Bank undertakes screening of each proposed

project to determine the appropriate extent and type of EA to be undertaken and whether or not the project may trigger other safeguard policies. The Bank classifies the proposed project into one of four categories (A, B, C, and FI) depending on the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impacts.

IFC PERFORMANCE STANDARDS ON ENVIRONMENTAL AND SOCIAL SUSTAINABILITY	
<p>Performance Standard 1: ASSESSMENT AND MANAGEMENT OF ENVIRONMENTAL AND SOCIAL RISKS AND IMPACTS Underscores the importance of identifying E&S risks and impacts, and managing E&S performance throughout the life of a project.</p>	<p>Performance Standard 5: LAND ACQUISITION AND INVOLUNTARY RESETTLEMENT Applies to physical or economic displacement resulting from land transactions such as expropriation or negotiated settlements.</p>
<p>Performance Standard 2: LABOR AND WORKING CONDITIONS Recognizes that the pursuit of economic growth through employment creation and income generation should be balanced with protection of basic rights for workers.</p>	<p>Performance Standard 6: BIODIVERSITY CONSERVATION AND SUSTAINABLE MANAGEMENT OF LIVING NATURAL RESOURCES Promotes the protection of biodiversity and the sustainable management and use of natural resources.</p>
<p>Performance Standard 3: RESOURCE EFFICIENCY AND POLLUTION PREVENTION Recognizes that increased industrial activity and urbanization often generate higher levels of air, water and land pollution, and that there are efficiency opportunities.</p>	<p>Performance Standard 7: INDIGENOUS PEOPLES Aims to ensure that the development process fosters full respect for Indigenous Peoples.</p>
<p>Performance Standard 4: COMMUNITY HEALTH, SAFETY AND SECURITY Recognizes that projects can bring benefits to communities, but can also increase potential exposure to risks and impacts from incidents, structural failures, and hazardous materials.</p>	<p>Performance Standard 8: CULTURAL HERITAGE Aims to protect cultural heritage from adverse impacts of project activities and support its preservation.</p>
WHAT ARE THE BENEFITS OF THE PERFORMANCE STANDARDS	
<p>GUARD AGAINST UNFORESEEN RISKS AND IMPACTS Implementing the Performance Standards helps companies identify and guard against interruptions in project execution, legal claims, brand protection, and accessing international markets.</p> <p>IMPROVE FINANCIAL AND OPERATIONAL PERFORMANCE IFC believes that meeting the Performance Standards helps clients improve their bottom line. Implementation of the Standards can help optimize the management of inputs such as water and energy, and minimize emissions, effluents, and waste, leading to a more efficient and cost-effective operation.</p>	<p>SOCIAL LICENSE TO OPERATE In addition, the Standards help clients find ways to maximize local development benefits and encourage the practice of good corporate citizenship. This often results in greater acceptance of the project by local communities and governments, allowing companies to acquire a social license to operate. Enhanced brand value and reputation may also be attractive to new investors or financiers.</p> <p>GAIN AN INTERNATIONAL STAMP OF APPROVAL The "Equator Principles," which have been adopted by more than 70 of the world's leading investment banks in developed and developing countries, are based on IFC's Performance Standards. These principles are estimated to cover nearly 90% of project financing in emerging markets.</p>

ADB Safeguard Policy Statement Requirements

The Asian Development Bank has defined its Safeguard requirements under its 'Safeguard Policy Statement, 2009 (SPS, 2009). This policy requires assessment, mitigation and commitment towards environmental protection. The prime objectives of safeguard policy are to: (i) avoid adverse impacts of projects on the environment and affected people, where possible; and (ii) minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible. The extent of assessment depends on the category of the project. ADB's SPS 2009 classify a project depending on following three categories viz., **Category A:** if the proposed project is likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works and an EIA is required; **Category B:** if its potential adverse environmental impacts are less adverse than those of category A projects. These impacts are site-specific,

none or very few of them are irreversible, and in most cases mitigation measures can be designed more readily than for category A projects and an initial environmental examination is required; **Category C:** A proposed project is classified as category C if it is likely to have minimal or no adverse environmental impacts.

Purpose of the Report

Rapid Environmental Impact Assessment (EIA) is a process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of development proposal prior to major decisions are being taken and commitments are made. The study integrates the environmental concerns of developmental activities in to the process of decision making. EIA study is executed in the project planning stage such that the potential environmental impact due to the project implementation is identified at the planning stage itself and necessary mitigation measures to avoid, minimise or mitigate is duly integrated in the project design phase towards ensuring that the proposed developments are made in due compliance with the environmental sustainability.

1.4 Objectives of the EIA Study

The overall objective of the present assignment is to carry out a Rapid Environment Impact Assessment (EIA) for the proposed SilverLine Project between Thiruvananthapuram to Kasaragod (Total Length of corridor: 529.45 km); to help the K-Rail in identifying environment and social impacts; prepare an Environmental Management Plan to mitigate the identified issues and to ensure that the proposed works are designed and constructed in line with the regulations made by the organizations and funding agencies like MOEF&CC, CPCB, SPCB, KRDC and KfW/ ADB/ JICA/ WB/ AIIB.

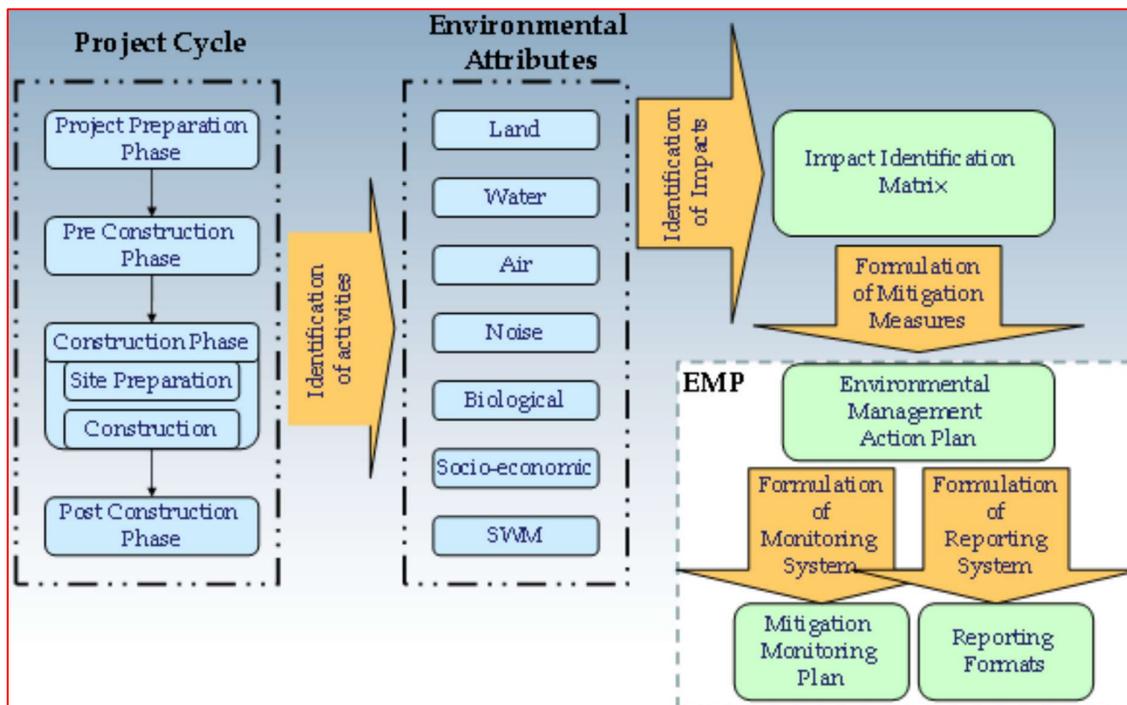
The specific objectives are:

1. To analyze the project based on the components and identify activities that can have considerable effect on the local environment - be it positive or negative;
2. To foresee and quantify the magnitude and intensity of the impacts of the various project components on the local environment;
3. To specifically undertake hydrological Environmental Impact Assessment;
4. To carry out an appraisal of the present environmental settings in the area with regard to parameters like air, land, water quality, biodiversity of the region, socio-economic conditions of the people, infrastructure capabilities of the area, etc.
5. To suggest mitigation / control measures for the major impacts of the SilverLine Project and also to prepare an Environmental Management Plan for the SilverLine Project.

6. To prepare a detailed environmental and social baseline situation.
7. To predict and evaluate possible environmental and socio-economic impacts.

1.5 Approach and Methodology Adopted for EIA Study

The Government of India guidelines for Rail/ Road/ Highway project; EIA notification 2006 of MoEFCC, and Highway Sector EIA guidance manual 2010 has also been followed in the process of this environmental assessment. The study methodology has been adopted in such a manner to ensure that environmental concerns are given adequate weightage in the selection of alignment and design of proposed SilverLine Project. The study employs an iterative approach in which potential environmental issues have been examined at successive levels in detail and specificity, at each step in the process. The Environmental assessment is based on the information collected from primary as well as secondary sources on various environmental attributes. The major steps in the EIA process for the project were as follows:



Establishment of Baseline Environmental Status

A comprehensive database on the baseline environmental status/ conditions of the study area has been established through review, compilation and analysis of (i) Existing published secondary data / literature / information, and (ii) Primary data generated/ collected through initial site surveys and field study. The field monitoring has been carried out as per the

guidelines of CPCB and requirement of the MoEFCC for one complete season. Field study/ monitoring has been conducted on: Soil Quality; Water Quality (ground and surface waters); Ambient Air Quality; Noise; Geology; Hydrology; Land Use Pattern; Ecological Aspects (Flora & Fauna); and Socio- Economic Aspects. Secondary data on environment for the project corridor was collected both from published and other relevant sources including the Kerala Forest Department, Kerala State Pollution Control Board, and State Statistical Department. Ambient Air quality monitoring has been carried out as per MoEFCC notification of November 2009; the revised Air Quality standards and the on-site monitoring results are incorporated in Chapter 3 of this EIA report. In order to assess presence of flora and fauna along the proposed alignment field surveys were carried out.

Analysis of Alternative

Alternate analysis for the present project, i.e. the SilverLine semi-high-speed rail alignment has been made on the basis of “with” and “without” project scenario as well as other alternate options. The parameters considered for the analysis are the environmental as well as social features and their likely impact on the natural ecosystem.

Assessment of Potential Impacts

The project data has been analysed & linked with the existing baseline environmental conditions in order to list out the affected environmental parameters and assess the likely impacts on such parameters. Compliance of the project with national standards has been duly checked. Potential significant impacts were identified on the basis of: analytical review of baseline data; review of environmental conditions at project corridor; analytical review of the underlying socio-economic conditions with the project influence area.

Preparation of the Environment Management Plan

Environmental Management Plan (EMP) is the key to ensure a safe and clean environment. An EMP for the project is prepared to specify the steps required to ensure that the necessary measures have been taken and the same will be incorporated during construction and operation stage of the project. The EMP includes the monitoring plan giving details of the resources budgeted and the implementation arrangements. The EMP envisages the plans for the proper implementation of mitigation measures to reduce the adverse impacts arising out of the project activities. EMP has been prepared addressing issues such as: Details of management plans; Pollution control/ mitigation measures for abatement of the undesirable impacts caused during construction and operational activities; Maintenance of water resources and water quality; Post project environmental monitoring programme; Institutional set up identified/ recommended for implementation of the EMP.

1.6 Structure of the Report

This EIA Report is organised into following eleven chapters, a brief of each chapter is described below:

Chapter 1 - Introduction: This section describes the background information about the project; Applicable Policies, Legal and Institutional Frame work; Objectives of EIA study; Approach and Methodology Adopted; and the Structure of the Report.

Chapter 2 - Project Description: This section presents the key features and components of the proposed project. This includes Type, Need, and Location of the Project; Magnitude of Operation; Project input (Route details, Land, and Water requirements); Project Implementation Schedule; Electrical Power Supply and Traction; Signalling and Tele communication; and Project Profile (Basic Design Parameters).

Chapter 3 - Environmental Baseline Data: This section discusses the relevant physical, biological, and socio-economic features that may be affected by the proposed project. This includes Environmental Scoping; Land Environment (Physiography, Soil, Geology and Minerals; Landuse and Landcover, Seismicity); Water Environment (Water Resources, Drainage, Water Quality); Meteorology; Ambient Air Quality; Noise Environment; Ecological Environment (Forest & Wetlands, Flora and Fauna); Archaeological Sites or Monuments; etc.

Chapter 4 - Anticipated Environmental Impacts: This section presents the environmental assessment of likely positive and adverse impacts attributable to the proposed project and concomitant mitigation measures. This includes Impacts due to Project Location (Land Acquisition: Displacement and loss of livelihood and impact on community assets, Loss of trees/forest, Utility/Drainage Problems, Aesthetics, Climate change impacts, and Impact on Historical and Cultural Monuments; Impacts due to Project Design (Right of Way, Alignment and Architectural Design, Inter-modal integration); Impacts due to Construction (Air Pollution, Noise Pollution, Vibration Impacts and Risk to Existing Buildings, Soil Erosion and Spoils Disposal, Transportation of construction material, Traffic Diversions, Impact due to Labour Camp, Increased water demand, Impact on Water Quality, Loss of Historical and Cultural monuments); Impacts due to Project Operation (Employment Opportunities, Air pollution, Noise pollution, Vibration, Energy supply, Water supply and Sanitation, Pedestrian and Traffic Congestion around stations, Impacts due to Depot).

Chapter 5 - Analysis of Alternatives with or without Project Scenario: This section covers analysis of various alternatives considered to minimise the overall impacts of proposed development and suggest most appropriate alternatives based on detailed analysis of impact and risk associated with each alternative. This includes, Alternative 1 -

SilverLine with Embankment, Cuttings and viaducts with minimal cut and cover, Tunnels and Bridges; Alternative 2 - No SilverLine - Business-as-Usual; Alternative 3 - Express Highway; and Comparison of Alternatives.

Chapter 6 - Additional Studies and Activities: This section covers the Hydrological Impact Assessment, Soci-economic Assessment, and Disaster Management Plan for the Project including Capacity Building to Handle Disaster; Communication for Disaster Management; etc.

Chapter 7 - Project Benefits: This chapter describes the possible benefits of the projects which includes High speed connectivity; Improvements in physical infrastructure; Improvements in social infrastructure; Employment potential-skilled; semi-skilled and unskilled; Other tangible benefits; Reduction in Green House Gas (GHG) Emission; etc.

Chapter 8 - Environmental Management Plan: This section discusses the lessons from the impact assessment and translated into action plans to avoid, reduce, mitigate or compensate adverse impacts and reinforces beneficial impacts. This plan is divided into three sub-sections; mitigation, monitoring, and implementation arrangements. This includes Environmental Management Plan for various activities; Institutional Framework for Implementation of EMP; Grievance Redressal Mechanism Under EMP; Reporting Arrangement; and Cost for Implementation of EMP.

Chapter 9 - Environmental Monitoring Programme: This section describes Environmental Monitoring Programme (EMoP); Institutional Framework for Implementation of EMoP; and Cost for Implementation of EMoP.

Chapter 10 – Summary and Conclusion: This section is stating whether there is a need for further detailed environmental studies / assessments and highlights key findings and recommendations to be implemented by the borrower.

Chapter 11 – Disclosure of Consultant Engaged in EIA Study: This section gives a brief description about CED and the Project Team.

Chapter 2

PROJECT DESCRIPTION

2.1 Type of Project

The present proposal is for the Thiruvananthapuram - Kasaragod Semi High-Speed Railway (The SilverLine) Project being executed by Kerala Rail Development Corporation Limited (K-Rail), a joint venture of Government of Kerala and Ministry of Railways, Government of India. The SilverLine project of 529.45km, begins at Kochuveli (near Thiruvananthapuram Airport) in Thiruvananthapuram District and runs through Kollam, Alappuzha, Kottayam, Ernakulam, Thrissur, Malappuram, Kozhikode and Kannur districts before entering Kasaragod District. The planned route lies between Latitude 8°30'44.88"N-Longitude 76°53'52.43"E and Latitude 12°29'28.37"N -Longitude 74°59'15.57"E.

The alignment has been prepared keeping in focus all the basic technical requirements for a semi high speed rail line with techno and economic considerations. To cut down land requirement as much as possible, cause less dislocation for the population in congested areas, cause least hindrance to the movement of people and vehicles on the roads, highways and streets, boats and ferries in the canals and backwaters, following strategies have been adopted;

- Alignment to have minimum numbers of curves, grades to get desired speed
- Alignment has to utilise less intensively used lands not to affect the agricultural potential of the state.
- Alignment to have minimum numbers of tunnels, major bridges and viaducts length to get economical design
- Alignment to be safe from the landslide in cuttings or embankment failure during operation
- Alignment to be easy to construct
- Alignment to pass through mid of the catchment of the population to the best extent to get more traffic and make the project more useful and financially viable
- Alignment connecting important locations of the project to serve maximum population conveniently
- Alignment not to divide the state in to two
- Alignment to be built at a safe level to avoid any submergence of the track during the flood

Considering above parameters, following strategies have been evolved for desired track supporting structures for alignment design;

Alignment at At Grade - Embankment and Cutting: Bank height and cutting depth not to be more than 8m and 9m respectively in normal cases.

Underground - Cut & cover and Tunnels: Cut and cover has been considered for depth exceeding 9m and tunnel if the depth is more than 20m and ground has adequate cover.

Elevated - Viaduct and bridges: Viaduct has been limited for some of the locations like where bank exceeding 8m height, slushy and flood prone stretches, habitated areas, etc.

2.2 Need of the Project

Kerala State, which has one of the highest densities of population in India, has eleven National Highways which run for about 1781.5 km. There are 72 state highways in Kerala. Of them, MC Road (Main-Central Road), proposed Hill Highway (Kerala) and Main Eastern Highway are the longest. The road transport infrastructure of the state consists of over 2.29 lakh kms of road and road density in Kerala is 590 km per 100 square km (which includes classified & non-classified roads). The road traffic has been growing at a rate of 10 to 12%, whereas Road length growth has been negligible. This has resulted in great increase in road congestion. Four international airports at Thiruvananthapuram, Kochi, Kozhikode and Kannur, link the state with the rest of the nation and the world.

The total rail network in Kerala is 1045 km in length, with 181 stations and serving 9 routes, connects all major towns and cities of Kerala except in highland districts of Idukki and Wayanad. The existing railway and road networks in the state are not amenable to faster travel. Average speed on road and by trains in the State is among the lowest of all regions of the country. Hence, the necessity for developing SilverLine corridors has been felt, which will cater the needs of rapidly growing and expanding economy and thereby curb the high road-based greenhouse gas emissions.

A detailed proposal on proposed SilverLine project from Thiruvananthapuram to Kasaragod was presented before Railway Board, Government of India on 10th December 2019. While according in-principle approval, Railway Board has expressed concern about the land acquisition issues in Kerala. It was assured that all efforts will be made to acquire the land and proper compensation will be given to the affected parties.

The SilverLine is expected to complete by 2025, will reduce journey time from Thiruvananthapuram to Kasaragod from 12 hours to just 4 hours. This line will reduce congestion and pollution on the roads, improve safety and comforts. The positive impacts of the project are safety; High Capacity and Frequency; High Energy Efficiency and Low Emission of Greenhouse Gas (Reduce impact of ClimateChange); Travel time reduction; Employment generation; and Strong Infrastructure to counter Natural Disaster.

2.2.1 Category of the Project

The SilverLine project is categorized as **Category A** as per JICA's Guidelines for Environmental and Social Consideration, April 2010. However, the SilverLine project does not attract requirements of prior Environmental Clearance (EC) as per EIA Notification, 2006 in India, as the Railway sector is not included in the Schedule of the notification.

2.3 Location of the Project

The proposed SilverLine alignment starts at the Kochuveli near Thiruvananthapuram and ends at Kasaragod. This rail line will pass through eleven districts, and will stop at 11 stations namely Thiruvananthapuram, Kollam, Chengannur, Kottayam, Ernakulam, Kochi Airport, Thrissur, Tirur, Kozhikode, Kannur and Kasaragod. The total length of SilverLine alignment is 529.45 km consisting of embankments, tunnels, and viaducts. The salient features of SilverLine project are given in Table 2.1.

Table 2.1 Salient features of Thiruvananthapuram- Kasaragod SilverLine Project

Sl. No.	Description	Details
1	Route Length	529.45 km
2	Gauge	1435 mm (Standard Gauge)
3	Maximum Operational Speed	200 km/h
4	Stations	Thiruvananthapuram at Kochuveli, Kollam, Chengannur, Kottayam, Ernakulam, Kochi Airport, Thrissur, Tirur, Kozhikode, Kannur and Kasaragod
5	Type of Structures	Tunnel – 11.53 km (2.17%), Bridges – 12.99 km (2.44%) Viaducts – 88.41 km (16.61%), Embankments – 292.73 km (55.00%), Cuttings – 101.74 km (19.12%), Cut & Cover – 24.79 km (4.66%)
6	Track Structure	Mostly Ballasted and ballast-less in viaduct & tunnels
7	Maintenance Depots	Workshop at Kollam and Inspection Depot at Kasaragod
8	Train type	EMU type
9	Car body Width	3400mm (max)
10	Seating	2+2 (Business), 3+2 (Standard)
11	Passenger capacity per Train	675 (9 car set)
12	Traction	2x25kV Auto Transformer Type Feeding System Overhead Contact System – simple catenary type

Sl. No.	Description	Details
13	Power Supply	Kerala State Electricity Board supply supplemented by renewable energy supplies
14	Signalling & Train Control System	ETCS level 2 system
15	Communication	LTE with BTN
16	Daily Ridership	79934 in 2025 – 26 (including Airport trips, additional trips due to introduction of city feeder, TOD) increasing to 158946 (including additional trips) in 2052 – 53
17	Train Set	9 cars extendable to 12/15
18	Train operation	37 services in 2025 with peak headway of 20 minutes, increasing to 65 in 2052 with peak headway of 10 minutes
19	Cars requirement	261 in 2025 increasing to 492 in 2052
20	Fare Collection	Automatic Fare collection system with Centralized Computer and other supporting systems
21	Completion time	5 years
22	Capital cost (Rs) (March 2020 price)	49919 Crores
23	Cost with IDC (Rs)	63941 Crores
24	Financing	Debt Rs.33700cr (52.7%), Equity-MoR-Rs.3125cr (4.89%), GoK-Rs.3253cr (5.09%) and other equities-4252cr (6.65%), GoK (land, EIA and R&R)-13362cr (20.90%), Subordinated debt-Gol-Rs.3189cr (4.99%), GoK-Rs.2896cr (4.53%) and balance in IDC-Rs164cr (0.26%)

2.4 Magnitude of Operation

The SilverLine corridor links most of the district headquarters in Kerala. The corridor runs from Thiruvananthapuram, the Capital city to Kasaragod, the northern most district interlinking major industrial cities, such as Kollam, Ernakulam, Thrissur, and Kozhikode on the way. The project will link major tourism destinations of the State that results in high movement of people and goods. According to traffic study report, the daily ridership in the horizon years 2025-26, 2029-30, 2041-42 and 2052-53 were estimated as 79934, 94672, 132944 and 158946 respectively.

Table 2.2 Details of Stations of SilverLine project

Sl. No.	Station Name	Latitude	Longitude	Chainage (km)	Elevated / At grade
1	Thiruvananthapuram	8°30'44.94"N	76°53'50.63"E	0	Elevated
2	Kollam	8°53'44.51"N	76°39'25.56"E	55.338	At grade
3	Chengannur	9°18'28.66"N	76°38'26.37"E	102.900	At grade
4	Kottayam	9°34'33.43"N	76°32'18.74"E	136.108	At grade
5	Ernakulam	10° 0'48.99"N	76°22'36.56"E	195.329	Elevated
6	Kochi Airport	10° 9'21.98"N	76°22'51.02"E	212.318	At grade
7	Thrissur	10°30'31.32"N	76°12'19.67"E	259.117	Elevated
8	Tirur	10°56'46.40"N	75°54'8.66"E	320.562	At grade
9	Kozhikode	11°14'49.70"N	75°46'46.89"E	357.868	At grade
10	Kannur	11°52'19.04"N	75°22'8.96"E	446.095	Underground
11	Kasaragod	12°29'27.51"N	74°59'13.30"E	529.450	At grade

Maintenance Depot Locations

Sl. No.	Depot Name	Latitude	Longitude	Chainage (km)
1	Kollam Depot	8°53'3.23"N	76°38'53.47"E	55.338
2	Kasaragod Depot	12°30'45.59"N	74°58'21.03"E	530.953

2.5.2 Land Requirement

Land required for the alignment (Viaduct, embankment, Cutting, etc.) and for stations together works out to 1383 Ha. This includes 185 Ha of Rly land between Tirur and Kasaragod and between Kochuveli and Murukkumpuzha stations of S. Railway and the balance 1198 Ha of private land. In addition, temporary land will be required for casting depots and for movements of material and machinery vehicles during construction period. Land requirement of SilverLine project is given in Table 2.3 to 2.5.

Table 2.3 Land for Station Area

	Station	Area (ha)	Property	Ownership
1.	Thiruvananthapuram	16.77	Open land	Private
2.	Kollam	53.68	Waterlogged Land	Private
3.	Chengannur	14.18	Open land	Private
4.	Kottayam	15.51	Waterlogged Land	Private
5.	Kochi	16.97	Open land	Private
6.	Thrissur	36.48	Waterlogged Land	Private
7.	Tirur	13.04	Open land	Private
8.	Kozhikode (West Hill)	19.13	Open land	Private
9.	Kannur	13.75	Thinly populated	Private
10.	Kasaragod	46.66	Thinly populated	Private
11.	Total	246		
12.	Government Land	0	Private land	246 ha

Table 2.4 Land Requirement for Alignment

Sl. No	Description	Length (km)	Width (m)	Total Land (Ha)
1.	Viaduct	88.41	15	81.57
2.	Tunnel	11.53	-	-
3.	Bank	292.73	20	673.0
4.	Cut & Bank			Balancing
5.	Cutting	101.74	25	251.25
6.	Cut & Cover	24.79	25-40 m	76.21
			Total	1082.0

Table 2.5 Requirement of Total Permanent Land

Sl. No	Type of alignment	Route Length (Km)	Width of the Land to be acquired (m)	Land area required (Hectares)
1.	Viaduct	88.41	15	81.57
2.	Cut & Cover	24.79	25 to 40 m	76.21
3.	Cut & Bank			Balancing
4.	Tunnel	11.53	-	
5.	Bank	292.73	20	673.0
6.	Cutting	101.74	25	251.25
7.	Approaches of Tunnels & Waterway bridges			
8.	Land of TSS & RSS	-	-	10.9
9.	Land of Emergency Evacuation and S & T etc.			
10.	Station (11 Nos.)			246
11.	Depots (2)			44
Total				1383

2.5.3 Water Requirement

In the Construction Phase – approximately 30 MLD of water will be required and in Operational Phase – approximately 5 MLD water demand is envisaged. The demand will be distributed along the alignment, at the stations, construction camps, maintenance depots, rolling stock, *etc.* and will be sourced from local municipal supply as well as tanker supplied water (as approved by local authorities).

2.6 Project Implementation Schedule

Based on the information disclosure of K-Rail, the project is expected to be commissioned over a period of five years from 2020-21 to 2024-25. All the clearances required for the commencement of construction activities shall be secured before commencement of the construction activities.

2.7 Electrical Power Supply and Traction

Un-interrupted electric power supply is essential for a Semi High Speed Rail system for running trains, Operation Control Centre, tunnel ventilation, station services (lighting, air-conditioning, firefighting and alarm system, lifts and escalators, Signalling and Telecommunications, Depot services (Inspection Shed, Workshop and Pit, wheel lathe, etc.) and other maintenance infrastructure. EHV supply at the voltage level of 220/110 kV must be obtained from the Kerala State Electricity Board Ltd (KSEBL) to the various Receiving/ Traction Substations for train operation and a 33 kV/ 11 kV supply to be obtained from KSEBL, for the operation of auxiliary systems at Stations and Depot. The power supply and Overhead Control System (OCS) is designed to cater the speed of 250 kmph of train services. Traction power supply is proposed to derive from dedicated double circuit transmission line 220 kV /110 kV of state electricity board. The feeding system will be single phase AC 50 Hz, 2x25 kV with Auto transformer (AT) feeding system to suit the semi high-speed train operation (Fig 2.2). Simple catenary systems are used for the operation of SilverLine up to the speed of 250 kmph. The spacing of traction sub stations (TSS) will be approximately 70-100 km. The distance between traction substation (TSS) and Sectioning and paralleling post (SP) will be approximately 35 - 50km and Sub sectioning and paralleling post (SSP) will be placed between SP and TSS. Auto transformer feeding at regular intervals will be provided.

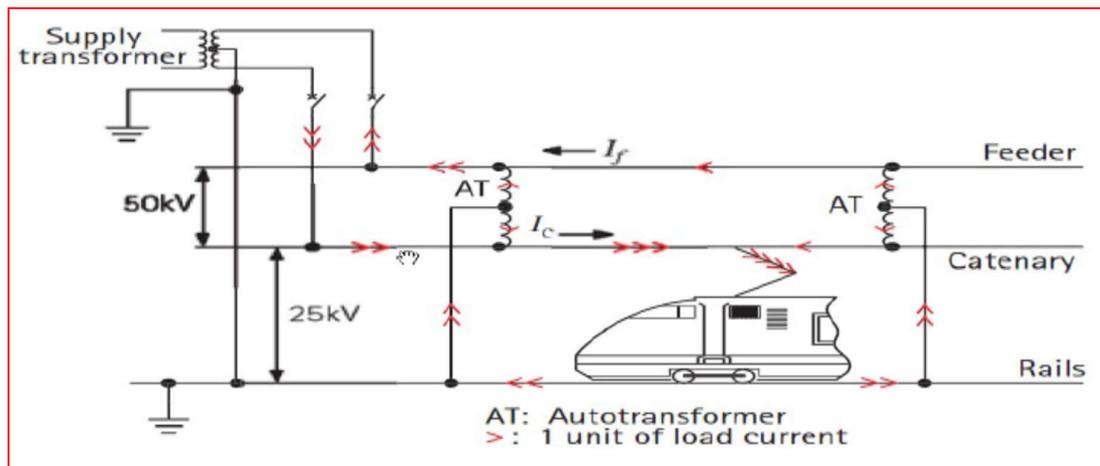


Fig. 2.2. 2x25 kV System with Auto Transformer (AT) Feeding System

Power requirement and energy consumption for the years from 2025 to 2052, considering the traffic level projected and the train operation plan is given in Table 2.6.

Table 2.6 Power requirement and energy consumption for traction and auxiliary

Year	Total Energy Consumption (Traction and auxiliary) in million unit	Power Demand (MVA)
2025-2026	279	104
2032-2033	321	119
2042-2043	427	158
2052-2053	497	184

Source: Systra

2.8 Signaling and Telecommunication

2.8.1 Signaling & Train Control System

ERTMS (European Railway Traffic Management System) Level-2 is the most performant train control system in the world and brings significant advantages in terms of maintenance costs savings, safety, reliability, punctuality and traffic capacity. As per feasibility study, ERTMS Level -2 with LTE is proposed for the SHSR Project. The Signalling & Train Control (ERTMS level-2) description for the Semi High-Speed rail corridor includes ETCS level-2 System; LTE System; Interlocking System (EI/CBI) suitable for ETCS Level-2 and LTE system; Electric Point Machine; Automatic Train Supervision (ATS); Track Vacancy Detection system (Axle counter); Operation Control Centre (OCC) with backup BCC; Fall-Back Block System; and Tunnel Alarm and other Safety System.

2.8.2 Communication System

The Communication system for the SilverLine rail corridor includes the following sub-systems namely LTE System with Radio System and Train borne equipment; Backbone Transmission Network (with SDH and GbEN); Telephone system (IP PBX exchange system); Centralised Digital Recording System (CDRS); Passenger Address System (PAS); Passenger Information and Display System (PIDS); Time Distribution System with GPS system; Closed Circuit Television System (CCTV); and Facility -Supervisory Control and Data Acquisition (F-SCADA).

2.8.3 Ticketing & fare collection System

The ticketing and fare collection system of the proposed SilverLine Rail includes the following subsystems namely Centralized Computer Ticketing System; Station Computer System; Cash Handling equipment's; Automatic Gate with card reader; Ticket Vending Machine (TVM); Ticket office Machine (TOM); Mobile Ticket Machine; Portable Processing unit (PPU); and Mobile ticketing (Scanner & Printer).

2.9 Project Profile: Basic Design Parameters

As Indian Railway is yet to evolve standards for Semi High-Speed Rail Lines, based on standards prevalent on the major railway systems outside India, Standard Gauge has been adopted. The design parameters for Standard Gauge, 1435mm is shown in the Table 2.7.

Table 2.7 General Basic Planning Parameters

Sl. No.	Parameters	Values
1	Design Speed for Passenger Tilting Trains	250 kmph
1 a	Maximum Permissible Speed (System speed or Operation speed or Commercial speed) for Passenger trains	200 kmph
1 b	Maximum Permissible Speed for Freight trains	120 kmph
2	Maximum Static Axle Load for design	25.0 tonnes
2 a	Maximum axle Load for Passenger Coaching stock	16.0 tonnes
2 b	Maximum Axle Load for RORO	22.5 tonnes
3	Spacing of Tracks	4.5 m
4	Maximum width of Rolling Stock	3.4m
5	Gradients	
	5 a - Ruling Gradient	1 in 60 (Continuous steep grade to be limited to a length of 3 kms)
	5 b- Limiting Gradient	1 in 40 (Connecting ramp on non-running on lines)
	5 c- Station Yards	Level for All Stations (except approaches to the non-running lines)

Sl. No.	Parameters	Values
6	Turn-outs	1 in 18 for all the first passenger loops and for RO-RO cum Passenger loop at Kollam connecting the Depot. 1 in 9 for other loops and sidings including RORO.
Horizontal Curves		
7	7 a - Minimum Permissible Radius	1850 m (This permits an operating speed of 200 kmph though the design speed of 220 kmph requires minimum radius of 2200 m. For occasional train running international codes permit relaxation in curvature through acceleration levels permitted. However, in future raising of speed can be further considered with suitable adjustments of cant and cant deficiency if required)
	7 b - Limiting Radius for Station Approaches	650 m (Distance between centre line of Station & end of Curve is to be restricted to 2 Kms) except at Thrissur
8	8 a - Maximum Cant	160mm
	8 b - Maximum Cant Deficiency	100mm (240mm required for Tilting Coaches for 250 kmph while introducing later)
	8 c - Maximum Cant Excess	100mm (To be re-verified when Goods trains are introduced based on stock)
Vertical Curves		
9	9 a- Desirable Radius	17,500 m (As proposed for SilverLine)
	9 b- Limiting Radius	10,000 m
	9 c- Minimum Vertical Curve Length	70 m
10	General Width of Formation	12.00 m
11	Right of Way considered for Permanent Land Acquisition	15 m for Viaduct 25 m for Cuttings 20 m for Embankment and Cut & Cover

Sl. No.	Parameters	Values
12	Tunnel Cross-section Area	80.0 m ² (Minimum width of Tunnel at 2000mm above rail level is 12000mm)
13	Desirable Minimum Gradient in Tunnels and Cuttings	1 in 400 (With summit vertical curve for easy drainage)
14	Minimum Vertical Clearances at Structures	<ul style="list-style-type: none"> i. Above rail level to bottom of structure for New ROBs - 6450mm & Existing ROBs - 5800mm ii. Above rail level to bottom of structure for Cut & Cover - 6450mm iii. Above rail level to intrados of Tunnel - 8000mm at centre of tunnel profile and 7150mm at OHE location iv. Above road level to bottom of structure of NH/SH RUBS- 5500mm (as per IRC SP:84) v. Above road level to bottom of structure of Minor roads - 3500mm vi. Above Ground level to bottom of structure for Pedestrian- 2500mm
15	Platform Length	410m for Class 'A' & 'B' Stations (For Class 'C' stations, it is to be considered at design stage)
16	Type of Traction	2x 25KV AC 50Hz
17	Type of Trains	EMU Train Set with 50% -75% Motoring Axle(approximately) for Passenger trains Loco hauled Freight trains
18	Type of Signalling	ERTMS-2 with LTE
19	Conicity in Rail & Wheel Profile	As per international standards

2.9.1 Track and Line Structural Systems

As per feasibility study, ballasted track is considered except for tunnels for estimate purpose, which will be revised as per decision later during DPR or execution stage. The system proposed is double line track with Standard Gauge 1435mm on PSC sleepers with approved fitting embedded in ballast over designed formation for Embankments and Cuttings and viaduct. The dynamic gauge works out to 1507mm (1435+72). Ballast sample should satisfy the following physical properties in accordance with IS:2386 Pt. IV-1963 when tested. Good drainage gains importance due to higher speed of the trains and high

rainfall in the state. The continuous embankments & viaducts along the corridor shall collect a lot of rainwater like an umbrella and these needs to be properly drained out.

The issue of land acquisition is another important issue which is reflected in the optimum Right of way (ROW) proposed in the Feasibility report. To mitigate this problem, it is proposed to restrict 25m ROW for embankments and cuttings and 15 m ROW for viaducts with 10m extra space during construction. Side road are required during the construction and maintenance of the corridor and will become essential in case of an accident along the corridor. So, road width not less than 4.0 m is considered in the cross section to provide single lane road.

2.9.2 Tunnels, Embankment/ Cuttings and Viaducts/ Bridges,

The alignment has been finalised keeping in focus all the basic technical requirements for the SilverLine with techno and economic considerations. In order to avoid hindrance to the movement of people and vehicles on the roads, highways and streets, boats and ferries in the canals and backwaters, following strategies will be adopted.

Viaduct preferably less than 20 m; Bank height not to be more than 8 m in normal case; Cutting depth up to 9 m normally; Cut and cover has been considered for depth exceeding 9 m and tunnel if the depth is more than 20 m and have adequate cover of 12 m; Proposed formation level kept at least 1m above the HFL. The breakup of the alignment at grade (cutting, banking), elevated, Bridges and underground is given in Table 2.8.

Table 2.8 Details of Tunnels, Bridges, Viaducts, Embankment and Cuttings

SI. No.	Type of Structure	Length (km)	(%) of Route Length
1	Tunnel	11.53	2.17
2	Bridge	12.99	2.44
3	Viaduct	88.41	16.61
4	Embankment	292.72	55.00
5	Cutting	101.74	19.12
6	Cut & Cover	24.79	4.66

Internationally, hollow cylindrical friction piles of large diameters (1.6 to 2.0 m) have been extensively used to cross large stretches of marshy ground on viaducts/bridges. For laying a railway line for 200 kmph train operation, the geometrical tolerances of railway tracks are quite stringent compared to normal mixed traffic lines for 100 to 160 kmph. So, the

performance standards for the settlement of embankments, formation in cuttings, and foundations of viaducts & bridges are also very stringent for such semi high-speed lines.

Tunnels: Tunnels total length 11.53 km has been proposed in the SilverLine Alignment. The tunnels are constructed with NATM Technology.

River Crossings: The SilverLine alignment passes through major rivers at many locations and wetlands at various locations. Bridges totaling length 12.99 km has been proposed in the SilverLine Alignment.

State and National Highway: The SilverLine alignment crosses various National Highways, State Highways, and other district roads, village roads, etc. The SilverLine alignment traverses through road network at these intersections *via* either bridges or viaduct as a dedicated line causing no interference in road traffic movement except during the construction phase.

Viaduct: The SilverLine runs on elevated viaduct in certain portion of the alignment. The viaduct length is approximately 88.41 km. The ground elevation of the viaduct is 9 m and the width is 11 m for dual trackway.

Embankments: The SilverLine runs on Embankments in major portion of the alignment. The Embankments length is approximately 292.73 km.

Embankment where the risk of soil piping problem is likely: Particularly in the northern part of the corridor, piping may occur when water erodes beneath the surface of the ground creating an underground tunnel known as soil pipe. This usually begins as small pores underground and are enlarged with increase erosion. In areas where there are cracks in the soil or areas of less resistance, water will start to move through creating a void. Eventually after constant erosion the surface layer of the ground will not have any support beneath and thus collapse creating a depression. These voids provide an opening for moving water and create ideal situations for soil pipe formation. As more water seeps into the bank, the soil becomes heavier and more likely to break apart making it prone to erosion and failure. Since it occurs beneath the soil it makes it difficult to identify the soil pipe up until the ground has collapsed. Small openings known as flute holes connect the soil pipe to the surface. Soil piping is a natural process, but often human induced activities may result into change in surface and underground water flow and result in increased subsurface erosion and making soil pipe a potential risk. Soil pipe collapse may become a threat to the stability of a railway bank. When considering flood defense, there are always new engineering solutions that can be adopted while constructing embankments next to a river to reduce the effect of soil piping. One of the measures proposed here is driving of sheet

piles of size 1000x 300 mm at 75mm gap for adjusting tilt of 1 in 150, near the side of embankment where the hydraulic gradient is h . The depth of sheet pile below existing ground level is taken as D . Heave piping may occur within $D/2$ on the downstream of sheet pile, as per Terzaghi. Let the average excess hydrostatic pressure at the base of the soil prism of size $D \times D/2$ beyond sheet pile is $0.35h$ (average of the equipotential line, a general value adopted in the book "Soil mechanics and Foundation Engineering" by K. R. Arora).

Now, Upward seepage force, $U = r_w \cdot (0.35 h) (D/2 \times 1)$ per unit length; Downward force due to submerged weight $W' = r' \times (D/2 \times D)$; Keeping the factor of safety with respect to heave piping, $F=2$; $F = W' / U = r'D / (r_w \cdot ha) = (1.76-1) \times D / (1 \times 0.35 h) = 2 \times (D/h)U$; Hence, when $D=h$, there will be a factor of safety of 2. A maximum hydraulic gradient of 4m has been considered in the Fig. 2.3.

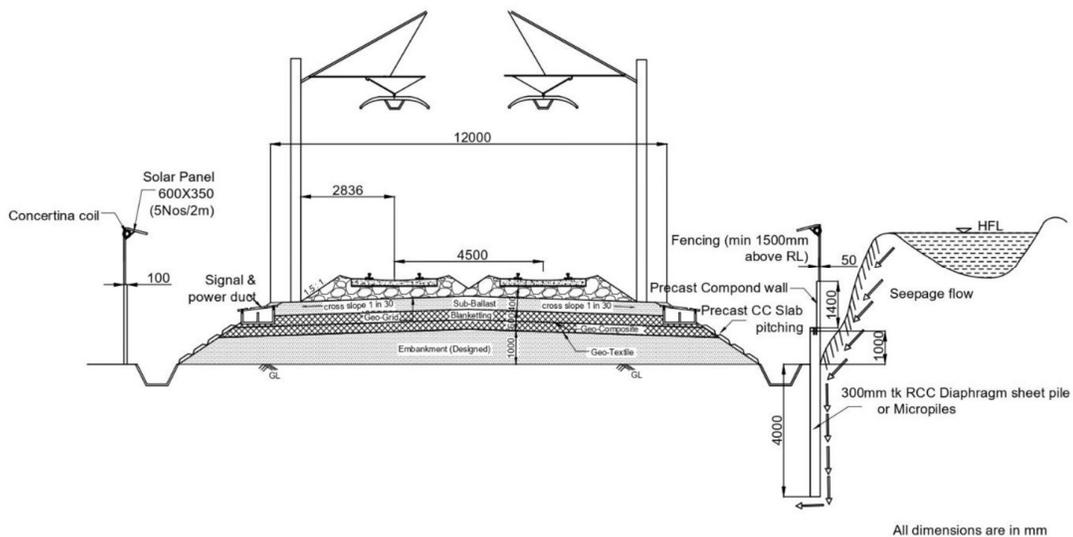


Fig 2.3 Measures with RCC sheet piles against soil piping

Cuttings: The SilverLine runs on Cuttings in 101.74 km of the alignment.

Cut and Cover: The SilverLine runs on Cut and cover on 24.79 km of the alignment.

2.9.3 Rolling Stock Depot

For efficient traffic control, car depots will be set up near ends of corridor, i.e., Kollam & Kasaragod (Table 2.7). Inspection lines planned at both the stations & workshop lines planned at Kollam only.

Table 2.7 Rolling Stock Depot Locations

Sl. No.	Depot Name	Latitude	Longitude	Chainage (km)
1	Kollam Depot	8°53'3.23"N	76°38'53.47"E	55.338
2	Kasaragod Depot	12°30'45.59"N	74°58'21.03"E	530.953

2.10 Rolling Stocks

Rolling Stock is an important asset and proper planning is required in selecting its right type and design. EMU (Electric Multiple Unit) trains are recommended for using in Thiruvananthapuram- Kasaragod Corridor because of the inherent advantages like the better operating parameters and travel time, faster acceleration and deceleration, better adhesion, reduced axle load, more suited for regenerative braking, higher Energy Efficiency etc. In addition, it will enable full use of the floor area of a train for passengers, and thus increase the transportation efficiency. The proposed train set is a 9 (nine) car train, which consists of six motor cars and three trailer cars, designed considering technical features of rolling stock of Thiruvananthapuram- Kasaragod Corridor and to provide adequate frequency of train operations. Train length will be increased up to 12/15 cars from the year 2028 onwards to meet the PHPDT demand by augmentation of suitable multiples of additional motor cars and trailer cars.

Rolling stock technical data and operating parameters	
Track Gauge:	1435 mm
Type of Train:	EMU train set
Maximum operational speed:	200 kmph
Numbers of cars per train:	9 extendable to 12/15 in future
Car body width:	3.4m (maximum)
Car body material:	Aluminium
Power System:	2 x 25 kV AC
Braking system:	Regenerative brake, Electric/ Pneumatic brake blending
Emergency braking distance:	<1800m
Traction circuit & configuration:	VVVF inverter control using IGBT and asynchronous traction motor

Chapter 3

ENVIRONMENTAL BASELINE DATA

3.1 Study Area

This chapter presents information on the existing environmental status in the project corridor of SilverLine spanning from Thiruvananthapuram to Kasaragod covering a length of 529.45 km. For the present EIA study, 500 m on either side of the proposed centre line of the SilverLine project has been considered as the Zone of Influence. For most of the issues involving physical impacts, the study area could be considered as the project “footprint,” or the area that would be directly used for the proposed SilverLine alignment and associated project facilities like construction yard, stations, maintenance depots, tunnel inspection shafts, power sub-stations, various locations proposed for traction power facilities and power connections, *etc.*



The SilverLine alignment of 529.45 km begins at Kochuveli (near Thiruvananthapuram Airport) in Thiruvananthapuram District and runs through Kollam, Pathanamthitta, Alappuzha, Kottayam, Ernakulam, Thrissur, Malappuram, Kozhikode and Kannur districts before entering Kasaragod District. The planned route lies between Latitude 8°30'44.88"N-Longitude 76°53'52.43"E and Latitude 12°29'28.37"N-Longitude 74°59'15.57"E. Collection of baseline information on bio-physical, socio-economic aspects of the project area is a very important initial step for environmental assessment studies. The description of environmental settings includes the characteristic of area in which the activity of project corridor would occur and cover area affected by all environmental impacts. For environmental assessment along the project corridor, information and data have been obtained by intensive site visits, primary data collection, secondary data from published sources, and various government agencies. All ecosystem components have been systematically analysed and presented in this chapter. The present rapid EIA Study was carried out during November 2019 to February 2020.

3.2 Regional Physical Settings

3.2.1 Topography

Kerala, the southernmost State of India lies in between 8°18' and 12°48' N latitude and 74°52' and 72°22' E longitude. Kerala has an undulating topography, from the steep hills of the Western Ghats (with valleys and hills) in the east to the Malabar coast (with plain lands) to the west (Fig. 3.1). The total geographic area of the State is 38,86,300 ha. Kerala borders with Tamil Nadu and Karnataka to its east and north-east, and the Lakshadweep Sea to its west, respectively.

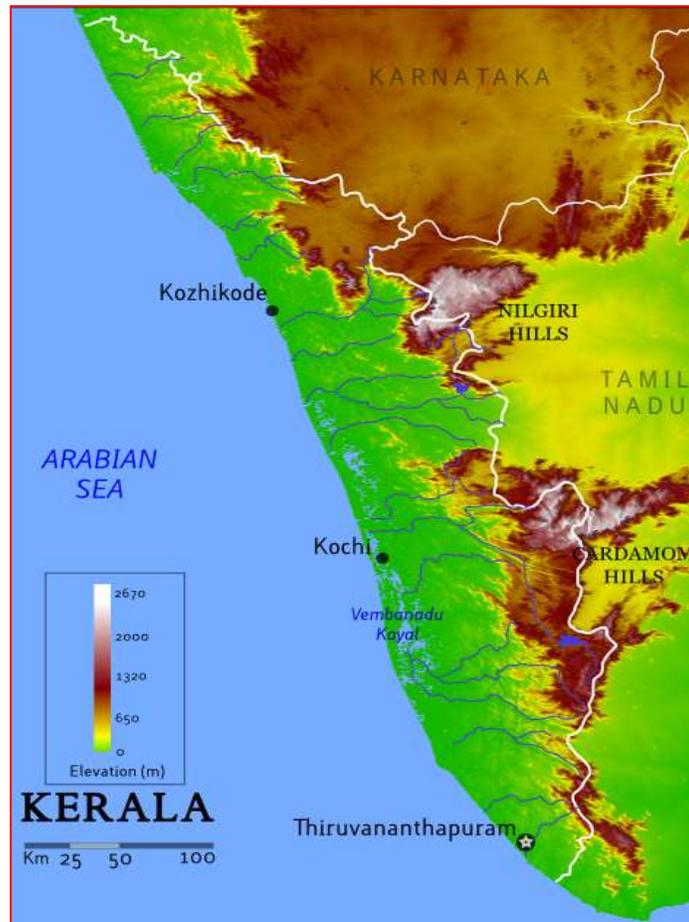


Fig. 3.1 Topographic Map of Kerala

3.2.2 Physiography

There are mainly three broad physiographic divisions in the State, viz., low lands, middle lands and highlands (Fig. 3.2).

The low land (covers 10.24%) is adjacent to the coast and extends up to an altitude of 7.5 m MSL, with extensive coconut groves, paddy fields, and backwaters. The midland region (covers 41.76%) having an undulating topography which extends from 7.5 m to 75 m above MSL, is made up of fertile reddish hills and valleys that grow most of Kerala's agricultural crops. The high land (covers 48% of the State) is on the eastern part consisting of peaks, extensive ridges and ravines of the Western Ghats which extends from 75 m MSL and above.

A physiographic classification, identified mainly in terms of broad geomorphic surfaces and altitudinal characteristics, is also used in the parlance of geographers (CESS, 1984). It has five physiographic zones, namely, high ranges with elevation above 600 m, foothill zone

between 300 to 600 m, upland regions between 100 - 300 m, midland between 20 - 100 m and coastal areas and low land below an altitude of 20 m.

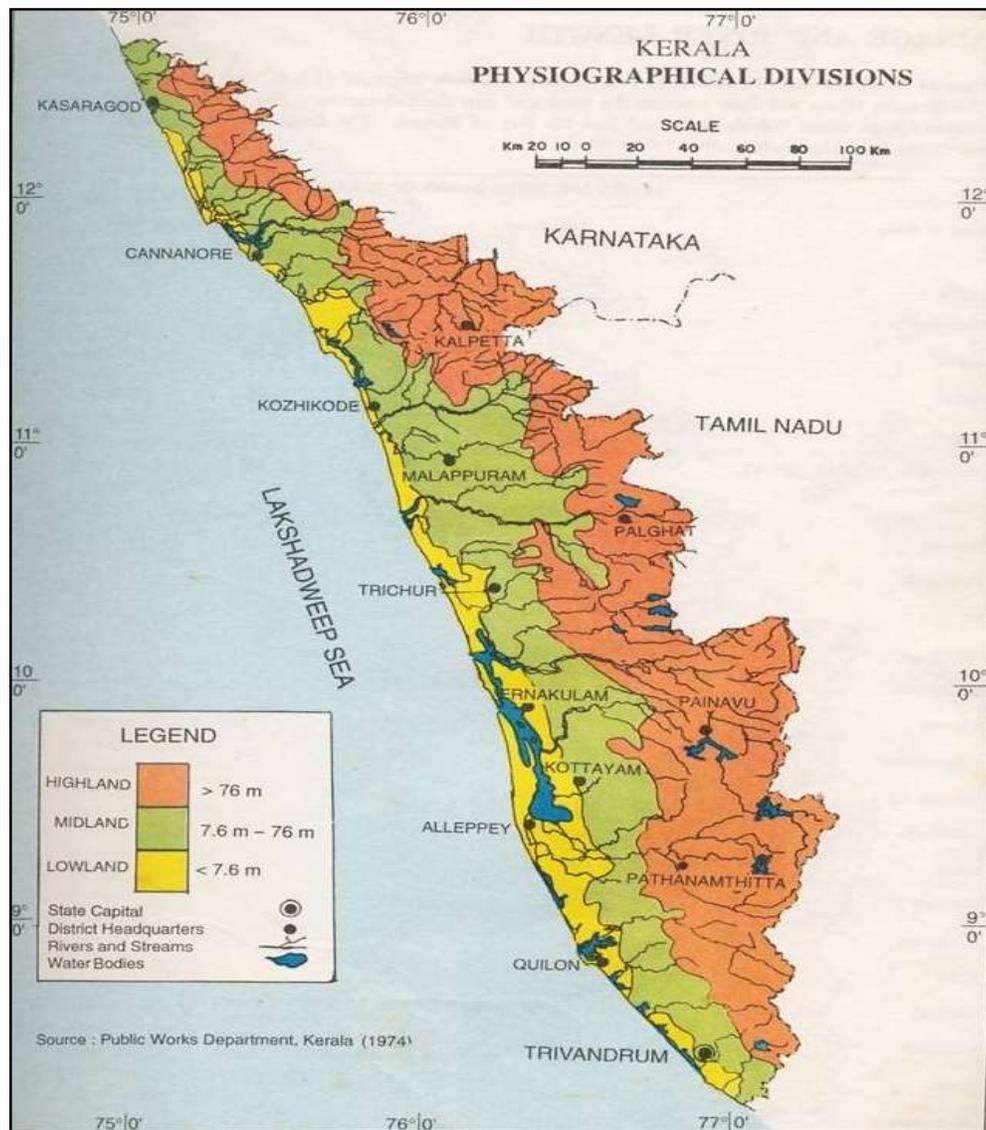


Fig. 3.2 Physiographic Map of Kerala

3.2.3 Drainage Pattern

Of Kerala's 44 rivers, 41 flow westwards and the rest towards east. The basin area of major rivers is located within the Western Ghats, a global biodiversity hotspot, while some other northern rivers originate in laterite hills. The short length of the rivers coupled with very high population density (over 30 million people living in a land area of 38,000km²) creates high dependency on water and the rivers susceptibility towards environmental onslaughts (Fig. 3.3).



Fig. 3.3 Drainage Pattern of Kerala

As per a survey by CWRDM (1988), a total of 236 springs were identified in the state. About 80% of these springs are situated in the eastern side of the Western Ghats belt of the state. District-wise distribution of springs is given in Table 3.1. Most of the springs are formed in the highlands (more than 75 m from MSL).

Table 3.1 District-Wise Distribution of Springs in Kerala

Sl. No.	Name of District	Number of Springs
1.	Kasaragod	8
2.	Kannur	34
3.	Wayanad	24
4.	Kozhikode	46
5.	Malappuram	26

Sl. No.	Name of District	Number of Springs
6.	Palakkad	18
7.	Thrissur	8
8.	Kottayam	22
9.	Idukki	18
10.	Kollam	2
11.	Thiruvananthapuram	30
	Total	236

3.3 Geology & Seismicity

3.3.1 Geology

The geology of Kerala is a part of the south Indian Precambrian terrain, which is composed of granulites, gneisses, granites and greenstones. The granulites and associated gneisses belong to the Precambrian in Kerala state. The younger Meso-Cenozoic dykes and pegmatites are found to intrude late Precambrian rocks. The tertiary sedimentary formations of the land belong to Neogene period only (Soman, 2002). The geology map of Kerala state is shown as Fig 3.4.

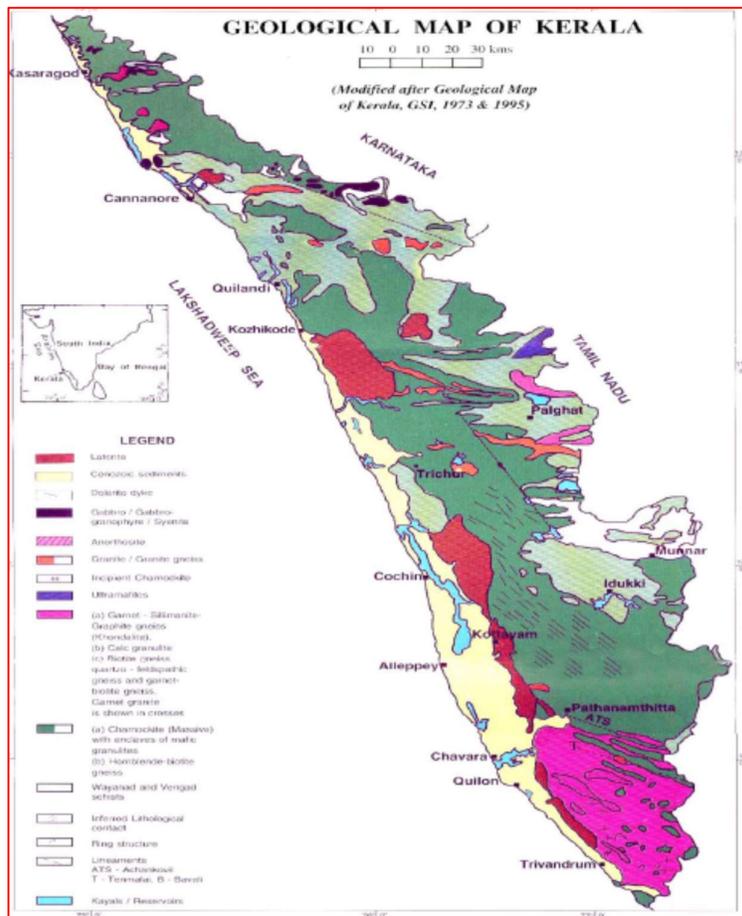


Fig 3.4. Geological Map of Kerala

The Charnockites and charnockitic gneisses are the oldest rock complex units of Kerala state. Charnockitic

gneisses, gneisses and the pyroxene-bearing granulites occupy the major parts of the Western Ghats and the midland regions located within Kerala state. The granulitic gneisses are very well spatially connected with lineaments and faults in Kerala state (Soman, 2002). Khondalites are yet another major rock formation of south Kerala and are associated with garnet-biotite gneiss and garnet ferrous quartzo feldspathic gneiss. The presence of intrusives especially, the dykes, have hydrogeological role to find good zones of water bearing fractures. Intrusive formation dykes of Lower-Middle Proterozoic age, pegmatites of Middle Proterozoic age, host of younger granites (Late Precambrian-early Palaeozoic age) and later dolerite dykes, contemporaneous with Cretaceous-Paleocene Deccan Basalt magmatism, are the common elements seen in granulitic terrain of this state. The western parts of the State consist of sedimentary formations of Neogene period and quaternary period having four distinct beds viz. Alleppey, Vaikom, Quilon and Warkali. In midland regions, the Tertiary and crystalline formations are found as lateritized units. Along the coastal regions, alluvial deposits of recent origin are found. The general Stratigraphic Sequence of Kerala State is presented in Table 3.2.

Table 3.2 General Stratigraphic Sequence of Kerala State

Period	Formation	Lithology
Quaternary	Vembanad formation	Sand, Clay, Molluscan shell beds, riverine alluvium and flood plain deposits, laterite capping the crystalline and Tertiary sediments
Tertiary	Warkalli formation	Sandstone, clay with lignite seams
	Quilon formation	Limestone, marls, clay/ calcareous clays with marine fossils
	Vaikom formation	Sandstone with pebbles and gravels beds, clays and lignite and carbonaceous clay.
Mesozoic to Archean	Intrusive	Veins of quartz, pegmatites, granite, granophyres, dolerite and gabbro.
	Crystalline	Garnet sillimanite gneiss, Hornblende biotite gneiss, garnet biotite gneiss, quartzo-feldspathic gneiss, charnockites, charnockite gneiss, etc.

3.3.2 Seismicity

The earthquake catalogue of the Kerala State indicates that the central part of the state (Wadakkancheri-Trissur and Idukki – Kottayam- Pala) is witnessing repeated seismicity (Fig 3.5). Though lineaments of all directions are identified in Kerala, some NW-SE trending structures are identified as geotectonically active and some of these NW-SE trending structures are even the source of recent seismicity. Some of the fault related geological studies in Peninsular India (Wadakkancheri, Periyar and Thenmala faults) identified

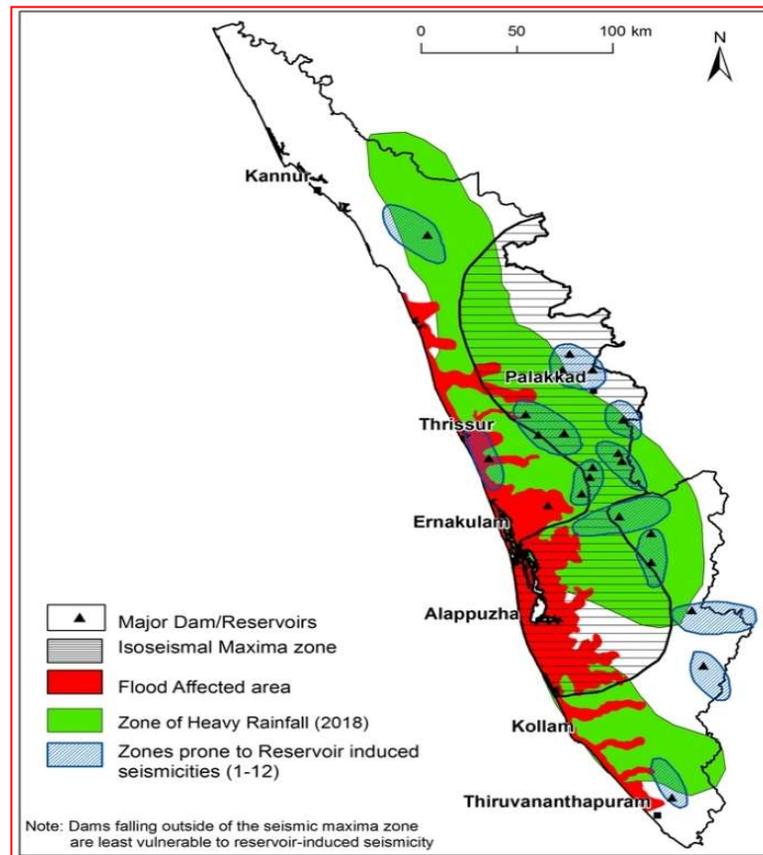


Fig. 3.5 Status of Seismicity in Kerala

that the region is responding to compressive tectonic regime. The slickensides from these faults indicate the recent movements are consistent with the present tectonic stress regime. Though the geological observations and seismological data indicate northeast directed stress regime, the in-situ stress measurement carried out at northern side of the study area shows local perturbation in maximum horizontal stress. Analysis of available seismic data of the region suggest that the seismic source at Idukki-Pala is indicating some recurrence pattern for moderate earthquakes and are spatially located close to the southeastern end of Periyar fault. The seismicity in the Wadakkancheri-Trissur, on the other hand, falls in the northwestern end of Periyar fault. It is also to be noted that the earthquakes in central Kerala were occurring as doublets. Thus, the estimation of earthquake potential of these regions through a proper integration of different disciplines and techniques is the need of the hour.

Kerala has experienced earthquakes since historical times. From 1953, seven earthquakes have occurred in Kerala, as detailed in Table 3.3. In the regional seismic zonation map of India, Kerala has been placed in Zone III where the maximum expected intensity is VIII in MM scale or 5.6 Min Richter scale. Though small and medium earthquakes have occurred

in Kerala region, large earthquakes with casualty are yet to occur. Fig. 3.6 shows the seismic map of Kerala clearly indicating historic & recent earthquakes along with location of major fault & minor lineaments. Higher levels of seismicity are seen in Kottayam – Idukki districts and Thrissur – Palakkad districts. Other districts like Thiruvananthapuram, Kannur and Kozhikode also show moderate levels of seismicity.

Table 3.3 Past Earthquake Incidents in Kerala

Sl. No.	Date	Location	Remarks
1.	8 th February 1900	Coimbatore area of Tamilnadu	Felt over a large section of south India, the largest event during the historical period
2.	27 th April 1901	Off the Kerala Coast	Maximum observed intensity is 5
3.	26 th July 1953	Tekkumuri area, Kerala	Maximum observed intensity 5
4.	October 1964	Kozhikode area, Kerala	Maximum observed intensity 5
5.	7 th June 1988	Kalar- Idukki area	Three events recorded; largest magnitude is 4.5 Ms
6.	12 th December 2000	Idukki- Kottayam area, Kerala	Local magnitude of 5.0 felt strongly in Kochi, Idukki, Kottayam, Alappuzha and Ernakulam
7.	7 th January 2001	Idukki –Kottayam area, Kerala	Felt though out the Tamil Nadu, local magnitude of 4.8
8.	2 nd Sep 2001	North Indian Ocean	Felt in the city of Thiruvanthapuram in Kerala
9.	28 th Oct 2001	Laccadive Sea	Magnitude 4.4

Seismic hazard pockets of higher ground acceleration have identified in central Kerala. In this region, higher levels of earthquake hazard are expected calling for the introduction of better building practices. Experience shows that sudden release of accumulated strain energy along planes of weakness in the earth's crust can generate large earthquakes and no region is safe from earthquakes. In Kerala, several deep-seated faults exist, the notable among them are Periyar fault, Idmalayar fault, Muvattupuzha fault, Bhavali fault and Kuthuparamba fault. Besides, there are many more minor faults and fractures that can generate tremors as a result of crustal re-adjustment. Minor tremors in Kerala are also explained by hydro-sismicity model where in pressure transients generated due to sudden increase in hydrostatic heads especially after rains results in increased pore pressure and movement along pre-existing faults.

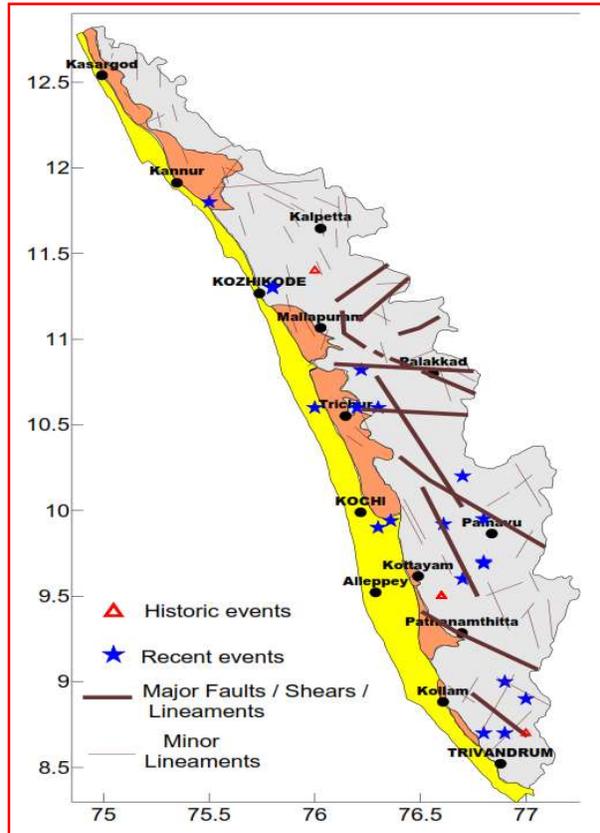


Fig. 3.6 Location of Earthquake in Kerala

3.4 Soil

Kerala is endowed with a variety of soils due to the climate, topography, and vegetation characteristics. Laterite and loams form the major soil types of Kerala. The other soil types developed as a result of agro-climatic variations include riverine and coastal alluvium, black soils, and problem soils like acid saline, hydromorphic and grayish Onattukara (Fig 3.7).

Laterite Soil: Majority of area comprises this type of soil. Heavy rainfall and high temperature are conducive for laterization. Laterite are poor in available Nitrogen and Phosphorous, low in waterholding capacity and cation exchange capacity (CEC).

Coastal Alluvial Soil: Seen in the coastal tracts along the west, they have been developed from recent marine deposits. More permeability, low organic matter content, low CEC and less Water holding capacity characterizes the coastal alluvial soil.

Riverine Alluvial Soil: Seen along the banks of rivers, shows wide variation in physio-chemical properties

depending on the nature of alluvium and the characteristic of the catchment area through which the river flows. Organic Matter, N and K are moderate.

Red Soil: The red colour of soil is due to the presence of Fe_2O_3 , mainly localized in southern parts of Thiruvananthapuram. The soil is almost homogeneous. Acidity ranges from 4.8 to 5.9. The gravel content is comparatively less & low in essential nutrients and organic matter.

Forest Soil: A product of weathering of crystalline rocks under forest cover. Rich in organic carbon. pH acidic. Rich in N and poor in P.

Black Soil: is found in some areas of Palakkad district. These soils are developed on Khondalite suite of rocks traversed by lenticular bands of crystalline limestone and calc-granulites. These soils are very deep, black and calcareous.



Fig. 3.7 Soil Types of Kerala

the coastal stretches of Kerala have shown long term erosion with nest loss of land. The eroding sectors along the Kerala coast having nine districts are given in Table 3.4.

Table 3.4 Eroding Sectors along the Kerala Coast

District	Length		Length		Length	
	km	%	km	%	km	%
	High (without Seawall)		High (with Sea wall)		Low	
Thiruvananthapuram	11.9	15.86	15.66	20.88	30.84	41.11
Kollam	1.14	2.34	37.77	77.58	0.91	1.86
Alappuzha			29.98	37.84	3.7	4.67
Ernakulam			33.39	69.02		
Thrissur	2.58	3.43	17.37	23.16	0.98	1.3
Malappuram			15.4	31.63	6.44	13.23
Kozhikode			35.4	44.68	8.47	10.69
Kannur			9.33	14.27	17.38	26.58
Kasargod	1.3	1.47	4.34	4.93	28.31	32.15
Total	16.91	3.02	198.63	35.47	97.02	17.33

3.5.4 Tsunami

The Tsunami of 26 December 2004 added new dimension to the disaster profile of the state. Although tsunami affected parts of Kerala coast, maximum devastation was reported in the low coastal land of Kollam, Allapuzha and Ernkulam districts, particularly a strip of 10km in Azhikkal, Kollam district. The tsunami waves attained heights of 3 to 5 m and inundated the coastal areas at different times. This varying effect along the caost could be attributed to local amplification of tsunami waves in certain regions.

3.5.5 Floods

Reclamation and settlement in floodplain areas is a major cause of flood damage in Kerala. The flood prone areas of the state are depicted in Fig 3.9. Study by CESS (2010) shows that 5642.68 km² of area (14.52% of the total Area of the State) is prone to floods.

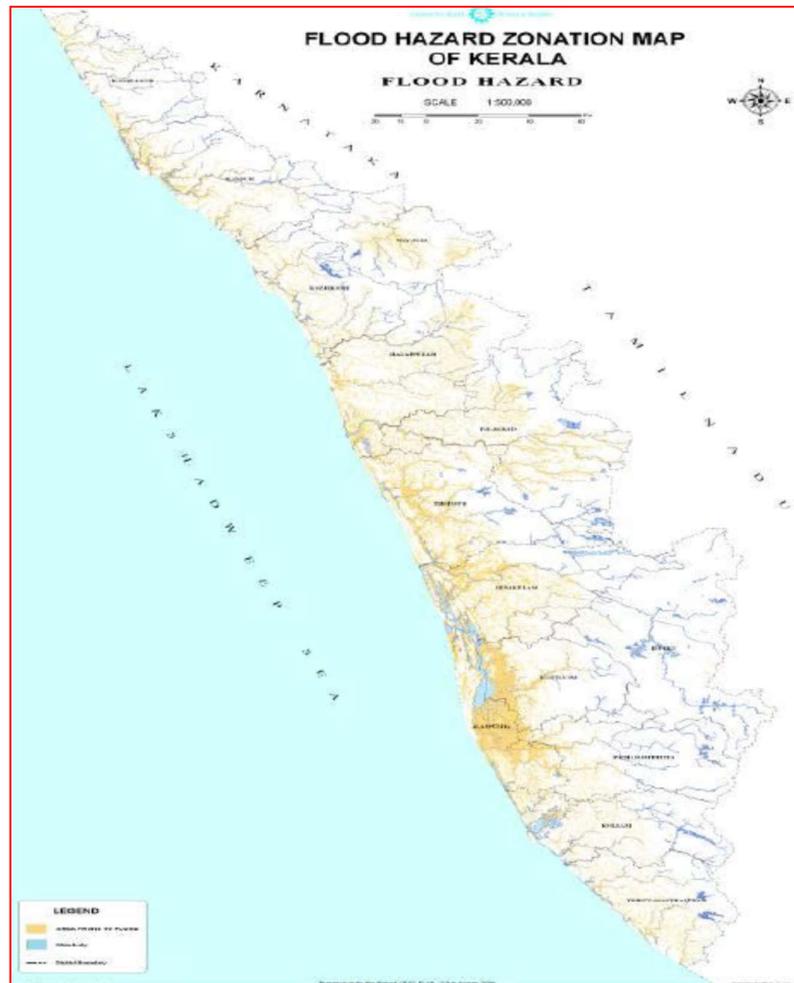
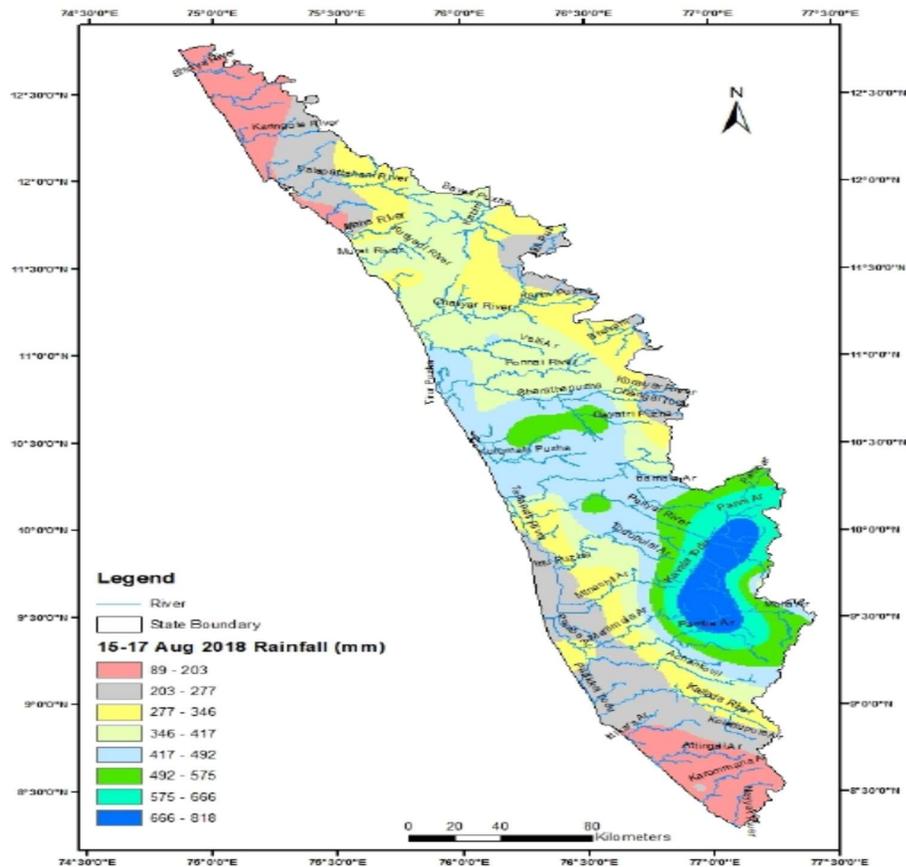


Fig. 3.9 Flood Hazard Zonation of Kerala

However, in the Month of June-August 2018, Kerala experienced an abnormally high rainfall which resulted in severe flooding in 13 out of 14 districts in the State, resulted in loss of over 483 lives, displaced more than a million people and caused a loss of about Rs.310 billion. As per IMD data, Kerala received 2346.6 mm of rainfall from 1st June 2018 to 19th August 2018 in contrast to an expected 1649.5 mm of rainfall (~42% above the normal). Further, the rainfall over Kerala during June, July and 1st to 19th of August was 15%, 18% and 164% respectively, above normal (Fig 3.10). It is the worst flood happened in the State after the great flood of 1924. 2019, in the Month of June and July experienced inadequate rains, followed by a burst of intense rains in the early weeks of August, causing floods and landslides in the northern districts of Kerala.



Source: Study Report Kerala Floods of August 2018, p 43, Central Water Commission 2018

Fig. 3.10. 3 days cumulative rainfall 15-17 Aug, 2018

The satellite images released by the National Aeronautics and Space Administration (NASA) before and after the 2018 August flood is shown below (Fig. 3.11). The images below showed the most-affected regions of Pathanamthitta, Alappuzha and Kottayam districts, indicating the alarming level of inundation.



Fig. 3.11 Satellite images by NASA before and after the 2018 August flood in Kerala

During June-August 2018, the state received cumulative rainfall that was 42% in excess of the normal average. The heaviest spell of rain was during 1-20 August, when the state received 771mm of rain, which forced the release of excess water from 37 dams across the state, aggravating the flood impact (Fig. 3.12).

3.5.6 Landslides

The highland region of Kerala characterized by rugged hills and steep slopes (>25° slope) on which rests the soil and earth materials and is prone to landslides. The most common type of landslides in Kerala is debris flows (Fig. 3.13). The torrential rains during 1-20 August, 2018 triggered several landslides in the State. Again, in the early weeks of August 2019, there was a burst of intense rains, causing landslides in the northern districts.

3.5.7 Lightning

Lightning is a common weather phenomenon in Kerala and on an average about 70 people die in the State due to lightning every year. The Cb clouds usually form and produce lightning in the State usually in the months of April & May and again in October & November. Analysis of the 17 years data (1986 to 2002) indicated that 83% of the lightning events happened between 3 pm and 5 pm. The frequency and distribution of lightning incidence is more in the midlands of Kerala (Fig. 3.14).

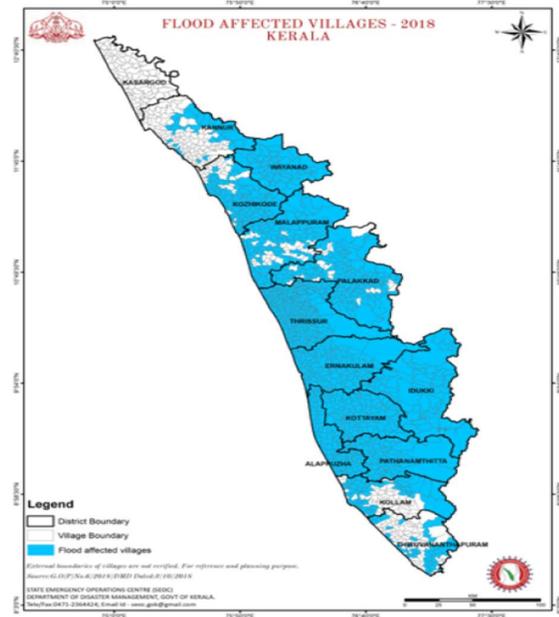


Fig. 3.12 Flood affected villages in Kerala, Aug 2018

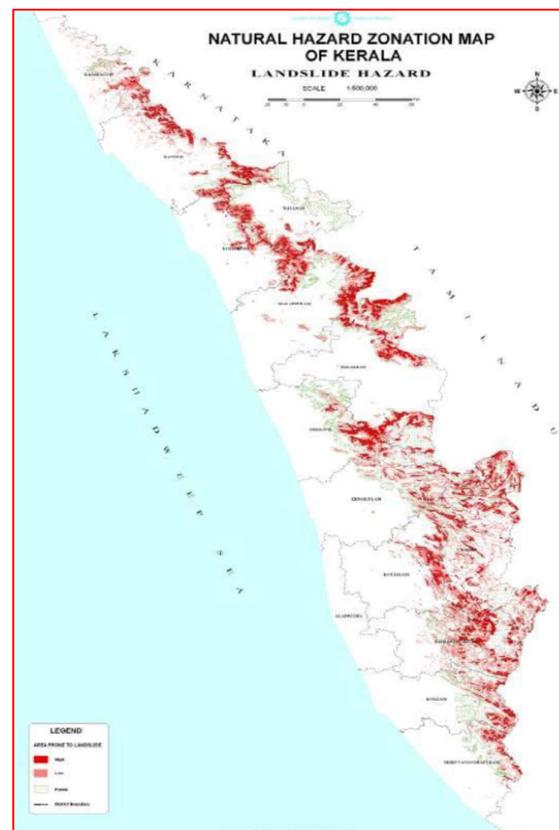


Fig 3.13 Landslide Hazard, Kerala

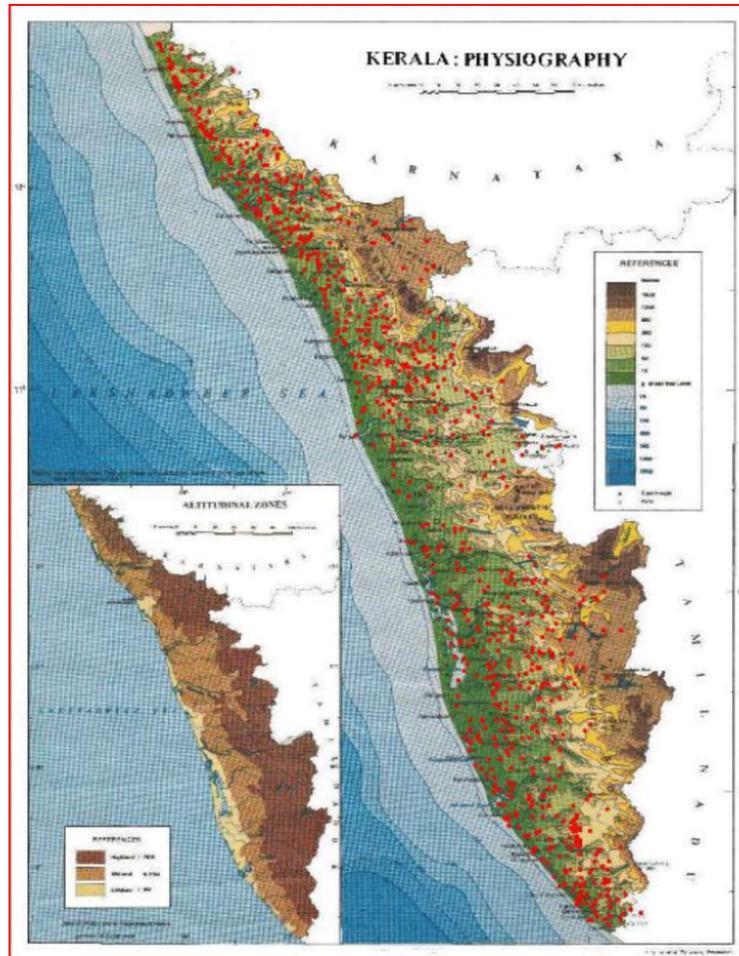


Fig. 3.14 Lightning hits plotted over Physiography

3.6 Climate and Meteorology

Kerala State experiences a uniform climate with respect to its physiographic location. No distinct winter and summer season are experienced in the State and the seasonal variation of temperature and relative humidity are not significant. The frequency and intensity of rainfall cause drainage and flooding problems in the region.

3.6.1 Temperature

In Kerala, the mean maximum daily temperature in the coldest month (January) rarely falls below 21° C and in the summer season (March to May) reaches 37-38° C. December, January and February represent winter months with daily mean minimum temperature around 18°C and daily mean maximum temperature around 28°C. March till May is the summer season in Kerala with daily mean maximum temperature at 36°C and daily mean minimum temperature at 32°C. The rainy season in Kerala is the Southwest monsoon (June

to September). During monsoon daily mean maximum and minimum temperature recorded around 30°C and 19°C respectively.

3.6.2 Relative Humidity

As the State stretches from north to south with the Arabian Sea in its west, relative humidity is in general high over the State. In the period January to March afternoon humidity reduce to 60-63%, varying from 35% in the interior to 71 % in the coastal area. The diurnal variation in relative humidity during this period 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. The variation in this period is minimum.

3.6.3 Rainfall

In Kerala, the southwest monsoon normally occurs in early June and usually 70-85 % of the total annual rainfall occurs during June, July, August and September (Fig 3.15). The northeast monsoon normally occurs in the month of October and November.

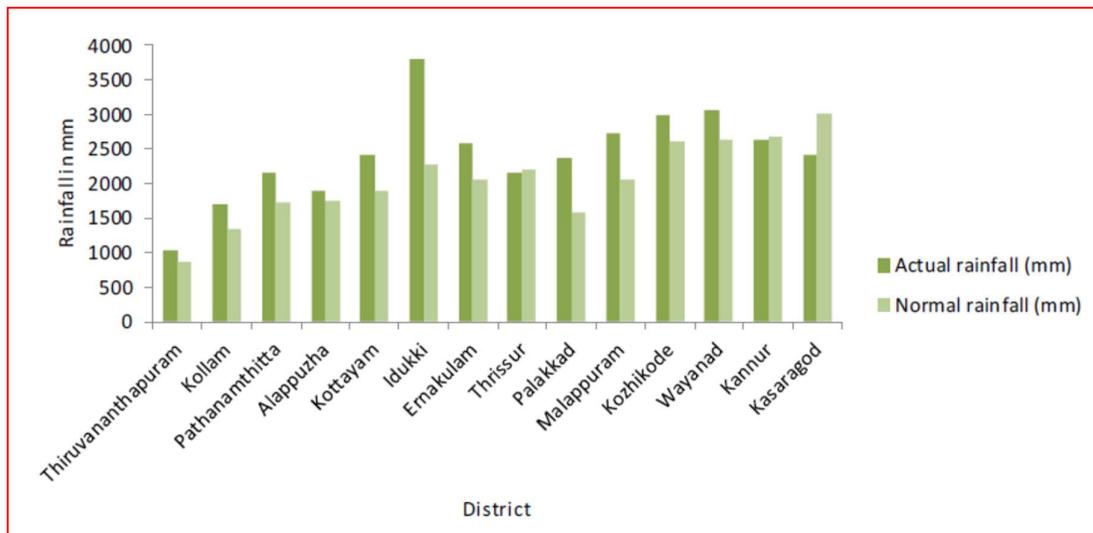


Fig. 3.15 SW Monsoon rainfall received from June 1 to Sep 30, 2018

The monthly average rainfall recorded in the districts of Kerala from 2014 to 2018 is presented in the following Tables (Tables 3.5 to 3.18). The district Rainfall (R/F) are the arithmetic averages of rainfall of the stations under the district.

Table 3.5 Rainfall (in mm) for the year 2014-2018 – Thruvananthapuram District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	45.8	13.1	35.1	136.4	272.6	142.4	118.7	458.6	189.4	288.3	128.6	83
2015	9.6	0.4	50.6	257.3	336.8	358.7	60.6	71.4	307.1	367	275.8	156.8
2016	3.2	3.7	19	58.1	429.1	395	119.4	42.2	15.7	43.4	47.2	21.8
2017	5	0	85	54.2	228.3	318.8	52.9	123	269.3	241.4	274.7	151.2
2018	9.2	13.1	19.3	79	267.7	355.9	237.5	373.8	56.5	207.9	207.7	31.3

Table 3.6 Rainfall (in mm) for the year 2014-2018 – Kollam District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	0.5	15.7	51.4	151.7	290.8	283.5	287.9	591.5	260	386.6	151.7	40.1
2015	7.7	32.9	34.6	279	226.4	411.7	185	141.1	255.8	386	307.6	68.6
2016	1	50.3	55.3	67.3	384.4	508.5	262.8	136.7	42.9	188.9	198.2	19.7
2017	21.5	1.3	147.6	137.7	356.8	532.5	128.5	282.4	412.2	322.5	369	258.5
2018	3.5	8.6	110.7	128.3	246.7	459.2	485.4	644.1	117.7	317.9	163	22.4

Table 3.7 Rainfall (in mm) for the year 2014-2018 – Pathanamthitta District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	2.9	35.8	36.4	287	295.1	415.6	429.4	778.7	289.6	401.2	94.6	77.2
2015	7.8	18.3	76	477	177	369.6	186.1	269.1	347.8	546.4	336	79.1
2016	0.5	4.6	70	123.3	427.4	459.4	344.8	211.7	79.5	224.1	193.9	7.8
2017	30.9	0	314.5	100	260.1	553.7	204.8	454.3	541.2	427	389.3	76
2018	4.7	42.7	109.8	223.2	433.8	558.2	672	764.9	169.2	615.9	209.9	78.8

Table 3.8 Rainfall (in mm) for the year 2014-2018 – Alappuzha District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	0.2	23.3	32.7	143.8	250.6	362.8	355.6	615.3	227.6	311.0	93.8	52.3
2015	3.2	5.2	98.9	237.2	177.8	474.5	235.7	188.6	238.4	375.9	189.7	120.4
2016	5.9	56.0	45.6	24.6	296.0	524.0	365.6	165.6	79.6	124.0	63.4	21.0
2017	29.9	0.9	86.2	40.3	287.9	544.7	280.4	323.5	438.5	226.2	195.2	63.5
2018	1.5	14.8	40.3	105.5	309.2	567.1	650.2	608.2	72.8	326.6	154.5	65.7

Table 3.9 Rainfall (in mm) for the year 2014-2018 – Kottayam District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	11.1	18.7	45.2	145.3	303.6	496.8	490.9	805.1	313.4	468.4	156.5	94.8
2015	9.1	4.4	131.7	301.7	239.9	615.5	306.8	293.1	374.1	402.9	203	122
2016	11.5	43.7	72.5	56.5	318.7	630.6	431.1	198.6	70.4	154	90.7	7.7
2017	27.8	0.2	128.3	58.2	315.9	654	342.3	450.3	482.4	287.3	267.4	79.1
2018	0.2	5.1	38.3	245.1	403.1	814.3	921.6	617.1	54.1	389.5	344.2	65.2

Table 3.10 Rainfall (in mm) for the year 2014-2018 – Idukki District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	7.9	14.1	27.1	86.8	237.2	493	898.7	904.7	410.4	421.6	127.1	54.4
2015	1.4	14.4	78.4	280.6	165.9	644.9	436.3	271.3	344	253.6	248.1	127.6
2016	5.1	5.1	26.4	39.1	292.7	586.3	540.8	322.6	119.8	117.1	37.9	19.1
2017	12.8	1.1	122.2	71.1	210	517.9	293.4	713.1	534.5	285.3	117.1	91
2018	1.8	41.5	52.6	134.8	356	806.4	1296	1478.9	212.4	325.6	194.3	6.5

Table 3.11 Rainfall (in mm) for the year 2014-2018 – Ernakulam District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	0	11.1	22.4	90.7	287.9	550.1	650.2	877	298.8	434.8	118.5	94
2015	2.4	0.5	37.2	229.3	176.2	573.9	367.2	241.2	393.8	355	332.5	182.3
2016	0.4	91.4	3.4	43.8	322.8	624.6	620.4	238.7	85.7	160.5	115.1	19.5
2017	16.8	0	97.9	31.4	306	706.3	435.4	415.8	445.3	293	217.8	28.1
2018	1.4	7.1	52.5	193.2	324.9	833.5	1044.2	648.4	63.1	402.7	246.9	56.6

Table 3.12 Rainfall (in mm) for the year 2014-2018 – Thrissur District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	0	5.9	3.2	47.7	250	455.6	560	672.2	259.9	407.9	94.1	21.1
2015	0.9	0	38.4	139.5	188.4	622.1	463.2	277.5	314.3	274.4	183.3	91.9
2016	10.8	4	6.2	37.2	257.5	588.4	422.2	148.7	60.3	98.2	8.3	45.6
2017	1.4	0	43.6	12.9	175.7	674.8	419.3	427.2	354.7	188	113	15.5
2018	0	3.7	26.9	30.9	347.1	629.3	732.8	734.7	49.9	274.2	51.9	7.5

Table 3.13 Rainfall (in mm) for the year 2014-2018 – Palakkad District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	0	3.1	5.2	36.4	190.8	314	602.2	561.4	230.6	282.5	40.2	12.1
2015	0	2	27.1	184.2	245.6	455.2	281.8	219.2	199.3	141.8	185.8	43.2
2016	0.2	0	4.2	4.1	169.2	461.5	336.6	159.2	77.4	88.2	21.7	27.6
2017	0	0	83.1	28.3	139.5	433.2	317.2	398	375.6	102.8	35.2	38.9
2018	0	25.7	47	73.5	353.6	679.9	776.9	848.8	72.3	227.7	37.9	1.1

Table 3.14 Rainfall (in mm) for the year 2014-2018 – Malappuram District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	1.1	0.5	0	49.8	236.4	542.1	856.8	615.9	297.4	371.1	121.3	40.7
2015	0	0	37.2	167	187.2	593.8	411.5	264	266.8	291.8	232	36.3
2016	0	1.8	2.6	4.7	154.5	585.2	406.5	186.3	73.2	87.1	14.8	16.3
2017	4	0	29.4	26.6	122.9	568.8	427	459.7	472.7	211.1	95.6	37.1
2018	0	5.9	19.1	105.4	403.6	860.8	888.4	914.5	59.9	277	110.9	13

Table 3.15 Rainfall (in mm) for the year 2014-2018 – Wynad District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	0	5.9	3.2	47.7	250	455.6	560	672.2	259.9	407.9	94.1	21.1
2015	0.9	0	38.4	139.5	188.4	622.1	463.2	277.5	314.3	274.4	183.3	91.9
2016	10.8	4	6.2	37.2	257.5	588.4	422.2	148.7	60.3	98.2	8.3	45.6
2017	1.4	0	43.6	12.9	175.7	674.8	419.3	427.2	354.7	188	113	15.5
2018	0	3.7	26.9	30.9	347.1	629.3	732.8	734.7	49.9	274.2	51.9	7.5

Table 3.16 Rainfall (in mm) for the year 2014-2018 – Kozhikode District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	0	0	0.8	90.7	254.4	508.2	1068.2	879	318.3	331.6	105.6	9.3
2015	0	0	35.3	90.5	189.5	667.9	780.5	256.9	290.1	351.3	199.3	8.8
2016	0	0	32.4	5.7	260.1	916.4	604.2	268.5	98.2	42.5	8.9	23.2
2017	7.7	0.1	21.3	68.1	251.8	822.5	662.9	544.6	491.6	216.2	46.1	9.1
2018	7.7	0.9	36.9	79	563	1081.8	1037.4	836	29.3	267.8	57.5	35

Table 3.17 Rainfall (in mm) for the year 2014-2018 – Kannur District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	2.3	8.4	0	23.2	253.4	634.2	1027.2	876	325	256.8	97.4	29.6
2015	5	0	12.3	93.9	172.5	696.6	803	352.9	317.2	331.5	167.3	28.6
2016	0	0	0.8	1	138.4	801.8	616.1	436.5	136.6	45.1	22	17.3
2017	11.5	0	6.1	48.2	181.2	694.3	623.6	553	430.4	170.9	69.4	5.9
2018	2	0	12.6	86.2	346.1	975.3	969.5	685.4	11.9	256	25.6	23

Table 3.18 Rainfall (in mm) for the year 2014-2018 – Kasaragod District

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2014	0	0	0	15.4	243.4	595.3	747.1	979.4	398.5	311.8	27	24.7
2015	0.9	0	36.3	117.7	151.8	549.3	846.5	432.7	203.6	296	92.1	19.1
2016	2.9	0.5	0	0.1	138.3	945.5	719	455.8	132.7	23.8	21.7	25.7
2017	18.1	0	0	15.5	71.8	858.7	752.8	702.8	331.4	126.2	39.5	14.4
2018	0	4.8	26	81.9	331	972.4	780.9	636.9	36.1	145.9	42.4	20.2

3.6.4 Wind

In Kerala, the distribution pattern of calm days indicates that the inland stations experience more calm days due to the sheltering effects of the Western Ghats. The wind speed is highest during the south-west monsoon, the direction being from the northwest. The average wind speed during south west monsoon (June to Sept) period is 35 km/h, frequently raising up to 45 to 55 km/h. In general, the wind speed decreases from November to April. Generally, wind from the north east and east prevails in the morning (8.30 hrs), while in the afternoon (1730 hrs) it is from the west and northwest. This is clearly attributable to the effects of land and sea breezes. The average wind speed during North East monsoon (October to December) prevails around 20 km/h. During the cyclonic period wind speed often exceeds 100km/h.

3.7 Air Environment

3.7.1 Air Quality

Air Quality Index is a tool for effective communication of *air quality* status to people in terms, which are easy to understand. In the Indian context, the Air Quality Index is based on measurement of particulate matter (PM_{2.5} and PM₁₀), Nitrogen Dioxide (NO₂), and Sulfur Dioxide (SO₂). Ambient air quality is being monitored by Pollution Control Board (PCB) for Sulphur Dioxide (SO₂), Nitrogen Dioxides (NO₂) and Respirable Suspended Particulate Matter (RSPM), at various industrial and residential locations in different districts. Fine particles (PM_{2.5}) pose greatest health risk and exposure to these particles can affect a person's lungs and heart. Coarse particles (PM₁₀).

AQI Key	
Air Quality Index (AQI) Values	Levels of Health Concern
0-50	Good
51-100	Moderate
101-150	Unhealthy for Sensitive Groups
151-200	Unhealthy
201-300	Very Unhealthy
301-500	Hazardous

2.5) are of less concern, although they can irritate a person's eyes, nose and throat (USEPA, 2018). Hence CPCB eliminated SPM in ambient air from the standard in November 2009. Average Air Pollution Index (API) values excluding SPM in different districts of Kerala during 2011-2016 is given in Table 3.19.

Table 3.19 Average API values excluding SPM in different districts of Kerala (2011-2016)

Sl. No.	Districts	API excluding SPM	Inference
1	Thiruvananthapuram	52.76	Moderate air pollution
2	Kollam	37.07	Light air pollution
3	Pathanamthitta	24.28	Clean air
4	Alappuzha	29.8	Light air pollution
5	Kottayam	58.04	Moderate air pollution
6	Idukki	17.72	Clean air
7	Ernakulam	44.39	Light air pollution
8	Thrissur	40.24	Light air pollution
9	Palakkad	29.66	Light air pollution
10	Malappuram	30.88	Light air pollution
11	Kozhikode	41.15	Light air pollution
12	Wayanad	27.55	Light air pollution
13	Kannur	36.53	Light air pollution
14	Kasaragod	32.19	Light air pollution

Source: Water and Air Quality Directory published by KSPCB

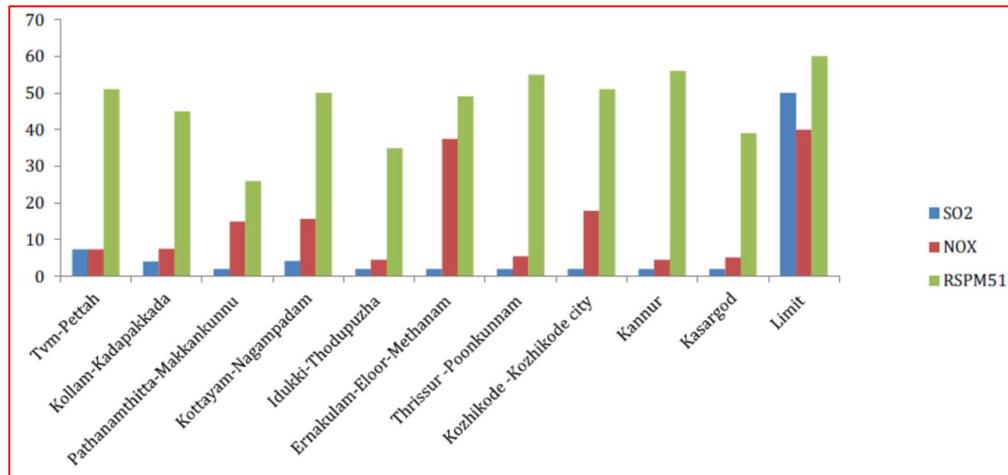


Fig 3.16 Annual average values of air pollutants at 10 monitoring stations in residential areas of Kerala 2017 (Source: KSPCB)

Air quality in India is governed by the National Ambient Air Quality Standards (NAAQS) formulated under the Air (Prevention and Control of Pollution) Act, 1981. A baseline study of Ambient Air Quality was conducted by the study team to establish the existing air quality and to compare with the NAAQS. The major sources of anthropogenic air pollution in a region are vehicular traffic, industrial emissions, domestic fuel burning, construction and demolition activities etc. The prime objective of the baseline air quality monitoring is to establish the existing representative ambient air quality along the project corridor. This will also be useful for assessing the incremental impact and conformity to standards of the ambient air quality specified by CPCB due to the construction and operation of the SilverLine project.

To establish baseline air quality 10 monitoring locations were identified along the proposed alignment, where the stations are planned. The air quality monitoring has been carried out according to the 16th November, 2009 Notification. At all the monitoring stations PM_{2.5}, PM₁₀, SO₂, NO₂ and CO were monitored on 24 hourly bases with frequency of twice a week. The ambient air quality monitoring was conducted in November 2019 – February 2020 (post monsoon season in Kerala) at 10 locations during baseline survey to assess the ambient air quality status along the proposed alignment.

The details of Ambient Air Quality sampling locations along with the ambient air quality for the sites are presented in the tables below. The data collected were subjected to statistical analysis to arrive at maximum, minimum and average value. The results were compared with NAAQS to find out whether any of the measured parameters exceeded the prescribed limits. The spatial variation of Ambient Air Quality in the state based on the IDW model is also attached.

Ambient air quality never exceeded the limits of NAAQS in any of the measured locations. Air quality parameters showed variations in sections of rail alignment where it is passing through urban areas particularly due to existing traffic and industries. During the construction phase exposure of soil will occur due to movement of vehicles, due to foundation works for elevated bridges, cutting, and embankments. Based on the soil analysis the average silt percentage is very low in the Southern Regions of the alignment from Kochuveli to Ernakulam. But from Thrissur to Kasragod the slit percent was at medium level and showed an average of 20.4%. The maximum slit percentage was 30 % and the minimum value 11%. Hence it is anticipated that dust will be produced during construction work. Due to operation of construction machinery and movement of construction vehicles gaseous as well as particulate emissions will be increased. Since the emissions are of fugitive in nature it will not be long lasting and will subside after the construction phase. Adequate measures like wetting the surface of roads during the construction phase to be undertaken to control the emission of dust. Air quality will not be affected during the operation of the semi high speed trains as it uses electric power and hence no gaseous and particulate emissions. At the stations there can be chances of increase in emissions due to increased vehicular traffic and hence monitoring of air quality to be done regularly. Description of Ambient Air Quality monitoring locations of the present study is given in Table 3.20 (See Annexure 5). The results of the ambient air sampling and measurements made during the present study are given in Table 3.21 to Table 3.30; and Fig 3.17 to Fig 3.21.

Table 3.20 Description of Ambient Air Quality Monitoring Locations

	Name of Location	Coordinates	Description of site
1	Kochuveli, Thiruvananthapuram	8°30'42.5" N; 76°54'05.2" E	Commercial area and is near to NH (>30m). Busy commercial area
2	Mulakuzha, Kollam	8°54'05.6" N; 76°39'37.0"E	Paddy field surrounded by Residential area.
3	Edanadu, Chengannur	9°20'20.6"N 76°38'36.3" E	Paddy field surrounded by Residential area
4	Muttambalam, Kottayam	9°34'50.32" N 76°32'32.1" E	Commercial cum residential area and by the side of a road with heavy traffic.
5	Info park, Kakkanad, Ernakulam	10°00'51.9" N 76°21'49.7" E	Commercial area surrounded by industries like KRL, FACT& other small-scale units.
6	Thrissur	10° 31' 36.9" N 76° 13' 52.7" E	Residential area.
7	Tirur	10° 55' 33.8" N 75° 54' 57.7" E	Near to railway track, residential area
8	Kozhikode	11° 15' 37.7" N 75° 46' 20.8" E	Residential area
9	Kannur	11° 52' 42.2" N 75° 22' 20.1" E	Business and office complex
10	Kasaragod	12° 29' 11.5" N 74° 59' 26.6" E	Near to a main road, Residential area

Table 3.21 Ambient Air Quality, Kochuveli, Thiruvananthapuram

Date of sampling	Measured Parameters	PM10 ($\mu\text{g}/\text{m}^3$)	PM2.5 ($\mu\text{g}/\text{m}^3$)	SO ₂ ($\mu\text{g}/\text{m}^3$)	NO ₂ ($\mu\text{g}/\text{m}^3$)	CO (mg/m^3)
	*Limit as per NAAQS	100 ($\mu\text{g}/\text{m}^3$)	60 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	4 (mg/m^3)
14.11.2019		67.59	29.37	7.17	12.19	0.36
16.11.2019		55.67	27.05	**BDL(MDL-4)	9.21	0.38
19.11.2019		57.83	24.88	8.49	14.75	0.4
22.11.2019		67.87	31.88	**BDL(MDL-4)	13.68	0.36
26.11.2019		64.38	34.44	**BDL(MDL-4)	10.9	0.34
29.11.2019		63.53	27.96	**BDL(MDL-4)	13.34	0.38
03.12.2019		65.25	28.13	**BDL(MDL-4)	12.15	0.34
06.12.2019		64.63	25.05	**BDL(MDL-4)	10.86	0.39
10.12.2019		64.07	26.5	**BDL(MDL-4)	13.24	0.37
13.12.2019		58.05	25.37	**BDL(MDL-4)	10.1	0.36
17.12.2019		67.92	27.3	**BDL(MDL-4)	13.83	0.39
20.12.2019		60.73	25.08	**BDL(MDL-4)	11.33	0.32
24.12.2019		66.81	29.78	**BDL(MDL-4)	15.25	0.38
27.12.2019		61.41	26.37	**BDL(MDL-4)	10.89	0.34
31.12.2019		66.95	31.77	**BDL(MDL-4)	10.89	0.36
03.01.2020		59.44	24.14	**BDL(MDL-4)	9.9	0.34
07.01.2020		67.68	31.98	**BDL(MDL-4)	10.61	0.38
10.01.2020		63.59	29.53	**BDL(MDL-4)	13.08	0.33
14.01.2020		58.43	22.26	**BDL(MDL-4)	10.38	0.35
17.01.2020		65.53	28.76	**BDL(MDL-4)	11.56	0.39
21.01.2020		58.87	20.85	**BDL(MDL-4)	8.55	0.33
24.01.2020		63.98	28.55	**BDL(MDL-4)	10.64	0.38
26.01.2020		61.79	25.33	**BDL(MDL-4)	9.95	0.36
28.01.2020		59.05	24.46	**BDL(MDL-4)	11.47	0.37
	Average	62.96	27.37	<4	11.61	0.36
	Maximum	67.92	34.44	8.49	15.25	0.40
	Minimum	55.67	20.85	<4	8.55	0.32
Percentage of observations above the Limit		Nil	Nil	Nil	Nil	Nil

*Permissible Limit in Ambient Air as per National Ambient Air Quality Standards (NAAQS) for Industrial, Residential, Rural & Other Areas, measured at the site for 24 hours.

** BDL – Below Detectable Limit (MDL- 4 $\mu\text{g}/\text{m}^3$ for SO₂ & MDL- 6 $\mu\text{g}/\text{m}^3$ for NO₂)

Table 3.22 Ambient Air Quality, Kollam

Date of sampling	Measured Parameters	PM10 ($\mu\text{g}/\text{m}^3$)	PM2.5 ($\mu\text{g}/\text{m}^3$)	SO ₂ ($\mu\text{g}/\text{m}^3$)	NO ₂ ($\mu\text{g}/\text{m}^3$)	CO (mg/m^3)
	*Limit as per NAAQS	100 ($\mu\text{g}/\text{m}^3$)	60 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	4 ($\mu\text{g}/\text{m}^3$)
11.11.2019		35.45	14.28	**BDL(MDL-4)	9.84	0.3
14.11.2019		30.26	13.65	<4	3.98	0.33
16.11.2019		40.62	17.25	<4	12.03	0.35
19.11.2019		41.67	18.17	<4	16.34	0.32
22.11.2019		37.26	15.78	<4	11.05	0.3
26.11.2019		36.73	11.13	<4	13.48	0.26
29.11.2019		38.82	14.69	<4	12.47	0.29
03.12.2019		30.47	13.19	<4	10.58	0.31
06.12.2019		43.89	17.77	7	13.67	0.36
10.12.2019		31.45	12.33	<4	6.04	0.34
13.12.2019		33.14	11.63	<4	10.74	0.32
17.12.2019		38.31	15.04	<4	10.1	0.34
20.12.2019		30.02	12.4	<4	10.8	0.31
24.12.2019		39.55	17.77	<4	9.08	0.35
27.12.2019		35.35	16.59	<4	13	0.34
31.12.2019		30.73	14.52	<4	12.15	0.32
03.01.2020		43.75	18.63	<4	7.18	0.36
07.01.2020		44.68	22.03	<4	**BDL(MDL-6)	0.38
10.01.2020		32.97	12.25	<4	9.57	0.36
14.01.2020		39.13	15.98	<4	10.41	0.35
17.01.2020		41.53	19.73	<4	6.74	0.33
21.01.2020		38.19	17.21	<4	10.2	0.36
24.01.2020		33.27	12.56	<4	9.08	0.34
28.01.2020		39.31	16.95	<4	11.1	0.37
	Average	36.94	15.48	<4	9.98	0.33
	Maximum	44.68	22.03	7	16.34	0.38
	Minimum	30.02	11.13	<4	**BDL(MDL-6)	0.26
	Percentage of observations above the Limit	Nil	Nil	Nil	Nil	Nil

*Permissible Limit in Ambient Air as per National Ambient Air Quality Standards (NAAQS) for Industrial, Residential, Rural & Other Areas, measured at the site for 24 hours.

** BDL – Below Detectable Limit (MDL- 4 $\mu\text{g}/\text{m}^3$ for SO₂ & MDL- 6 $\mu\text{g}/\text{m}^3$ for NO₂)

Table 3.23 Ambient Air Quality, Chengannur

Date of sampling	Measured Parameters	PM10 ($\mu\text{g}/\text{m}^3$)	PM2.5 ($\mu\text{g}/\text{m}^3$)	SO ₂ ($\mu\text{g}/\text{m}^3$)	NO ₂ ($\mu\text{g}/\text{m}^3$)	CO (mg/m^3)
	*Limit as per NAAQS	100 ($\mu\text{g}/\text{m}^3$)	60 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	4 (mg/m^3)
11.11.2019		38.47	10.51	**BDL(MDL-4)	**BDL(MDL-6)	0.31
14.11.2019		34.35	15.05	<4.0	<6.0	0.32
16.11.2019		27.04	13.46	<4.0	<6.0	0.33
19.11.2019		33.68	8.21	<4.0	<6.0	0.32
22.11.2019		44.33	22.59	<4.0	<6.0	0.31
26.11.2019		40.04	16.15	<4.0	<6.0	0.32
29.11.2019		29.52	13.93	<4.0	<6.0	0.34
03.12.2019		26.44	7	<4.0	<6.0	0.31
06.12.2019		41.77	19.63	<4.0	<6.0	0.34
10.12.2019		43.02	19	<4.0	<6.0	0.32
13.12.2019		44.95	21.66	<4.0	<6.0	0.33
17.12.2019		32.66	13.56	<4.0	<6.0	0.32
20.12.2019		31.9	14.18	<4.0	<6.0	0.31
24.12.2019		28.56	10.1	<4.0	<6.0	0.3
27.12.2019		43.3	21.46	<4.0	<6.0	0.33
31.12.2019		30.24	15.07	7.02	<6.0	0.32
03.01.2020		37.08	16.16	<4.0	<6.0	0.31
07.01.2020		33.58	15.13	<4.0	<6.0	0.33
10.01.2020		38.68	16.63	<4.0	<6.0	0.32
14.01.2020		40.71	20.16	7.15	<6.0	0.33
17.01.2020		43.59	21.89	<4.0	<6.0	0.36
21.01.2020		38.39	16.76	<4.0	<6.0	0.33
24.01.2020		41.79	18.18	<4.0	<6.0	0.34
28.01.2020		35.55	13.03	7.17	<6.0	0.32
	Average	36.65	15.81	<4.0	<6.0	0.32
	Maximum	44.95	22.59	7.17	<6.0	0.36
	Minimum	26.44	7	<4		0.3
Percentage of observations above the Limit		Nil	Nil	Nil	Nil	Nil

*Permissible Limit in Ambient Air as per National Ambient Air Quality Standards (NAAQS) for Industrial, Residential, Rural & Other Areas, measured at the site for 24 hours.

** BDL – Below Detectable Limit (MDL- 4 $\mu\text{g}/\text{m}^3$ for SO₂ & MDL- 6 $\mu\text{g}/\text{m}^3$ for NO₂)

Table 3.24 Ambient Air Quality, Kottayam

Date of sampling	Measured Parameters	PM10 ($\mu\text{g}/\text{m}^3$)	PM2.5 ($\mu\text{g}/\text{m}^3$)	SO ₂ ($\mu\text{g}/\text{m}^3$)	NO ₂ ($\mu\text{g}/\text{m}^3$)	CO (mg/m^3)
	*Limit as per NAAQS	100 ($\mu\text{g}/\text{m}^3$)	60 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	4 (mg/m^3)
11.11.2019		73.2	33.85	6.99	16.42	0.36
14.11.2019		71.29	30.44	7.11	14.66	0.38
15.11.2019		73.3	32.15	10.5	15.7	0.39
19.11.2019		64.77	26.64	14.23	16.99	0.36
22.11.2019		59.16	27.02	7.3	14.53	0.35
26.11.2019		80.54	37.1	17.39	24.15	0.42
29.11.2019		73.96	35.97	10.76	22.31	0.4
03.12.2019		78.61	34.33	14.02	20.53	0.39
06.12.2019		65.27	26.83	10.42	18.85	0.37
10.12.2019		62.87	31.63	24.32	15.9	0.35
13.12.2019		69.84	30.98	10.56	22.93	0.38
17.12.2019		76.19	34.32	13.88	23.85	0.39
20.12.2019		66.77	26.74	10.79	22.12	0.38
24.12.2019		70.09	30.96	10.85	18.21	0.36
27.12.2019		80.27	35.42	17.83	20.89	0.41
31.12.2019		63.11	25.95	7.05	12.49	0.34
03.01.2020		60.17	24.17	11.07	19.42	0.33
07.01.2020		61.18	26.77	14.07	16.54	0.38
10.01.2020		72.86	33.14	17.49	18.22	0.36
14.01.2020		65.1	29.85	10.38	18.53	0.4
17.01.2020		68.68	30.64	14.12	20.17	0.36
21.01.2020		58.21	25.7	10.79	13.53	0.34
24.01.2020		56.85	22.41	7.23	14.39	0.35
28.01.2020		55.16	24.53	7.16	12.43	0.36
	Average	67.81	29.90	11.93	18.07	0.37
	Maximum	80.54	37.1	24.32	24.15	0.42
	Minimum	55.16	22.41	6.99	12.43	0.33
Percentage of observations above the Limit		Nil	Nil	Nil	Nil	Nil

*Permissible Limit in Ambient Air as per National Ambient Air Quality Standards (NAAQS) for Industrial, Residential, Rural & Other Areas, measured at the site for 24 hours.

** BDL – Below Detectable Limit (MDL- 4 $\mu\text{g}/\text{m}^3$ for SO₂ & MDL- 6 $\mu\text{g}/\text{m}^3$ for NO₂)

Table 3.25 Ambient Air Quality, Ernakulam

Date of sampling	Measured Parameters	PM10 ($\mu\text{g}/\text{m}^3$)	PM2.5 ($\mu\text{g}/\text{m}^3$)	SO ₂ ($\mu\text{g}/\text{m}^3$)	NO ₂ ($\mu\text{g}/\text{m}^3$)	CO (mg/m^3)
	*Limit as per NAAQS	100 ($\mu\text{g}/\text{m}^3$)	60 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	4 (mg/m^3)
09.11.2019		32.84	13.67	**BDL(MDL-4)	9.84	0.32
12.11.2019		33.57	11.73	6.97	6.81	0.34
15.11.2019		28.15	10.56	<4	12.45	0.31
19.11.2019		27.26	8.31	<4	8.16	0.35
22.11.2019		27.95	11.43	<4	10.64	0.30
26.11.2019		32.99	12.30	<4	13.79	0.32
29.11.2019		48.43	15.86	6.90	11.74	0.36
03.12.2019		39.85	10.64	<4	10.62	0.34
06.12.2019		26.69	11.74	7.03	9.92	0.35
10.12.2019		45.93	10.76	7.05	13.25	0.37
13.12.2019		29.26	11.35	6.88	14.68	0.36
17.12.2019		35.37	12.45	<4	12.27	0.38
20.12.2019		29.20	12.19	<4	10.10	0.32
24.12.2019		37.83	17.07	<4	9.13	0.30
27.12.2019		31.87	14.64	<4	10.69	0.33
31.12.2019		32.35	13.34	<4	13.36	0.32
03.01.2020		38.22	18.08	<4	14.71	0.34
07.01.2020		43.92	14.30	<4	11.64	0.30
10.01.2020		36.95	10.22	<4	9.78	0.31
14.01.2020		44.20	18.28	<4	11.63	0.34
17.01.2020		30.08	11.65	<4	8.30	0.32
21.01.2020		25.19	13.36	<4	9.07	0.32
24.01.2020		29.11	14.46	<4	8.08	0.31
28.01.2020		33.98	16.55	<4	7.66	0.3
	Average	34.22	13.12	<4	10.76	0.33
	Maximum	48.43	18.28	7.05	14.71	0.38
	Minimum	25.19	8.31	<4	6.81	0.3
Percentage of observations above the Limit		Nil	Nil	Nil	Nil	Nil

*Permissible Limit in Ambient Air as per National Ambient Air Quality Standards (NAAQS) for Industrial, Residential, Rural & Other Areas, measured at the site for 24 hours.

** BDL – Below Detectable Limit (MDL- 4 $\mu\text{g}/\text{m}^3$ for SO₂ & MDL- 6 $\mu\text{g}/\text{m}^3$ for NO₂)

Table 3.26 Ambient Air Quality, Thrissur

Date of sampling	Measured Parameters	PM10 ($\mu\text{g}/\text{m}^3$)	PM2.5 ($\mu\text{g}/\text{m}^3$)	SO ₂ ($\mu\text{g}/\text{m}^3$)	NO ₂ ($\mu\text{g}/\text{m}^3$)	CO (mg/ m ³)
	*Limit as per NAAQS	100 ($\mu\text{g}/\text{m}^3$)	60 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	4 (mg/ m ³)
12.11.2019		62.30	33.20	5.20	6.80	0.60
19.11.2019		59.30	26.20	4.80	7.20	0.80
21.11.2019		51.20	24.60	6.30	8.20	0.90
25.11.2019		54.10	27.80	**BDL(MDL-4)	7.20	0.70
28.11.2019		49.60	20.10	5.80	6.20	0.90
02.12.2019		50.70	23.70	8.70	10.20	0.70
05.12.2019		48.50	21.40	6.10	8.10	0.90
09.12.2019		56.20	32.40	5.50	6.40	1.10
12.12.2019		54.30	30.20	4.10	7.20	0.90
16.12.2019		52.30	31.70	5.30	6.10	0.80
19.12.2019		52.60	29.60	5.50	6.60	0.80
23.12.2019		58.60	29.60	4.80	6.80	0.80
26.12.2019		56.30	31.20	5.20	7.10	0.70
30.12.2019		54.30	27.10	<4	7.30	0.90
02.01.2020		49.80	23.40	5.60	6.20	0.80
06.01.2020		51.30	22.40	4.30	7.80	0.60
09.01.2020		57.40	27.70	4.00	6.30	0.70
13.01.2020		51.80	24.30	5.70	7.00	0.60
16.01.2020		48.60	24.10	4.20	8.10	0.40
20.01.2020		50.70	26.30	<4	6.40	0.70
23.01.2020		54.3	26.3	4.6	6.5	0.9
27.01.2020		51.2	24.8	<4	6.1	0.8
30.01.2020		50.1	24.1	4.6	**BDL(MDL-6)	0.6
03.02.2020		49.6	21.2	5.1	6.5	0.7
	Average	53.13	26.39	5.27	7.06	0.76
	Maximum	62.3	33.2	8.7	10.2	1.1
	Minimum	48.5	20.1	<4	**BDL(MDL-6)	0.4
	Percentage of observations above the Limit	Nil	Nil	Nil	Nil	Nil

*Permissible Limit in Ambient Air as per National Ambient Air Quality Standards (NAAQS) for Industrial, Residential, Rural & Other Areas, measured at the site for 24 hours.

** BDL – Below Detectable Limit (MDL- 4 $\mu\text{g}/\text{m}^3$ for SO₂&MDL- 6 $\mu\text{g}/\text{m}^3$ for NO₂)

Table 3.27 Ambient Air Quality, Tirur

Date of sampling	Measured Parameters	PM10 ($\mu\text{g}/\text{m}^3$)	PM2.5 ($\mu\text{g}/\text{m}^3$)	SO ₂ ($\mu\text{g}/\text{m}^3$)	NO ₂ ($\mu\text{g}/\text{m}^3$)	CO (mg/m^3)
	*Limit as per NAAQS	100 ($\mu\text{g}/\text{m}^3$)	60 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	4 (mg/m^3)
12.11.2019		48.6	26.3	5.2	6.1	0.9
19.11.2019		42.5	22.4	4.6	6.4	0.6
21.11.2019		46.3	21.6	<4	6.9	0.4
25.11.2019		40.7	19.8	6.3	**BDL(MDL-6)	0.3
28.11.2019		38.9	18.6	5.1	7.2	0.6
02.12.2019		43.2	20.7	**BDL(MDL-4)	<6	0.7
05.12.2019		41.7	18.7	<4	<6	0.7
09.12.2019		49.6	24.3	5.5	<6	0.7
12.12.2019		48.7	23.6	5.4	6.0	0.6
16.12.2019		47.5	18.7	7.2	<6	0.5
19.12.2019		46.3	16.3	4.1	6.6	0.6
23.12.2019		50.3	26.1	4.6	6.3	0.8
26.12.2019		47.2	25.3	5.2	6.7	0.6
30.12.2019		49.6	24.1	4.3	<6	0.6
02.01.2020		46.2	22.1	5.7	6.3	0.7
06.01.2020		46.3	23.4	<4	<6	0.8
09.01.2020		48.7	26.7	5.1	6.7	0.7
13.01.2020		47.2	24.3	5.7	7.2	0.9
16.01.2020		44.1	21.0	6.3	6.4	0.8
20.01.2020		40.2	20.1	<4	<6	0.6
23.01.2020		50.3	26.1	4.6	6.3	0.7
27.01.2020		47.2	25.3	5.2	6.7	0.6
30.01.2020		49.6	24.1	4.3	<6	0.8
03.02.2020		46.2	22.1	5.7	6.3	0.7
	Average	46.13	22.57	4.17	<6	0.66
	Maximum	50.3	26.7	7.2	7.2	0.9
	Minimum	38.9	16.3	<4	<6	0.3
	Percentage of observations above the Limit	Nil	Nil	Nil	Nil	Nil

*Permissible Limit in Ambient Air as per National Ambient Air Quality Standards (NAAQS) for Industrial, Residential, Rural & Other Areas, measured at the site for 24 hours.

** BDL – Below Detectable Limit (MDL- 4 $\mu\text{g}/\text{m}^3$ for SO₂&MDL- 6 $\mu\text{g}/\text{m}^3$ for NO₂)

Table 3.28 Ambient Air Quality, Kozhikode

Date of sampling	Measured Parameters	PM10 ($\mu\text{g}/\text{m}^3$)	PM2.5 ($\mu\text{g}/\text{m}^3$)	SO ₂ ($\mu\text{g}/\text{m}^3$)	NO ₂ ($\mu\text{g}/\text{m}^3$)	CO (mg/m^3)
	*Limit as per NAAQS	100 ($\mu\text{g}/\text{m}^3$)	60 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	4 (mg/m^3)
16.11.2019		48.9	22.7	4.8	6.9	0.9
19.11.2019		46.3	20.7	5.3	**BDL(MDL-6)	0.8
21.11.2019		48.7	21.3	**BDL(MDL-4)	<6	0.7
25.11.2019		49.6	21.6	<4	7.2	0.6
28.11.2019		35.6	18.4	7.1	6.6	0.8
02.12.2019		39.8	10.3	6.2	<6	0.8
05.12.2019		41.7	16.2	<4	<6	0.4
09.12.2019		50.3	30.2	5.5	<6	0.8
12.12.2019		47.4	20.6	5.3	<6	0.7
16.12.2019		46.5	19.8	4.1	6.0	0.8
19.12.2019		47.4	20.1	<4	<6	0.6
23.12.2019		52.3	29.8	<4	6.3	0.7
26.12.2019		51.3	24.6	4.8	<6	0.6
30.12.2019		49.8	23.7	4.6	6.8	0.5
02.01.2020		52.4	27.4	4.1	7.2	0.4
06.01.2020		47.2	23.4	<4	6.2	0.8
09.01.2020		54.2	26.3	<4	6.7	0.7
13.01.2020		52.3	30.1	4.9	6.8	0.9
16.01.2020		47.2	21.3	5.6	7.1	0.4
20.01.2020		53.6	21.7	5.2	<6	0.8
23.01.2020		54.3	27.4	5.2	7.2	0.8
27.01.2020		48.7	23.1	4.6	6.5	0.7
30.01.2020		51.2	24.6	<4	<6	0.8
03.02.2020		49.8	21.3	<4	6.3	0.6
	Average	48.60	22.78	<4	<6	0.69
	Maximum	54.3	30.2	7.1	7.2	0.9
	Minimum	35.6	10.3	<4	<6	0.4
Percentage of observations above the Limit		Nil	Nil	Nil	Nil	Nil

*Permissible Limit in Ambient Air as per National Ambient Air Quality Standards (NAAQS) for Industrial, Residential, Rural & Other Areas, measured at the site for 24 hours.

** BDL – Below Detectable Limit (MDL- 4 $\mu\text{g}/\text{m}^3$ for SO₂ & MDL- 6 $\mu\text{g}/\text{m}^3$ for NO₂)

Table 3.29 Ambient Air Quality, Kannur

Date of sampling	Measured Parameters	PM10 ($\mu\text{g}/\text{m}^3$)	PM2.5 ($\mu\text{g}/\text{m}^3$)	SO ₂ ($\mu\text{g}/\text{m}^3$)	NO ₂ ($\mu\text{g}/\text{m}^3$)	CO (mg / m ³)
	*Limit as per NAAQS	100 ($\mu\text{g}/\text{m}^3$)	60 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	4 (mg / m ³)
14.11.2019		40.2	24.1	4.6	6.2	0.9
20.11.2019		39.6	18.6	5.2	**BDL(MDL-6)	0.8
22.11.2019		46.5	19.5	**BDL(MDL-4)	<6	0.6
26.11.2019		43.2	21.3	<4	<6	0.8
29.11.2019		41.2	19.5	5.1	7.1	0.6
03.12.2019		48.6	19.8	<4	<6	0.8
06.12.2019		39.7	15.4	5.9	<6	0.7
10.12.2019		42.3	18.9	<4	6.6	0.8
13.12.2019		45.3	20.8	5.5	<6	0.7
18.12.2019		47.3	21.4	5.4	<6	0.8
20.12.2019		42.6	18.6	<4	7.2	0.8
24.12.2019		48.9	24.3	4.6	<6	0.7
27.12.2019		46.2	22.1	4.2	6.2	0.6
31.12.2019		40.2	20.4	<4	<6	0.7
03.01.2020		39.8	19.6	5.3	6.3	0.5
07.01.2020		42.5	20.4	4.1	<6	0.6
10.01.2020		43.7	19.7	<4	7.1	0.7
14.01.2020		47.6	21.4	5.4	<6	0.8
17.01.2020		45.6	18.7	4.8	6.8	0.4
21.01.2020		42.6	18.6	4.3	6.5	0.6
24.01.2020		49.6	21.3	4.2	6.2	0.8
28.01.2020		47.6	23.4	<4	<6	0.7
31.01.2020		45.3	21.4	5.1	<6	0.6
04.02.2020		41.3	20.3	4.3	6.4	0.6
	Average	44.06	20.40	<4	<6	0.69
	Maximum	49.6	24.3	5.9	7.2	0.9
	Minimum	39.6	15.4	<4	<6	0.4
Percentage of observations above the Limit		Nil	Nil	Nil	Nil	Nil

*Permissible Limit in Ambient Air as per National Ambient Air Quality Standards (NAAQS) for Industrial, Residential, Rural & Other Areas, measured at the site for 24 hours.

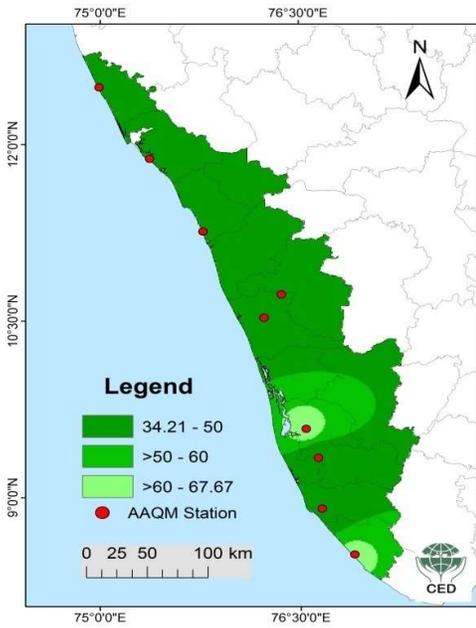
** BDL – Below Detectable Limit (MDL- 4 $\mu\text{g}/\text{m}^3$ for SO₂ & MDL- 6 $\mu\text{g}/\text{m}^3$ for NO₂)

Table 3.30 Ambient Air Quality, Kasaragod

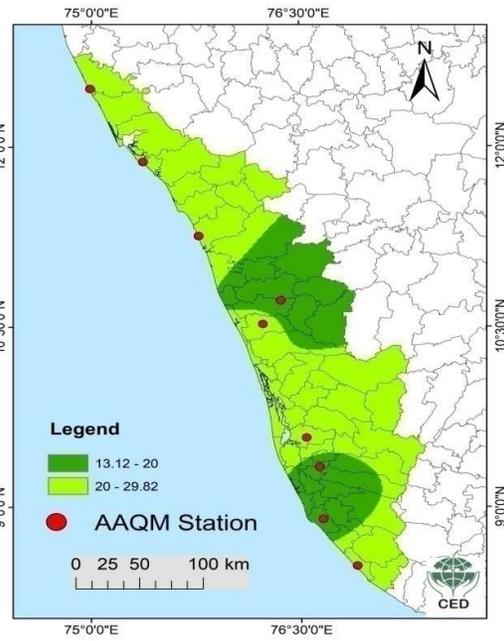
Date of sampling	Measured Parameters	PM10 ($\mu\text{g}/\text{m}^3$)	PM2.5 ($\mu\text{g}/\text{m}^3$)	SO ₂ ($\mu\text{g}/\text{m}^3$)	NO ₂ ($\mu\text{g}/\text{m}^3$)	CO (mg/m^3)
	*Limit as per NAAQS	100 ($\mu\text{g}/\text{m}^3$)	60 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	80 ($\mu\text{g}/\text{m}^3$)	4 (mg/m^3)
14.11.2019		50.90	29.90	4.80	6.50	0.50
20.11.2019		48.00	21.00	**BDL(MDL-4)	7.40	0.90
22.11.2019		45.90	23.90	5.20	**BDL(MDL-6)	0.80
26.11.2019		40.90	20.50	<4	<6	0.70
29.11.2019		39.40	18.50	5.10	8.30	0.90
03.12.2019		47.20	17.40	<4	<6	0.50
06.12.2019		49.50	20.70	<4	<6	0.80
10.12.2019		52.30	30.10	5.50	6.60	0.80
13.12.2019		47.60	19.80	<4	6.40	0.80
17.12.2019		49.60	20.30	6.80	7.20	0.90
20.12.2019		48.60	20.10	5.40	<6	0.80
24.12.2019		49.60	26.30	4.60	7.20	0.60
27.12.2019		48.60	21.70	<4	6.90	0.70
31.12.2019		46.30	20.80	4.80	<6	0.80
03.01.2020		45.20	22.40	5.30	6.40	0.60
07.01.2020		47.60	24.70	4.60	7.30	0.50
10.01.2020		50.20	29.60	5.30	6.80	0.70
14.01.2020		47.40	24.30	<4	<6	0.60
17.01.2020		46.30	19.80	5.70	6.90	0.60
21.01.2020		49.80	24.80	<4	7.20	0.50
24.01.2020		50.3	27.4	4.3	6.8	0.7
28.01.2020		49.5	24.3	<4	6.2	0.6
31.01.2020		48.7	24.1	4.5	<6	0.5
04.02.2020		47.6	22.8	<4	<6	0.6
	Average	47.79	23.13	<4	<6	0.68
	Maximum	52.30	30.10	6.80	8.30	0.90
	Minimum	39.4	17.4	<4	<6	0.5
Percentage of observations above the Limit		Nil	Nil	Nil	Nil	Nil

*Permissible Limit in Ambient Air as per National Ambient Air Quality Standards (NAAQS) for Industrial, Residential, Rural & Other Areas, measured at the site for 24 hours.

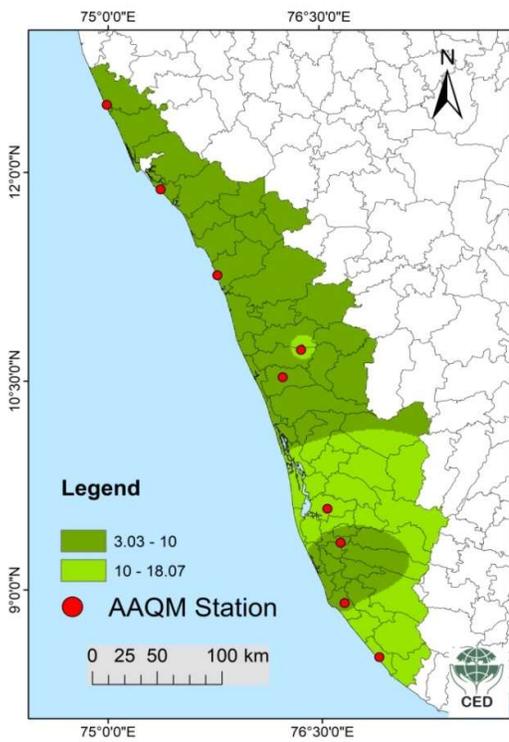
** BDL – Below Detectable Limit (MDL- 4 $\mu\text{g}/\text{m}^3$ for SO₂ & MDL- 6 $\mu\text{g}/\text{m}^3$ for NO₂)



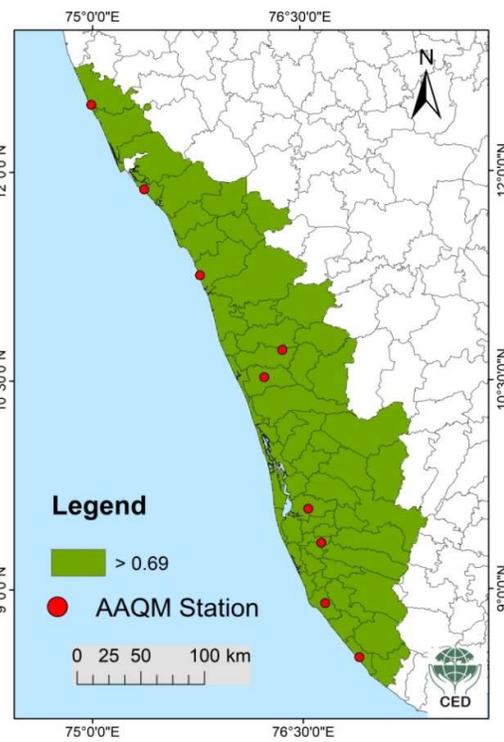
**Fig. 3.17. Variation PM10 ($\mu\text{g}/\text{m}^3$),
November 2019-January 2020**



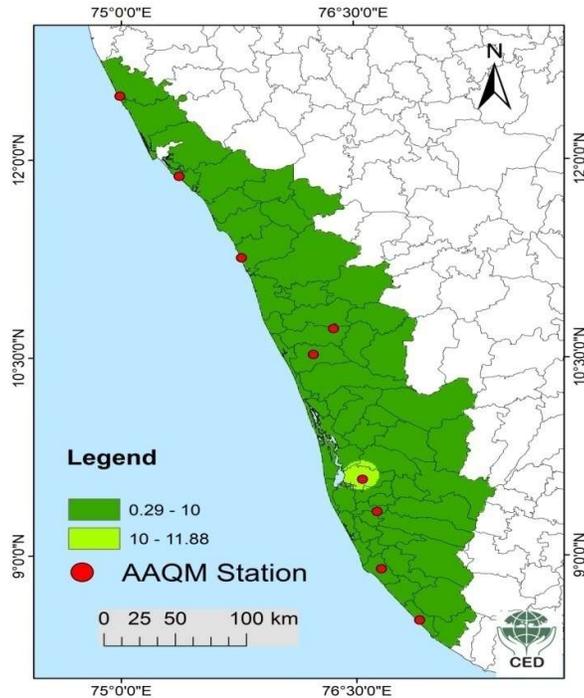
**Fig. 3.18. Variation PM2.5 ($\mu\text{g}/\text{m}^3$),
November 2019-January 2020**



**Fig. 3. 19. Variation NO₂ ($\mu\text{g}/\text{m}^3$),
November 2019-January 2020**



**Fig. 3.20. Variation CO (mg/m^3),
November 2019-January 2020**



**Fig.3. 21. Variation SO₂ (µg/m³),
November 2019-January 2020**

3.8 Water Environment

Water environment encompasses assessment of surface and ground water quality and quantity available in the region. This assessment is required from the point of view of assessment of water resource need during the various phases of project and impact of the proposed activities on these resources as groundwater and surface water is proposed to be used during construction and operation phase of the project.

3.8.1 Water Resources

Kerala is gifted with rich resources of freshwater bodies. The state has a total freshwater area of 1,58,358 ha, consisting of reservoirs (42,890ha), private ponds (21,986ha), irrigation tanks (2,835 ha), freshwater lakes (1,620ha), panchayat ponds (1,487ha), village ponds and other water holds (1,317ha) & check dams, bunds, barriers or anicuts (1,138ha). The state has 41 west-flowing and 3 east-flowing rivers, constituting an area of 85,000ha. The average annual stream flow from various rivers/surface water bodies flowing through different districts of the state. Kerala receives an average annual rainfall of 3049mm, partly appears as stream flow and rest contributes in groundwater recharge. Central Ground Water Board (CGWB) estimated the groundwater availability of the State as 4087.23 MCM/annum and the District wise availability of groundwater is given in Table 3.31.

Table 3.31 District Wise Groundwater Availability in Kerala State

	District	Groundwater Availability (MCM/annum)	Source
1	Thiruvananthapuram	304.74	CGWB (2013)
2	Kollam	409.27	CGWB (2013)
3	Alappuzha	453.65	CGWB (2013)
4	Kottayam	473.16	CGWB (2013)
5	Ernakulam	615.72	CGWB (2013)
6	Thrissur	640.60	CGWB (2013)
7	Kozhikode	347.38	CGWB (2013)
8	Kasargod	363.60	CGWB (2013)
9	Kannur	479.11	CGWB (2013)
	Total	4087.23	

3.8.2 Surface Water Quality Assessment

The Surface water quality analyses were carried out with respect to various parameters like temperature, pH, conductivity, DO, BOD, total coliforms and E-Coli. The sampling locations and the names of rivers from the surface water samples are collected are given in Table 3.32. The physico-chemical characteristics are given in Tables 3.33 to 3.36. On the basis of these characteristics, surface water quality was compared with Water Quality (Bureau of Indian Standards IS 2296:1992) Criteria under Class C (Drinking water source after conventional treatment and disinfection). The standard has recommended water quality parameters for different uses.

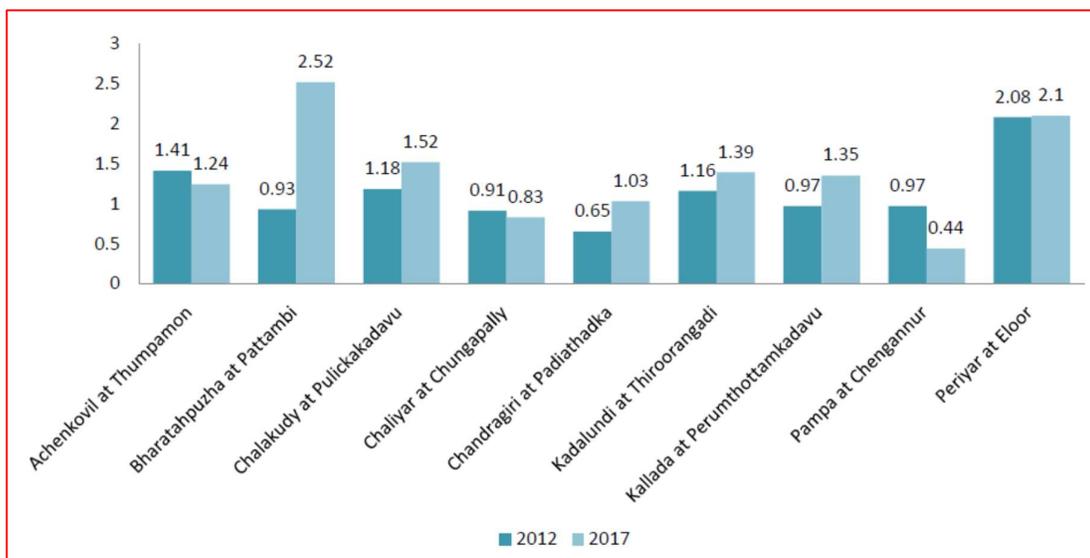


Fig 3.22 Biological Oxygen Demand levels at selected river stations for 2012 & 2017

Table 3.32 Surface Water sampling locations

S.No.	Sampling location code	Latitude	Longitude	Surface Water Source
1	SW1	8°31'4.29"N	76°53'33.67"E	Akulam Lake
2	SW2	8° 42' 9.26" N	76° 47' 56.41" E	Vamanapuram River
3	SW3	9° 1' 38.17"N	76° 40' 38.49"E	Kallada River
4	SW4	9° 19' 53.03" N	76° 38' 35.34" E	Pampa River
5	SW5	10° 7'17.297"N	76° 23' 10.785"E	Periyar River
6	SW6	10° 13' 28.658"N	76° 19' 33.955"E	Chalakupuzha
7	SW7	10°51'49.25"N	75°58'56.40"E	Bharathappuzha
8	SW8	11° 7'50.79"N	75°49'44.65"E	Kadalundipuzha
9	SW9	11°10'47.85"N	75°49'42.82"E	Beyapore River
10	SW10	11°42'15.76"N	75°32'46.55"E	Mahe River
11	SW11	12°24'30.81"N	75° 1'47.80"E	Bakel River
12	SW12	12°29'31.19"N	74°59'12.92"E	Chandragiripuzha

Table 3.33 Physico-chemical Characteristics of Surface Water – Akulam Lake, Vamanapuram River, Kallada River

Sl. No.	Parameters	Units	Sample Locations			Limit as per IS – 2296 (Class C)
			Akulam Lake (SW1)	Vamanapuram River (SW2)	Kallada River (SW3)	
1	pH	-	7.19	7.29	7.16	6.0 – 9.0
2	Conductivity	µS/cm	1935	70	108	--
3	Total Dissolved Solids	mg/l	905	32	32	1500 mg/l
4	Total Suspended Solids	mg/l	6.2	BDL(MDL-2.0)	3.4	--
5	Total Alkalinity as CaCO ₃	mg/l	80.15	9.16	9.16	--
6	Oil & Grease	mg/l	BDL(MDL-4.0)	BDL(MDL-4.0)	BDL(MDL-4.0)	-
7	Total Hardness as CaCO ₃	mg/l	170	10	12	-
8	Calcium as Ca	mg/l	36	3.2	3.2	-
9	Magnesium as Mg	mg/l	19.48	BDL(MDL-1.0)	1	-
10	Sulphate as SO ₄	mg/l	55.78	BDL(MDL-1.0)	3.65	400 mg/l
11	Nitrate as NO ₃	mg/l	2.38	BDL(MDL-0.1)	BDL(MDL-0.1)	50 mg/l
12	Total Kjeldahl Nitrogen	mg/l	7.49	BDL(MDL-1.0)	BDL(MDL-1.0)	--
13	Phosphate as PO ₄	mg/l	0.78	BDL(MDL-0.2)	BDL(MDL-0.2)	--
14	Organic Phosphorus as P	mg/l	ND	ND	ND	--
15	Dissolved Oxygen	mg/l	5.95	6.59	6.32	4 mg/l
16	BOD (3 days at 27° C)	mg/l	5.2	BDL(MDL-2.0)	BDL(MDL-2.0)	3 mg/l
17	COD	mg/l	12	BDL(MDL-10.0)	BDL(MDL-10.0)	--
18	Chloride as Cl ⁻	mg/l	446.81	11.65	18.45	600 mg/l
19	Fluoride as F	mg/l	0.1	0.15	0.19	1.5 mg/l
20	Sodium as Na	mg/l	305	7.8	11.1	--
21	Potassium as K	mg/l	22.9	6	5.7	--
22	Iron as Fe	mg/l	1.29	0.93	0.43	0.5 mg/l
23	Manganese as Mn	mg/l	0.024	0.031	0.02	-
24	Cadmium as Cd	mg/l	0.001	0.001	0.001	0.01 mg/l
25	Chromium as Cr	mg/l	BDL(MDL-0.01)	BDL(MDL-0.01)	BDL(MDL-0.01)	0.05 mg/l
26	Copper as Cu	mg/l	BDL(MDL-0.01)	BDL(MDL-0.01)	BDL(MDL-0.01)	1.5 mg/l
27	Nickel as Ni	mg/l	BDL(MDL-0.01)	BDL(MDL-0.01)	BDL(MDL-0.01)	---
28	Lead as Pb	mg/l	BDL(MDL-0.01)	BDL(MDL-0.01)	BDL(MDL-0.01)	0.01 mg/l
29	Zinc as Zn	mg/l	BDL(MDL-0.01)	BDL(MDL-0.01)	0.029	15 mg/l
30	Total Coliform Count	MPN/100ml	1600	<2	8	5000
31	E coli	MPN/100ml	34	<2	<2	--

BDL – Below Detection Limit, MDL – Minimum Detection Limit. ND – Not Detected. <2 indicate to absent.

Table 3.34 Physico-chemical Characteristics of Surface Water – Pampa River, Periyar River, Chlakkudippuzha

Sl. No.	Parameters	Units	Sample Locations			Limit Asper IS – 2296 (Class C)
			Pampa River (SW4)	Periyar River (SW5)	Chalakkudypuzha (SW6)	
1	pH	-	6.86	7.24	7.57	6.0 – 9.0
2	Conductivity	µS/cm	42	58	110	--
3	Total Dissolved Solids	mg/l	19	26	53	1500 mg/l
4	Total Suspended Solids	mg/l	BDL(MDL-2.0)	4.6	BDL(MDL-2.0)	--
5	Total Alkalinity as CaCO ₃	mg/l	6.87	11.45	16.05	--
6	Oil & Grease	mg/l	BDL(MDL-4.0)	BDL(MDL-4.0)	BDL(MDL-4.0)	-
7	Total Hardness as CaCO ₃	mg/l	8	12	28	-
8	Calcium as Ca	mg/l	2.4	3.2	8	-
9	Magnesium as Mg	mg/l	BDL(MDL-1.0)	1.0	1.95	-
10	Sulphate as SO ₄	mg/l	BDL(MDL-1.0)	BDL(MDL-1.0)	BDL(MDL-1.0)	400 mg/l
11	Nitrate as NO ₃	mg/l	BDL(MDL-0.1)	0.14	0.32	50 mg/l
12	Total Kjeldahl Nitrogen	mg/l	BDL(MDL-0.1)	BDL(MDL-0.1)	BDL(MDL-0.1)	--
13	Phosphate as PO ₄	mg/l	BDL(MDL-0.2)	0.37	BDL(MDL-0.2)	--
14	Organic Phosphorus as P	mg/l	ND	ND	ND	--
15	Dissolved Oxygen	mg/l	7.23	6.59	6.87	4 mg/l
16	BOD (3 days at 27° C)	mg/l	BDL(MDL-2.0)	2.6	BDL(MDL-2.0)	3 mg/l
17	COD	mg/l	BDL(MDL-10.0)	12	BDL(MDL-10.0)	--
18	Chloride as Cl ⁻	mg/l	5.83	9.71	19.4	600 mg/l
19	Fluoride as F	mg/l	BDL(MDL-0.1)	BDL(MDL-0.1)	BDL(MDL-0.1)	1.5 mg/l
20	Sodium as Na	mg/l	5.5	6.1	6.7	--
21	Potassium as K	mg/l	3.7	4.1	3.3	--
22	Iron as Fe	mg/l	0.39	0.50	1.09	0.5 mg/l
23	Manganese as Mn	mg/l	0.044	0.017	0.117	-
24	Cadmium as Cd	mg/l	BDL(MDL – 0.001))	BDL(MDL – 0.001)	0.001	0.01 mg/l
25	Chromium as Cr	mg/l	BDL(MDL – 0.01)	BDL(MDL – 0.01)	BDL(MDL – 0.01)	0.05 mg/l
26	Copper as Cu	mg/l	BDL(MDL – 0.010)	BDL(MDL – 0.01)	0.01	1.5 mg/l
27	Nickel as Ni	mg/l	BDL(MDL – 0.01)	BDL(MDL – 0.01)	BDL(MDL – 0.01)	---
28	Lead as Pb	mg/l	BDL(MDL – 0.01)	0.012	0.012	0.01 mg/l
29	Zinc as Zn	mg/l	BDL(MDL – 0.01)	0.026	0.139	15 mg/l
30	Total Coliform Count	MPN/100ml	900	22	TNTC	5000
31	E coli	MPN/100 ml	170	<2	43	-

BDL – Below Detection Limit, MDL – Minimum Detection Limit. ND – Not Detected.

Table 3.35 Physico-chemical Characteristics of Surface Water – Bharathapuzha, Beypore and Kadalundi Rivers

Sl.No	Parameters	Units	Sample Locations			Limit As per IS – 2296 (Class C)
			Bharathapuzha(S W 7)	Kadalundi puzha (SW 8)	Beypore River (SW 9)	
1	pH		7.92	7.14	7.21	6.0 – 9.0
2	Conductivity	µS/cm	350	28000	5300	--
3	Total Dissolved Solids	mg/l	262	18560	3361	1500 mg/l
4	Total Suspended Solids	mg/l	8	BDL(MDL-1 mg/l)	6.0	--
5	Total Alkalinity as CaCO ₃	mg/l	82.95	59.25	35.55	--
6	Oil & Grease	mg/l	BDL(MDL-1)	BDL(MDL-1 mg/l)	2.1	-
7	Total Hardness as CaCO ₃	mg/l	76	2800	380	-
8	Calcium as Ca	mg/l	19.24	240.48	40.08	-
9	Magnesium as Mg	mg/l	6.80	534.6	68.04	-
10	Sulphate as SO ₄ ,	mg/l	14.47	421.26	129.49	400 mg/l
11	Nitrate as NO ₃ ,	mg/l	6.07	BDL(MDL-1 mg/l)	10.73	50 mg/l
12	Total Kjeldahl Nitrogen	mg/l	2.6	4.3	6.3	--
13	Phosphate as PO ₄	mg/l	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	--
14	Organic Phosphorus as P	mg/l	BDL(MDL-0.1)	BDL(MDL-0.1 mg/l)	BDL(MDL-0.1 mg/l)	--
15	Dissolved Oxygen	mg/l	6.9	6.7	7	4 mg/l
16	BOD (3 days at 27O C)	mg/l	8.9	9.8	14.6	3 mg/l
17	COD	mg/l	190	190	114	--
18	Chloride as Cl ⁻	mg/l	30.86	9075.2	1315.9	600 mg/l
19	Fluoride as F	mg/l	0.22	1.06	0.28	1.5 mg/l
20	Sodium as Na	mg/l	24	1820	560	--
21	Potassium as K	mg/l	BDL(MDL-1 mg/l)	3.0	2.0	--
22	Iron as Fe	mg/l	1.57	0.23	0.32	0.5 mg/l
23	Manganese as Mn	mg/l	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	-
24	Cadmium as Cd	mg/l	BDL(MDL-0.001mg/l)	BDL(MDL-0.001 mg/l)	BDL(MDL-0.001 mg/l)	0.01 mg/l
25	Chromium as Cr	mg/l	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	0.05 mg/l
26	Copper as Cu	mg/l	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	0.04	1.5 mg/l
27	Nickel as Ni	mg/l	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	---
28	Lead as Pb	mg/l	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	0.01 mg/l
29	Zinc as Zn	mg/l	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	15 mg/l
30	Total Coliform Count	MPN/100ml	Absent	50	50	5000
31	E coli	MPN/100 ml	Absent	Absent	Absent	---

BDL – Below Detection Limit, MDL – Minimum Detection Limit. ND – Not Detected.

Table 3.36 Physico-chemical Characteristics of Surface Water - Mahe, Bakel and Chandragiri Rivers

Sl. No	Parameters	Units	Sample Locations			Limit As per IS – 2296 (Class C)
			Mahi River (SW 10)	Bakel River (SW11)	Chandragiripuzha (SW12)	
1	pH		6.85	6.89	6.50	6.0 – 9.0
2	Conductivity	µS/cm	20000	4100	15700	--
3	Total Alkalinity as CaCO ₃	mg/l	59.25	23.7	47.4	--
4	Total Dissolved Solids	mg/l	13521	2715	10764	1500 mg/l
5	Total Suspended Solids	mg/l	9	6	8	--
6	Oil & Grease	mg/l	BDL (MDL-1 mg/l)	1.2	2.6	-
7	Total Hardness as CaCO ₃	mg/l	1460	1360	1200	-
8	Calcium as Ca	mg/l	96.19	32.06	104.21	-
9	Magnesium as Mg	mg/l	296.46	68.04	228.42	-
10	Sulphate as SO ₄	mg/l	279.89	96.82	217.06	400 mg/l
11	Nitrate as NO ₃	mg/l	1.69	9.44	7.93	50 mg/l
12	Total Kjeldahl Nitrogen	mg/l	3.6	4.3	3.6	-
13	Phosphate as PO ₄	mg/l	BDL (MDL-1 mg/l)	BDL (MDL-1 mg/l)	BDL (MDL-1 mg/l)	--
14	Organic Phosphorus as P	mg/l	BDL (MDL-0.1 mg/l)	BDL (MDL-0.1 mg/l)	BDL(MDL-0.1 mg/l)	-
15	Dissolved Oxygen	mg/l	7.1	7.1	7.7	4 mg/l
16	BOD (3 days at 27° C)	mg/l	6.2	5.6	14.2	3 mg/l
17	COD	mg/l	124	89	210	-
18	Chloride as Cl ⁻	mg/l	7260.16	1134.4	5898.88	600 mg/l
19	Fluoride as F	mg/l	0.86	0.28	1.03	1.5 mg/l
20	Sodium as Na	mg/l	1880	460	1420	-
21	Potassium as K	mg/l	BDL (MDL-1 mg/l)	BDL (MDL-1 mg/l)	4	-
22	Iron as Fe	mg/l	0.54	0.40	0.37	0.5 mg/l
23	Manganese as Mn	mg/l	0.25	BDL (MDL-0.05 mg/l)	BD L(MDL-0.05 mg/l)	-
24	Cadmium as Cd	mg/l	BDL (MDL-0.001 mg/l)	BDL (MDL-0.001 mg/l)	BDL (MDL-0.001 mg/l)	0.01 mg/l
25	Chromium as Cr	mg/l	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	0.05 mg/l
26	Copper as Cu	mg/l	BDL (MDL-0.01 mg/l)	0.02	0.06	1.5 mg/l
27	Nickel as Ni	mg/l	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	-
28	Lead as Pb	mg/l	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	0.1 mg/l
29	Zinc as Zn	mg/l	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	15 mg/l
30	Total Coliform Count	MPN/100 ml	Absent	Absent	70	5000
31	E- coli	MPN/100 ml	Absent	Absent	Absent	--

BDL – Below Detection Limit, MDL – Minimum Detection Limit. ND – Not Detected.

The result of the analysis of water quality measurement at 12 major rivers that is passing through the alignment revealed that none of the parameters showed high values except for conductivity and TDS in locations which are close to the Arabian sea and in Akkulam Lake. The Suspended solids were very low in all the samples collected. The silt is at medium levels and during rainfall events for exposed areas will lead to the production of muddy water and hence suspended solids, which if directly discharged into nearby bodies of water without treatment will cause water contamination. The river water is already having high SS further increase during heavy rains may be negligible. At large rivers, bridge pier construction will accompany work done inside the water. This will temporarily involve drilling the river bottom which will cause muddy water to spread within the river. Provision of site offices and workers camps during construction will cause production of domestic sewage and wastewater including urine and feces. If directly discharged into nearby bodies of water without treatment, water contamination will occur.

During construction, exposure of soil will occur due to foundation works for elevated bridges, cutting, and embankment. During tunnel construction, mortar spraying will accompany tunnel lining works. With accompanying water seepage, wastewater with high pH levels will be produced. If directly discharged into nearby bodies of water without treatment, water contamination will occur. However, the measured pH levels in the surface water of the rivers were in the range 6.5 to 7.92 and hence further increase if there will be temporary.

3.8.3 Ground Water Quality Assessment

The stretch of SilverLine corridor will run through Thiruvananthapuram to Kasaragod via Districts Kollam, Pathanamthitta, Alappuzha, Kottayam, Ernakulam, Thrissur, Malappuram, Kozhikode, and Kannur. Ground water samples for the determination of various parameters are collected from open wells along the SilverLine alignment and also from the proposed stations. The details of the Ground water sampling locations are given in Table 3.37. Photograph of water sampling is presented in Annexure 5. The ground water quality status along the proposed alignments (compared with drinking water standards IS 10500-2012) are presented in Tables 3.38 to 3.41. The overall groundwater quality conforms to the permissible limit of drinking water standards (IS: 10500-2012) at most of the locations.

Table 3.37 Ground Water sampling locations

Sl.No.	Sampling location code	Latitude	Longitude	Ground Water Source
1	GW1	8° 30' 44.88" N	76° 53' 52.43" E	Kochuveli - (Open well)
2	GW2	8° 53' 40.55"N	76° 39' 27.09" E	Mukhathala, Kollam - (Open well)
3	GW3	9°20' 19.873"N	76° 38' 37.926" E	Chengannur RS - (Open well)
4	GW4	9° 34' 39.821"N	76° 32' 22.523"E	Kottayam- (Open well)
5	GW5	10° 00' 27.3"N	76° 22' 42.4" E	Ernakulam- (Open well)
6	GW6	10° 30' 34.4"N	76° 12' 20.6" E	Thrissur- (Open well)
7	GW7	10°55'42.9"N	75°54'52.0"E	Tirur- (Open well)
8	GW8	11°14'45.5"N	75°46'49.4"E	Kozhikode- (Open well)
9	GW9	11°35'22.2"N	75°37'17.2"E	Near to Badagra – Thiruvallur- Perumpa Rd- (Open well)
10	GW10	11°52'57.7"N	75°21'47.3"E	Kannur RS- (Open Well)
11	GW11	12°09'13.3"N	75°10'31.3"E	Near Vadamkumkad Bus Stop- (Open Well)
12	GW12	12°29'31.6"N	74°59'11.3"E	Kasragod RS- (Open Well)

**Table 3.38 Physico-chemical Characteristics of Ground Water (Open Wells) -
Thiruvananthapuram, Kollam, Chengannur**

Sl.No.	Parameters	Unit	Locations			Acceptable Limit As per IS 10500 – 2012
			GW1- Well water	GW2- Well water	GW3-Well Water	
1	pH	---	6.87	5.16	5.99	6.5 – 8.5
2	Conductivity	µs/cm	580	113	99	--
3	Total Dissolved Solids	mg/l	261	51	46	500
4	Total Suspended Solids	mg/l	BDL(MDL- 2.0)	BDL(MDL-2.0)	BDL(MDL- 2.0)	--
5	Oil & Grease	mg/l	BDL(MDL- 4.0)	BDL(MDL-4.0)	BDL(MDL- 4.0)	--
6	Alkalinity as CaCO ₃	mg/l	43.51	BDL(MDL-2.0)	20.61	200
7	Total Hardness as CaCO ₃	mg/l	110	4	24	200
8	Calcium	mg/l	39.2	1.6	5.6	75
9	Magnesium	mg/l	2.92	BDL(MDL-1.0)	2.43	30
10	Sulphate as SO ₄	mg/l	88.59	BDL(MDL-1.0)	10.43	200
11	Nitrate	mg/l	2.28	2.15	BDL(MDL- 0.1)	45
12	Total Kjeldhal Nitrogen	mg/l	BDL(MDL- 1.0)	BDL(MDL-1.0)	BDL(MDL- 0.1)	--
13	Phosphate	mg/l	ND	0.68	0.83	--
14	Organic Phosphorous	mg/l	BDL(MDL- 0.2)	ND	ND	--
15	Dissolved Oxygen (DO)	mg/l	6.22	6.5	6.96	---
16	BOD	mg/l	3.6	BDL(MDL-2.0)	BDL(MDL- 2.0)	--
17	COD	mg/l	12	BDL(MDL- 10.0)	BDL(MDL- 10.0)	--
18	Chloride (as Cl).	mg/l	53.42	23.31	7.77	250
19	Fluoride	mg/l	0.10	BDL(MDL-0.1)	BDL(MDL- 0.1)	1.0
20	Sodium as Na	mg/l	55.5	14.9	8	--
21	Potassium as K	mg/l	13.9	2.9	4.2	--
22	Iron as Fe	mg/l	0.10	0.09	BDL(MDL- 0.08)	0.30
23	Manganese as Mn	mg/l	0.029	0.028	0.118	0.1
24	Cadmium as Cd	mg/l	0.001	0.001	BDL(MDL – 0.001)	0.003
25	Chromium as Cr	mg/l	BDL(MDL – 0.01)	BDL(MDL – 0.01)	BDL(MDL – 0.01)	0.05
26	Copper as Cu	mg/l	BDL(MDL – 0.01)	BDL(MDL – 0.01)	BDL(MDL – 0.01)	0.05
27	Nickel as Ni	mg/l	BDL(MDL – 0.01)	0.01	BDL(MDL – 0.01)	0.02
28	Lead as Pb	mg/l	BDL(MDL – 0.01)	BDL(MDL – 0.01)	BDL(MDL – 0.01)	0.01
29	Zinc as Zn	mg/l	0.032	0.119	0.020	5.0
30	Total Coliform Count	MPN/100 ml	34	50	500	Absent
31	E.coli	MPN/100 ml	22	2	11	Absent

BDL – Below Detection Limit, MDL – Minimum Detection Limit. ND – Not Detected

Table 3.39 Physico-chemical Characteristics of Ground Water (Open Wells) - Kottayam, Ernakulam, Thrissur

Sl. No.	Parameters	Unit	Locations			Acceptable Limit As per IS 10500 – 2012
			GW4- Well water	GW5-Well Water	GW6 -Well Water	
1	pH	---	5.98	7.27	5.21	6.5 – 8.5
2	Conductivity	µs/cm	135	486	134	--
3	Total Dissolved Solids	mg/l	63	242	62	500
4	Total Suspended Solids	mg/l	3.2	2.5	32	--
5	Oil & Grease	mg/l	BDL(MDL-4.0)	BDL(MDL-4.0)	BDL(MDL-4.0)	--
6	Alkalinity as CaCO ₃	mg/l	16.03	74.43	BDL(MDL-2.0)	200
7	Total Hardness as CaCO ₃	mg/l	24	95	18	200
8	Calcium	mg/l	5.6	28	4.8	75
9	Magnesium	mg/l	2.43	6.09	1.46	30
10	Sulphate as SO ₄	mg/l	9.77	34.35	4.92	200
11	Nitrate	mg/l	BDL(MDL-0.1)	0.95	4.43	45
12	Total Kjeldhal Nitrogen	mg/l	BDL(MDL-0.1)	BDL(MDL-0.1)	BDL(MDL-1.0)	--
13	Phosphate	mg/l	BDL(MDL-0.2)	0.20	BDL(MDL-0.2)	--
14	Organic Phosphorous	mg/l	ND	ND	ND	--
15	Dissolved Oxygen (DO)	mg/l	6.96	7.1	6.96	---
16	BOD	mg/l	BDL(MDL-2.0)	BDL(MDL-2.0)	BDL(MDL-2.0)	--
17	COD	mg/l	BDL(MDL-10.0)	BDL(MDL-10)	BDL(MDL-10)	--
18	Chloride (as Cl).	mg/l	14.57	63.14	20.39	250
19	Fluoride as F	mg/l	BDL(MDL-0.1)	BDL(MDL-0.1)	BDL(MDL-0.1)	1.0
20	Sodium as Na	mg/l	11.5	48.3	10.8	--
21	Potassium as K	mg/l	7.9	11.9	7.6	--
22	Iron as Fe	mg/l	1.49	0.35	0.09	0.30
23	Manganese as Mn	mg/l	0.121	0.057	0.056	0.1
24	Cadmium as Cd	mg/l	BDL(MDL – 0.001)	BDL(MDL – 0.001)	0.001	0.003
25	Chromium as Cr	mg/l	BDL(MDL – 0.01)	BDL(MDL – 0.01)	BDL(MDL – 0.01)	0.05
26	Copper as Cu	mg/l	BDL(MDL – 0.01)	BDL(MDL – 0.01)	BDL(MDL – 0.01)	0.05
27	Nickel as Ni	mg/l	BDL(MDL – 0.01)	BDL(MDL – 0.01)	BDL(MDL – 0.01)	0.02
28	Lead as Pb	mg/l	BDL(MDL – 0.010)	0.010	BDL(MDL – 0.010)	0.01
29	Zinc as Zn	mg/l	0.032	0.104	0.091	5.0
30	Total Coliform Count	MPN/100 ml	30	500	70	Absent
31	E.coli	MPN/100 ml	<2	2	<2	Absent

BDL – Below Detection Limit, MDL – Minimum Detection Limit. ND – Not Detected.

Table 3.40 Physico-chemical Characteristics of Ground Water (Open Wells) – Tirur, Kozhikode, Badagra

Sl. No	Parameters	Unit	Locations			Acceptable LimitAs per IS 10500 – 2012
			GW7- Well water	GW8 -Well water	GW 9 – Well water	
1	pH	---	7.78	7.54	7.07	6.5 – 8.5
2	Conductivity	µS/cm	290	390	43 µS/cm	--
3	Total Dissolved Solids	mg/l	188.5	253.5	27.95 mg/l	500
4	Total Suspended Solids	mg/l	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	--
5	Oil & Grease	mg/l	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	BDL(MDL-1mg/l)	--
6	Total Alkalinity as CaCO ₃	mg/l	14.22	109.02	9.48 mg/l	200
7	Total Hardness as CaCO ₃	mg/l	56	112	10 mg/l	200
8	Calcium as Ca	mg/l	17.64	43.29	2.40 mg/l	75
9	Magnesium as Mg	mg/l	2.92	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	30
10	Sulphate as SO ₄	mg/l	19.08	10.80	3.91 mg/l	200
11	Nitrate as NO ₃	mg/l	13.17	10.80	BDL(MDL-1mg/l)	45
12	Total Kjeldahl Nitrogen	mg/l	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	BDL(MDL-1mg/l)	--
13	Phosphate as PO ₄	mg/l	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	
14	Organic Phosphorus as P	mg/l	BDL(MDL-0.1 mg/l)	BDL(MDL-0.1 mg/l)	BDL(MDL-0.1 mg/l)	--
15	Dissolved Oxygen	mg/l	7.4	6.9	7.2 mg/l	---
16	BOD (3 days at 27° C)	mg/l	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	--
17	COD	mg/l	14	10	8 mg/l	--
18	Chloride as Cl ⁻	mg/l	30.86	19.97	9.98 mg/l	250
19	Fluoride as F	mg/l	BDL(MDL-1 mg/l)	0.14mg/l	BDL(MDL-0.1mg/l)	1.0
20	Sodium as Na	mg/l	18	12	3 mg/l	--
21	Potassium as K	mg/l	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	--
22	Iron as Fe	mg/l	0.07	0.38	BDL(MDL-0.05 mg/l)	0.30
23	Manganese as Mn	mg/l	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	0.1
24	Cadmium as Cd	mg/l	BDL(MDL-0.001 mg/l)	BDL(MDL-0.001 mg/l)	BDL(MDL-0.001 mg/l)	0.003
25	Chromium as Cr	mg/l	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	0.05
26	Copper as Cu	µs/cm	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	0.05
27	Nickel as Ni	mg/l	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	0.02
28	Lead as Pb	mg/l	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	0.01
29	Zinc as Zn	mg/l	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	5.0
30	Total Coliform Count	MPN/100 ml	Absent	Absent	Absent	Absent
31	E coli	MPN/100 ml	Absent	Absent	Absent	Absent

Note: BDL – Below Detection Level, MDL-Minimum Detection Level

Table 3.41 Physico-chemical Characteristics of Ground Water (Open Wells) – Kannur, Vadakkumpad, Kasaragod

Sl. No	Parameters	Unit	Locations			Acceptable LimitAs per IS – 10500 – 2012
			GW 10- Well	GW 11-Well water	GW 12 – Well water	
1	pH	---	6.99	6.80	6.17	6.5 – 8.5
2	Conductivity	µS/cm	210 µS/cm	220 µS/cm	160 µS/cm	--
3	Total Dissolved Solids	mg/l	136.5 mg/l	143 mg/l	104 mg/l	500
4	Total Suspended Solids	mg/l	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	--
5	Oil & Grease	mg/l	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	--
6	Total Alkalinity as CaCO ₃	mg/l	28.44 mg/l	47.4 mg/l	28.44 mg/l	200
7	Total Hardness as CaCO ₃	mg/l	32 mg/l	44 mg/l	24 mg/l	200
8	Calcium as Ca	mg/l	12.02 mg/l	15.23 mg/l	8.02 mg/l	75
9	Magnesium as Mg	mg/l	BDL(MDL-1 mg/l)	1.46 mg/l	BDL(MDL-1 mg/l)	30
10	Sulphate as SO ₄	mg/l	5.29 mg/l	7.43 mg/l	5.42 mg/l	200
11	Nitrate as NO ₃	mg/l	6.21 mg/l	4.99 mg/l	3.70 mg/l	45
12	Total Kjeldahl Nitrogen	mg/l	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	--
13	Phosphate as PO ₄	mg/l	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	--
14	Organic Phosphorus as P	mg/l	BDL(MDL-0.1 mg/l)	BDL(MDL-0.1 mg/l)	BDL(MDL-0.1 mg/l)	--
15	Dissolved Oxygen	mg/l	6.9 mg/l	6.8 mg/l	7.1 mg/l	---
16	B PD (3 days at 27° C)	mg/l	1.33 mg/l	BDL(MDL-1 mg/l)	1.9 mg/l	--
17	COD	mg/l	24 mg/l	14 mg/l	18 mg/l	--
18	Chloride as Cl ⁻	mg/l	24.50 mg/l	20.87 mg/l	22.69 mg/l	250
19	Fluoride as F	mg/l	BDL(MDL-0.1 mg/l)	BDL(MDL-0.1 mg/l)	BDL(MDL-0.1 mg/l)	1.0
20	Sodium as Na	mg/l	21 mg/l	10 mg/l	19 mg/l	--
21	Potassium as K	mg/l	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	BDL(MDL-1 mg/l)	--
22	Iron as Fe	mg/l	0.05 mg/l	0.54 mg/l	0.10 mg/l	0.30
23	Manganese as Mn	mg/l	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	0.1
24	Cadmium as Cd	mg/l	BDL(MDL-0.001 mg/l)	BDL(MDL-0.001 mg/l)	BDL(MDL-0.001 mg/l)	0.003
25	Chromium as Cr	mg/l	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	0.05
26	Copper as Cu	µs/cm	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	0.05
27	Nickel as Ni	mg/l	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	0.02
28	Lead as Pb	mg/l	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	BDL(MDL-0.01 mg/l)	0.01
20	Zinc as Zn	mg/l	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	BDL(MDL-0.05 mg/l)	5.0
30	Total Coliform Count	MPN/100 ml	30	Absent	30	Absent
31	E coli	MPN/100 ml	Absent	Absent	Absent	Absent

Note: BDL – Below Detection Level, MDL-Minimum Detection Level

The overall groundwater quality conforms to the acceptable limit of drinking water standards (IS: 10500-2012) at most of the locations. At four locations, Iron exceeded the limit and bacteriological contamination was found at eight locations. The groundwater is suitable for domestic and drinking purposes after proper treatment.

3.9 Noise & Vibration Assessment

3.9.1 Noise Assessment

The unwanted sound is known as noise and is measured in decibel (dBA). Noise can originate from a variety of sources. Some of the manmade sources of noise generation are industries, domestic sources, transport and traffic, construction activities, festivals and religious activities etc. The baseline noise level measurements were made from different locations which involve commercial areas, premises of educational institutions, hospitals etc. The details of the sampling locations are given in Table 3.42 and photograph of sampling location is presented in Annexure 5. Ambient Noise measurements were taken from 22 locations and are presented in Tables 3.43 to 3.48.

Table 3.42 Noise sampling locations

	Sampling location code	Latitude	Longitude	Details of location
1	N1	8°30'44.88"N	76° 53' 53.43"E	Kochuveli rail way station, Thiruvananthapuram, Residential, commercial, industrial area
2	N2	8°32'54.80"N	76° 52' 47.10"E	Near Technopark, Thiruvananthapuram, Commercial area
3	N3	8° 35',2.38"N	76° 51' 27.95"E	Near to Kaniyapuram RS, Residential area
4	N4	8° 53'40.55"N	76° 39'27 .09"E	Kollam, Mukathala, Residential area
5	N5	9°10'2.126"N	76°38'23.082"	Nooranad Guest House, Commercial area
6	N6	9° 20'19.39"N	76°38'39.02"E	Chengannur RS (Proposed), Rural area
7	N7	9° 30'44.785"N	76°34'8.14"E	Near Govt. Hospital, Manarcaud
8	N8	9° 34'39.814"N	76°32'23.85"E	Muttampalam, Kottayam RS
9	N9	9° 10'2.126"N	76°38'23.082"E	Near Nursing College, Piravom, Educational site
10	N10	9° 20'19.39"N	76°38'39.02"E	Near BPCI, Irumpanam, Industrial area
11	N11	10° 0' 36.249" N	76° 22' 38.106" E	Near Sanskara School, Kakkanad, Educational site
12	N12	10° 0'52.2" N	76° 21'48.4" E	Info park, Kakkanad Commercial and office area
13	N13	10° 09' 34.097" N	76° 22' 58.916" E	Kochi International Airport area
14	N14	10°30'32.13"N	76°12'23.95"E	Thrissur RS (Proposed)
15	N15	10°30'33.20"N	76°12'25.75"E	Pookunnam School, Tirur – Kuttipuram Rd
16	N16	10°55'40.77"N	75°54'41.86"E	Tirur RS (Proposed)
17	N17	11° 7'47.05"N	75°49'53.59"E	Kadalundi
18	N18	11°14'41.52"N	75°46'49.40"E	Kozhikode RS (Proposed), Residential cum commercial site
19	N19	11°26'6.37"N	75°42'7.35"E	South L P school, Kothamangalam, educational institution
20	N20	12° 9'16.77"N	75°10'37.86"E	Kannur RS, (Proposed), Residential cum commercial site
21	N21	12°27'55.57"N	74°59'55.11"E	Kalanad Railway Station, Rural residential area
22	N22	11° 7'50.79"N	75°49'44.65"E	Kasaragod RS (Proposed), Rural area

Table 3.43 Noise Level at Locations N1, N2, N3, N4, N5

Sl. No.	Hourly Interval	Hourly Leq Values at				
		N1 Kochuveli RS	N2 Technopark	N3 Kaniyapuram	N4 Mukathala	N5 Nooranad
1	06.00 AM – 07.00 AM	42.9	64.6	45.5	43.8	43.7
2	07.00 AM – 08.00 AM	53.1	66.3	48.2	50.0	51.0
3	08.00 AM – 09.00 AM	54.4	69.9	55.3	54.1	52.8
4	09.00 AM – 10.00 AM	53.9	69.1	55.5	52.3	51.2
5	10.00 AM – 11.00 AM	55.5	70.6	52.2	55.8	51.4
6	11.00 AM – 12.00 AM	59.5	69.5	50.7	54.8	51.5
7	12.00 AM – 01.00 PM	55.8	67.9	50.9	54.8	52.6
8	01.00 PM – 02.00 PM	54.1	70.2	52.2	53.0	52.1
9	02.00 PM – 03.00 PM	54.2	69.1	51.9	58.7	51.2
10	03.00 PM – 04.00 PM	54.3	67.0	51.3	51.9	51.7
11	04.00 PM – 05.00 PM	54.3	63.9	51	47.6	51.7
12	05.00 PM – 06.00 PM	53.4	69.8	47.9	53.8	52.3
13	06.00 PM – 07.00 PM	54	65.9	45.9	47.3	52.3
14	07.00 PM – 08.00 PM	52.5	67.4	48.6	49.6	52.8
15	08.00 PM – 09.00 PM	49.4	67.5	50.7	50.3	55.1
16	09.00 PM – 10.00 PM	44.9	64.7	51.3	51.5	52.8
17	10.00 PM – 11.00 PM	43.5	60.7	46.4	44.2	43.4
18	11.00 PM – 12.00 PM	44.9	53.7	46.2	44.4	43.6
19	12.00 PM – 01.00 AM	44	53.9	46	44.0	42.6
20	01.00 AM – 02.00 AM	45.0	54.5	45.2	44.5	43.3
21	02.00 AM – 03.00 AM	45.4	53.1	44.7	45.0	43.0
22	03.00 AM – 04.00 AM	44.8	55	44	44.5	43.5
23	04.00 AM – 05.00 AM	44.3	57.4	44.1	44.5	42.8
24	05.00 AM – 06.00 AM	44.2	61.9	45.7	45.2	43.7

Table 3.44 Noise Level at Locations N6, N7, N8, N9, N10

Sl. No.	Hourly Interval	Hourly Leq Values at				
		N6 Chengannur	N7 Manarcaud	N8 Kottayam	N9 Piravom	N10 Irumpanam
1	06.00 AM – 07.00 AM	42.4	47.5	44.3	42.3	43.5
2	07.00 AM – 08.00 AM	51.3	51.0	53.0	53.2	54.0
3	08.00 AM – 09.00 AM	52.2	52.2	53.2	54.4	54.3
4	09.00 AM – 10.00 AM	50.6	51.2	52.8	53.3	53.3
5	10.00 AM – 11.00 AM	51.6	51.6	54.1	56.1	54.3
6	11.00 AM – 12.00 AM	51.2	51.0	54.9	59.9	53.3
7	12.00 AM – 01.00 PM	52.9	52.8	55.4	55.9	54.0
8	01.00 PM – 02.00 PM	52.1	52.0	54.5	54.9	53.3
9	02.00 PM – 03.00 PM	51.2	51.0	54.4	54.4	54.2
10	03.00 PM – 04.00 PM	52.0	51.9	53.9	54.4	52.9
11	04.00 PM – 05.00 PM	52.0	51.9	54.3	54.3	49.6
12	05.00 PM – 06.00 PM	51.8	51.7	53.4	53.4	45.4
13	06.00 PM – 07.00 PM	52.4	52.5	53.7	54.2	44.8
14	07.00 PM – 08.00 PM	50.3	52.6	51.9	52.7	45.0
15	08.00 PM – 09.00 PM	50.5	52.7	49.3	49.3	43.2
16	09.00 PM – 10.00 PM	49.3	51.5	49.0	49.0	43.4
17	10.00 PM – 11.00 PM	42.8	45.4	44.6	42.3	43.2
18	11.00 PM – 12.00 PM	41.9	44.9	44.6	43.1	43.2
19	12.00 PM – 01.00 AM	41.8	42.8	43.9	41.5	42.2
20	01.00 AM – 02.00 AM	43.1	42.5	45.1	41.3	43.9
21	02.00 AM – 03.00 AM	42.4	43.2	42.9	41.0	41.6
22	03.00 AM – 04.00 AM	41.9	44.1	44.0	40.9	42.2
23	04.00 AM – 05.00 AM	41.7	42.5	43.4	42.9	44.5
24	05.00 AM – 06.00 AM	42.0	44.6	45.2	41.7	43.1

Table 3.45 Noise Level at Locations N11, N12, N13

Sl.No.	Hourly Interval	Hourly Leq Values at		
		N 11 Near Sanskara School, Kakkanad	N 12 Info Park, Kakkanad	N 13 Near Airport, Nedumbassari
1	06.00 AM – 07.00 AM	44.7	50.3	59.7
2	07.00 AM – 08.00 AM	46.3	50.0	60.3
3	08.00 AM – 09.00 AM	46.9	54.1	60.0
4	09.00 AM – 10.00 AM	45.0	52.3	60.7
5	10.00 AM – 11.00 AM	43.9	57.0	59.8
6	11.00 AM – 12.00 AM	43.1	56.8	61.4
7	12.00 AM – 01.00 PM	43.3	62.0	57.6
8	01.00 PM – 02.00 PM	46.1	62.5	56.7
9	02.00 PM – 03.00 PM	45.3	62.6	56.8
10	03.00 PM – 04.00 PM	47.2	61.8	57.2
11	04.00 PM – 05.00 PM	46.8	62.3	56.9
12	05.00 PM – 06.00 PM	46.2	62.0	56.8
13	06.00 PM – 07.00 PM	45.4	60.9	57.5
14	07.00 PM – 08.00 PM	43.4	56.8	58.1
15	08.00 PM – 09.00 PM	41.9	55.8	59.9
16	09.00 PM – 10.00 PM	42.1	54.8	59.9
17	10.00 PM – 11.00 PM	42.7	54.8	59.3
18	11.00 PM – 12.00 PM	42.1	53.0	59.4
19	12.00 PM – 01.00 AM	42.4	58.7	59.6
20	01.00 AM – 02.00 AM	40.8	51.9	50.1
21	02.00 AM – 03.00 AM	40.8	47.6	61.1
22	03.00 AM – 04.00 AM	41.0	53.8	59.7
23	04.00 AM – 05.00 AM	41.0	47.3	59.1
24	05.00 AM – 06.00 AM	43.4	49.6	60.3

Table 3.46 Noise Level at Locations N14, N15, N16, N17

Sl.No.	Hourly Interval	Hourly Leq Values at			
		N14 Thrissur RS	N15 Pookunnam	N16 Tirur RS	N17 Kadalundi
1	06.00 AM – 07.00 AM	48.9	64.1	44.8	49.6
2	07.00 AM – 08.00 AM	51.6	66.0	48.6)	51.8
3	08.00 AM – 09.00 AM	56.0	61.2	50.1	53.1
4	09.00 AM – 10.00 AM	55.0	68.4	56.0)	52.6
5	10.00 AM – 11.00 AM	66.0	69.1	53.0	58.1
6	11.00 AM – 12.00 AM	60.6	76.0	52.4	50.1
7	12.00 AM – 01.00 PM	58.4	70.1	51.0	49.6
8	01.00 PM – 02.00 PM	59.1	78.6	48.6	56.8
9	02.00 PM – 03.00 PM	50.4	80.2	52.4	55.1
10	03.00 PM – 04.00 PM	51.6	80.4	56.5	54.1
11	04.00 PM – 05.00 PM	50.5	78.6	48.4	56.8
12	05.00 PM – 06.00 PM	59.4	69.6	49.6	49.6
13	06.00 PM – 07.00 PM	56.6	61.2	48.4	48.4
14	07.00 PM – 08.00 PM	50.1	71.2	50.4	48.6
15	08.00 PM – 09.00 PM	49.0	54.6	52.6	44.6
16	09.00 PM – 10.00 PM	51.2	50.8	46.4	49.4
17	10.00 PM – 11.00 PM	55.1	56.4	44.6	50.1
18	11.00 PM – 12.00 PM	50.0	46.8	40.6	40.6
19	12.00 PM – 01.00 AM	46.2	48.1	39.6	40.0
20	01.00 AM – 02.00 AM	44.0	40.6	38.0	48.4
21	02.00 AM – 03.00 AM	40.6	44.4	35.6	39.9
22	03.00 AM – 04.00 AM	38.4	40.2	35.0	38.6
23	04.00 AM – 05.00 AM	39.6	48.2	36.4	46.8
24	05.00 AM – 06.00 AM	42.9	54.6	37.6	50.4

Table 3.47 Noise Level at Locations N18, N19, N20, N21, N22

Sl. No.	Hourly Interval	Hourly Leq Values at				
		N18 Kozhikode RS	N19 L P school, Kothamangalam	N20 Kannur Rs	N21 Kalanad	N22 Kasaragod RS
1	06.00 AM – 07.00 AM	59.1	40.6	46.4	37.2	60.4
2	07.00 AM – 08.00 AM	61.1	41.4	54.6	39.1	71.1
3	08.00 AM – 09.00 AM	58.9	43.4	60.4	43.4	69.4
4	09.00 AM – 10.00 AM	63.6	50.4	66.8	46.8	73.1
5	10.00 AM – 11.00 AM	66.0	53.6	60.1	50.2	70.6
6	11.00 AM – 12.00 AM	74.2	59.4	54.6	46.4	71.2
7	12.00 AM – 01.00 PM	70.1	60.2	51.6	48.2	76.5
8	01.00 PM – 02.00 PM	69.2	59.6	52.0	49.2	70.1
9	02.00 PM – 03.00 PM	71.1	64.2	64.0	51.2	82.1
10	03.00 PM – 04.00 PM	70.2	58.6	60.1	47.4	68.4
11	04.00 PM – 05.00 PM	69.4	50.2	56.8	49.2	56.6
12	05.00 PM – 06.00 PM	68.9	44.1	58.0	47.2	64.8
13	06.00 PM – 07.00 PM	54.6	40.2	51.2	48.4	59.6
14	07.00 PM – 08.00 PM	55.0	42.4	49.6	49.0	62.4
15	08.00 PM – 09.00 PM	50.2	41.1	50.4	48.6	60.1
16	09.00 PM – 10.00 PM	56.4	39.6	48.6	49.0	58.6
17	10.00 PM – 11.00 PM	49.6	39.9	47.4	43.1	71.6
18	11.00 PM – 12.00 PM	46.0	40.0	41.2	40.0	65.4
19	12.00 PM – 01.00 AM	51.2	41.6	39.6	38.2	52.1
20	01.00 AM – 02.00 AM	50.6	38.4	38.4	35.2	44.1
21	02.00 AM – 03.00 AM	53.6	36.4	35.2	35.1	49.6
22	03.00 AM – 04.00 AM	53.0	35.1	34.0	34.8	56.5
23	04.00 AM – 05.00 AM	60.4	36.0	35.1	36.1	60.2
24	05.00 AM – 06.00 AM	58.2	38.4	38.4	36.4	66.8

Table 3.48 Noise Level Values dB (A) Leq at Locations N1..... N22

Location code	Noise Level Values dB(A)								*CPCB Standard Leq dB(A)	
	L ₁₀	L ₅₀	L ₉₀	L _{DN}	L _{Day}	L _{Night}	L _{Max}	L _{Min}	Day	Night
N 1	57.62	50.4	42.3	54.4	54.5	44.4	65.5	41.1	55	45
N 2	71.21	65.7	52.9	68.7	68.4	59.2	78.7	48.8		
N 3	56.4	48	42	53.4	51.6	45.4	72.6	36		
N 4	59	48	42	53.9	53.4	44.5	69.7	35		
N 5	56.9	49	41.3	52.7	52.3	43.3	59.9	35		
N 6	56.5	47.8	40.9	51.8	51.5	42.2	61.2	36.1		
N7	56.6	49.2	41.9	53.0	51.9	44.5	60.5	38.5		
N8	56.61	50.8	41.3	53.8	53.5	44.3	63.2	38.5		
N9	58.1	50.8	40.7	53.9	54.7	42.0	65.5	39.6		
N10	55.3	48.1	40.7	52.4	52.0	43.1	63.7	39.2		
N 11	48.6	43.1	40.4	49.3	45.2	42.3	60.7	38.6		
N 12	63.9	56.8	46.5	61.4	59.7	53.4	74.1	35.0		
N 13	61.7	58.8	56.7	66.1	59.8	58.9	82.3	54.9		
N 14	59.4	50.5	40.6	58.1	54.4	43.1	66.0	38.4		
N 15	78.6	61.2	44.4	73.1	68.0	46.1	80.4	40.2		
N 16	53.0	48.4	36.4	51.5	50.1	37.5	56.5	35.0		
N 17	56.8	49.6	40.0	55.2	51.6	43.5	58.1	38.6		
N 18	70.2	58.9	50.2	67.3	62.8	53.2	74.2	46.0		
N 19	59.6	41.4	36.4	54.9	48.8	37.9	64.2	35.1		
N 20	60.4	50.4	35.2	57.7	54.8	37.4	66.8	34.0		
N 21	49.2	46.4	35.2	48.3	44.7	36.5	51.2	34.8		
N 22	73.1	64.2	52.1	73.6	67.4	56.3	82.1	44.1		

*Limit is applicable for Residential area

Noise level measurements were made at the vicinity of 11 planned station locations along the SilverLine route and sensitive areas like schools, hospitals, industrial areas, etc. In a few locations the Leq exceeded the noise level of 55 dB and also the night time of 45 dB for residential areas. Except for two locations, it was below the limits for all commercial areas.

Table 3.49 Ambient Noise Standards (CPCB)

Area Category	Day Time (dBA)	Night Time (dBA)
A. Industrial Area	75	70
B. Commercial Area	65	55
C. Residential Area	55	45
D. Silence Zone	50	40

(The day time is between 6 a.m. and 10 p.m. whereas night time is 10 p.m. to 6 a.m.)

It can be inferred that the higher noise levels are as a result of mostly the noise from automobiles due to the locations being in urban areas. Having high density and spread of population as well as being a developed state with high vehicle population, high noise level compared to the limits prescribed is considered to be a natural phenomenon. Every where along the alignment, there are commercial areas as well as small and medium industries contributing to noise in addition the vehicles. It is a peculiar experience of Kerala having concentration of many industries near to households which can be attributed to the higher noise levels in certain locations.

However, levels at other areas were mostly low during day and night time. Due to construction work, the operation of construction machinery and running of construction vehicles is expected and will produce noise and may impact to residences in the vicinity. Although the specific number of construction vehicles is not yet determined, the amount of noise from construction machinery shall be assumed par below. However, the SilverLine will not generate higher noise compared to the present level because the tracks and rolling stocks are designed and operated in such way to reduce noise levels. Noise level measurements are made across different receptors like residential area, business areas, schools, hospitals and at proposed railway stations.

Noise level measurements were also made near to the track when trains are passing. The noise levels were recorded at a distance of 12.5 m from the track and 25 m from the track (Table 3.50). The levels were recorded when express and goods trains were passing. By

measuring the level of noise produced by the conventional trains, a comparison can be made with the noise of semi high speed trains which use noise reduction technologies.

Table 3.50 Noise level near track when train is passing

Train type	Latitude	Longitude	Highest noise level, dB	
			12.5 m from track	25 m from track
Express train	10° 59'57.79"N	75° 52'30.71"E	94.5	81.1
Goods train	10° 59'57.79"N	75° 52'30.71"E	98.6	84.5
Express train	10° 09'33.005"N	76° 22'50.734 E	95.6	80.9

3.9.2 Vibration Assessment

In India, railway locomotives are exempted from the provisions of "The Noise Pollution (Regulation and Control) Rules 2000. These rules are also silent regarding the limits for ground borne vibrations and noise. In India there are no standards for construction vibration. Standards provided in the FTA guidance manual (FTA 2006) guidelines for construction machinery assessment is followed in India. Table 3.51 shows the criteria for vibration effects on buildings and Table 3.52 shows vibration criterion level by land use category.

Table 3.51 Construction Vibration Damage Criteria

Building Category	PPV (inch/sec)	Approximate L _v ^a
Reinforced concrete, steel, or timber (no plaster)	0.5	102
Engineered concrete and masonry (no plaster)	0.3	98
Non-engineered timber and masonry buildings	0.2	94
Buildings extremely susceptible to vibration damage	0.12	90

^aAn RMS vibration velocity level in VdB relative to 1 micro-inch/second.

Source: FTA (2006)

Table 3.52 Approximate Distances to Vibration Criterion-Level Contours

Land Use Category	Vibration Criterion Level (VdB)	App Vibration Contour Distance (feet)
Tracts of land where quiet is an essential element in their intended purpose (E.g., outdoor amphitheatres, National Historic Landmarks, etc.)	65	175
Residences and buildings where people normally sleep (E.g., homes, hospitals, etc.)	72	130
Institutional land uses with primarily daytime and evening use (E.g., schools, churches, etc.)	75	70

Source: FTA (2006)

Construction activities usually produce vibration levels that may disturb people living nearby. Blasting below the surface would produce lower vibration levels at a receptor due to additional attenuation provided by distance and transmission through soil and rock. The ground borne vibration impacts may be perceptible to people who are outdoors, but does not cause a strong adverse human reaction. Table 3.53 shows the recommended typical levels of vibration for construction equipment by FTA. On the basis of reference values of vibration at 25 feet, an impact at 75 feet, 100 feet and 150 feet are calculated.

Table 3.53 Typical Levels of Vibration for Construction Equipment

Construction Activity	VdB at 25 Feet	VdB at 75 Feet	VdB at 100 Feet	VdB PPV at 150 Feet
Rock drilling	115.9	101.6	97.9	94.3
Dump trucks	122.7	108.3	104.6	99.3
Bulldozer	124.0	109.7	106.0	100.7
Excavator 0.089, 106	124.0	109.7	106.0	100.7
Crane 0.808, 87	143.2	128.9	125.1	119.8

Source: FTA, 2006

3.10 Land Environment

3.10.1 Land use Land Cover (LULC)

Land use land cover (LULC) pattern of Kerala State is given in Fig 3.23. As per the land use data of 2017-18, out of a total geographical area of 38.86 lakh ha, total cultivated area is 25.79 lakh ha (66 %) and the net area sown is 20.40 lakh ha (52 %). Out of the total geographical area (38864.9 km²) of the state, as much as 60% area is under agriculture. The recorded forest area in the state is 11,309 km² which is 29.11% of the state's total geographical area (FSI, 2019).

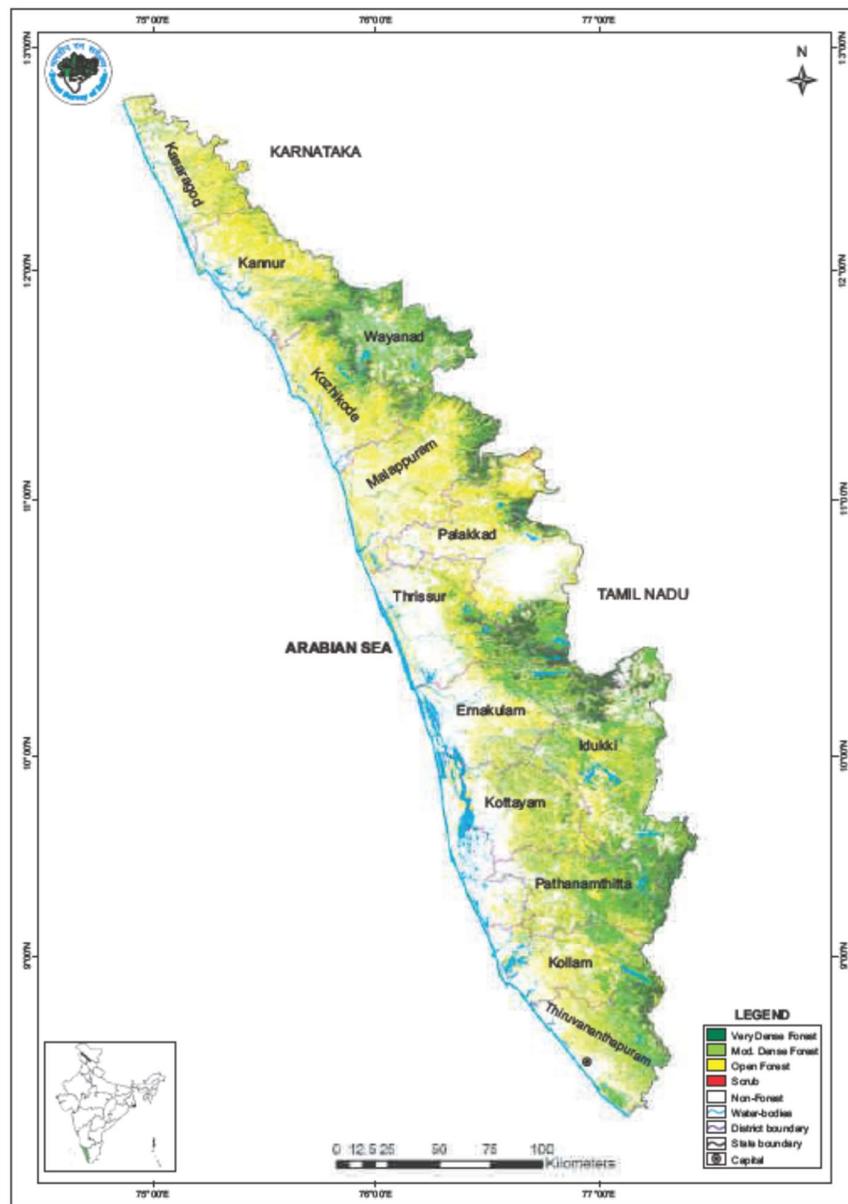


Fig. 3. 23 LULC Map of Kerala (FSI, 2019)

Forests and tree resources in the State can be broadly grouped into (a) those that are categorized as forests primarily under Government ownership and management and (b) trees outside forests. On comparing the 2019 FSI data with 2017, increase in forest cover is recorded in 10 Districts viz., Alappuzha, Ernakulam, Idukki, Kannur, Kasaragod, Kottayam, Malappuram, Palakkad, Pathanamthitta and Thrissur, while decrease is observed in Kollam, Kozhikode and Thiruvananthapuram Districts (Table 3.54).

Table 3.54 District wise Tree Cover, Kerala

District	Geographical Area (GA)	2019 Assessment				% of GA	Change wrt 2017 assessment	Scrub
		Very Dense Forest	Mod. Dense Forest	Open Forest	Total			
Alappuzha	1,415	0.00	27.00	52.90	79.90	5.65	11.90	0.00
Ernakulam TH	3,063	167.01	615.03	583.67	1,365.71	44.59	92.71	0.00
Idukki TH	4,356	348.36	1,795.63	1,006.66	3,150.65	72.33	11.65	0.93
Kannur TH	2,961	58.00	485.88	1,110.09	1,653.97	55.86	92.97	0.00
Kasaragod TH	1,989	1.90	294.31	670.27	966.48	48.59	19.48	0.00
Kollam TH	2,483	104.00	657.25	561.26	1,322.51	53.26	-33.49	0.00
Kottayam	2,206	12.00	531.95	560.34	1,104.29	50.06	137.29	0.00
Kozhikode ^H	2,345	70.81	409.89	956.27	1,436.97	61.28	-47.03	0.00
Malappuram TH	3,554	142.59	424.08	1,414.66	1,981.33	55.75	170.33	0.50
Palakkad TH	4,482	403.36	636.72	1,043.51	2,083.59	46.49	257.59	11.69
Pathanamthitta	2,652	161.95	1,235.81	557.76	1,955.52	73.74	125.52	0.00
Thiruvananthapuram TH	2,189	57.00	697.88	549.05	1,303.93	59.57	-23.07	0.00
Thrissur	3,027	218.86	475.81	464.55	1,159.22	38.30	7.22	0.25
Wayanad TH	2,130	188.99	1,221.00	170.23	1,580.22	74.19	0.22	0.00
Grand Total	38,852	1,934.83	9,508.24	9,701.22	21,144.29	54.42	823.29	13.37

Source: FSI, 2019

3.10.2 Soil Quality

In general, the soils of Kerala are acidic, kaolintic and gravelly with low CEC (Cation Exchange Capacity), low water holding capacity and high phosphate fixing capacity. Climate, topography, vegetation and hydrological conditions are the dominant factors of soil formation. On the basis of the morphological features and physico-chemical properties, the soils of the State have been classified into red loam, laterite coastal alluvium, riverine alluvium, Onattukara alluvium, brown hydromorphic, saline hydromorphic, Kuttanad alluvium, black soil and forest loam. As part of the study, soil samples were collected from 16 locations (Table 3.55) along the alignment including stations and depots sites and

analyzed. Soil sampling photograph is presented in Annexure 5. The results of soil quality analysis are given in Tables 3.56 to 3.60).

Table 3.55 Soil sampling locations

SI No.	Sampling location code	Latitude	Longitude	Sampling Locations
1	S1	8° 30' 44.88"N	76° 53' 52.43"E	Kochuveli, Proposed RS
2	S2	8° 44' 26.26"N	76° 48' 25.77"E	Thottakkad (Near NH)
3	S3	8° 53' 40.55"N	76° 39' 27.09"E	Kollam, Mukhathala, Proposed RS
4	S4	9° 20' 19.873"N	76° 38' 37.926"E	Chengannur, Proposed RS
5	S5	9° 34' 39.821"N	76° 32' 22.523"E	Muttampalam, Kottayam, Proposed RS
6	S6	10° 0' 31.564"N	76° 22' 38.743"E	Near Info park, Ernakulam, Proposed RS
7	S7	10°30'32.13"N	76°12'23.95"E	Thrissur Railway Station (Proposed)
8	S8	10°55'42.94"N	75°54'51.97"E	Tirur Railway Station
9	S9	10°32'5.05"N	76°12'54.21"E	Near TirurPonnani Road
10	S10	11°14'45.53"N	75°46'49.44"E	Kozhikode Railway Station
11	S11	11°29'51.81"N	75°38'35.13"E	Near Purakkad - Muchukunnu Road
12	S12	11°36'59.29"N	75°35'52.25"E	Near Chathamangalarn
13	S13	11°53'3.43"N	75°22'5.36"E	Kannur Railway Station
14	S14	12°16'7.59"N	75° 6'59.24"E	Near Nambrikal Dam
15	S15	12°29'31.56"N	74°59'11.32"E	Kasaragod Railway Station
16	S16	12°30'29.48"N	74°58'33.59"E	Kasaragod Depo

**Table 3.56 Characteristics of Soil samples – Thiruvananthapuram and Kollam Districts
(Kochuveli, Thottakkad, Mukhathala)**

Parameters	Unit	Locations			
		S1- Kochuveli, Thiruvananthapuram	S2- Thottakkad, Thiruvananthapuram	S3- Mukathala, Kollam	
pH		6.36	5.16	4.77	
Colour	Color Unit	Light Brown	Light Brown	Light Brown	
Conductivity	dS/m	0.027	0.061	0.019	
Porosity	%	51.76	57.31	58.94	
Bulk Density	gm/cm ³	1.401	1.068	1.0844	
Moisture Content	%	80.09	79.58	79.09	
Water Holding Capacity	%	46.34	44.32	47.17	
Organic Carbon	%	3.20	5.48	4.52	
Organic Matter	%	5.52	9.45	7.79	
Available Nitrogen as N	%	0.07	0.04	0.09	
Available Phosphorus	%	ND	ND	ND	
Orthophosphate	mg/kg	ND	ND	ND	
Sulphate	mg/kg	4.2	3.4	4.6	
Cation Exchange Capacity	meq/100g	6.27	5.79	6.32	
Calcium as Ca	mg/kg	34.76	64.41	69.31	
Magnesium as Mg	mg/kg	42.32	39.21	42.19	
Sodium as Na	mg/kg	21.72	35.43	20.93	
Potassium as K	mg/kg	75.59	83.73	79.12	
Chloride as Cl	mg/kg	424.52	442.57	449.17	
Bicarbonates	mg/kg	ND	ND	ND	
Iron as Fe	mg/kg	10.99	9.73	8.25	
Zinc as Zn	mg/kg	BDL(MDL-0.010)	BDL(MDL-0.010))	BDL(MDL-0.010))	
Copper as Cu	mg/kg	22.48	33.17	18.37	
Texture	Sand	%	69.12	69.27	63.39
	Silt	%	0.11	0.03	0.03
	Clay	%	30.77	30.7	36.58

Note: BDL – Below Detection Level, MDL-Minimum Detection Level

Table 3.57 Characteristics of Soil samples – Alappuzha Kottayam and Ernakulam Districts (Chengannur, Kottayam and Ernakulam)

Parameters	Unit	Locations			
		S4- Chengannur	S5- Kottayam	S6- Ernakulam	
pH		5.58	4.91	5.50	
Colour	Color Unit	Light Brown	Light Brown	Light Brown	
Conductivity	dS/m	0.048	0.045	0.105	
Porosity	%	52.54	54.56	50.98	
Bulk Density	gm/cm ³	1.120	1.201	1.0	
Moisture Content	%	79.28	78.76	79.08	
Water Holding Capacity	%	47.17	45.24	43.13	
Organic Carbon	%	3.80	3.83	2.97	
Organic Matter	%	6.56	6.61	5.12	
Available Nitrogen as N	%	0.13	0.1	0.04	
Available Phosphorus	%	ND	ND	ND	
Orthophosphate	mg/kg	ND	ND	ND	
Sulphate	mg/kg	3.1	3.0	5.2	
Cation Exchange Capacity	meq/100g	5.93	6.16	6.10	
Calcium as Ca	mg/kg	31.47	75.59	76.11	
Magnesium as Mg	mg/kg	38.32	22.40	46.33	
Sodium as Na	mg/kg	18.09	21.44	17.43	
Potassium as K	mg/kg	74.75	93.84	67.21	
Chloride as Cl	mg/kg	237.47	189.67	201.86	
Bicarbonates	mg/kg	ND	ND	ND	
Iron as Fe	mg/kg	11.17	10.24	9.64	
Zinc as Zn	mg/kg	BDL(MDL-0.010)	BDL(MDL-0.010)	BDL(MDL-0.010)	
Copper as Cu	mg/kg	23.89	38	23.20	
Texture	Sand	%	63.44	63.36	63.62
	Silt	%	0.01	0.02	0.061
	Clay	%	36.55	36.62	36.32

ND – Not Detected. BDL – Below Detection Limit, MDL – Minimum Detection Limit

Table 3.58 Characteristics of Soil samples – Thrissur, Malappuram and Kozhikode Districts (Trissur, Tirur, Kozhikode)

Parameters	Unit	Locations				
		S7- Trissur	S8- Tirur	S9- Tirur- Ponnani Road	S10- Kozhikode	
pH	-	5.65	6.51	6.51	6.23	
Colour	--	Reddish Brown	Black Brown	Light Brown	Red	
Conductivity	dS/m	0.015	0.05	0.029	0.03	
Porosity	%	14.1	21.3	15.7	9.8	
Bulk Density	gm/cm ³	1.430	1.463	1.478	1.452	
Moisture Content	%	14.06	12.8	8.56	15.2	
Water Holding Capacity	%	32.12	36.5	9.7	46.3	
Organic Carbon	%	2.1	2.6	3.09	0.63	
Organic Matter	%	3.6	4.48	5.32	1.08	
Available Nitrogen as N	%	0.07	0.12	0.07	0.08	
Available Phosphorus	%	0.08	0.05	0.07	0.04	
Orthophosphate	mg/kg	248	187	243.3	174.9	
Sulphate	mg/kg	236	198	294	165	
Cation Exchange Capacity	meq/100gm	16.7	19.4	19.7	17.8	
Calcium as Ca	mg/kg	580	412	783	367	
Magnesium as Mg	mg/kg	321	89.6	118	58.5	
Sodium as Na	mg/kg	207	68	167.8	63.5	
Potassium as K	mg/kg	60	32.6	49.3	34.5	
Chloride as Cl	mg/kg	19.6	13.93	29.8	18.57	
Bicarbonates	mg/kg	10.2	13.6	4.1	9.1	
Iron as Fe	%	1.32	0.74	0.61	0.36	
Zinc as Zn	mg/kg	1.83	2.32	3.45	1.63	
Copper as Cu	mg/kg	15.4	7.8	ND	ND	
Texture	Sand	%	73	80	74	50
	Silt	%	19	16	20	26
	Clay	%	8	4	6	2

ND – Not Detected. BDL – Below Detection Limit, MDL – Minimum Detection Limit

Table 3.59 Characteristics of Soil samples – Kannur District

Parameters	Unit	Locations			
		S11- Purakkad - Muchukunnu Road	S12- Chathamangalarn	S13- Kannur	
pH	-	5.87	6.03	6.81	
Colour	--	Dark Brown	Dark Brown	Light Red	
Conductivity	dS/cm	0.13	0.04	0.04	
Porosity	%	18.4	9.8	8.6	
Bulk Density	gm/cm ³	1.430	1.435	1.423	
Moisture Content	%	26.44	20.5	21.7	
Water Holding Capacity	%	12.85	47.2	46.3	
Organic Carbon	%	2.91	0.54	0.58	
Organic Matter	%	5.01	0.93	0.99	
Available Nitrogen as N	%	0.05	0.06	0.13	
Available Phosphorus	%	0.068	0.04	0.08	
Orthophosphate	mg/ kg	209	214	165	
Sulphate	mg/ kg	249	203	326	
Cation Exchange Capacity	meq/100gm	15.4	16.5	16.3	
Calcium as Ca	mg/ kg	535	369	326	
Magnesium as Mg	mg/ kg	43.29	89.6	95.6	
Sodium as Na	mg/ kg	80.97	62.3	65.4	
Potassium as K	mg/1 kg	26.99	32.4	28.9	
Chloride as Cl	mg/1 kg	24.7	23.1	17.5	
Bicarbonates	mg/ kg	3.6	6.3	13.6	
Iron as Fe	%	0.33	0.78	0.46	
Zinc as Zn	mg/ kg	ND	2.6	1.63	
Copper as Cu	mg/kg	18.9	12.0	ND	
Texture	Sand	%	42	68	80
	Silt	%	30	22	18
	Clay	%	28	10	2

ND – Not Detected. BDL – Below Detection Limit, MDL – Minimum Detection Limit

Table 3.60 Characteristics of Soil samples –Kasaragod District

Parameters	Unit	Locations			
		S14- Near Nambrikal Dam	S15- Kasaragod RS	S16- Kasaragod Depo	
pH	-	5.14	6.05	6.21	
Colour	--	Light Brown	Coffee Brown	Brown	
Conductivity	dS/m	0.023	0.04	0.027	
Porosity	%	11.7	12.7	13.7	
Bulk Density	gm/cm ³	1.427	1.432	1.416	
Moisture Content	%	17.73	21.4	13.6	
Water Holding Capacity	%	47.1	38.5	41.9	
Organic Carbon	%	0.29	0.87	1.43	
Organic Matter	%	0.49	1.49	2.46	
Available Nitrogen as N	%	0.07	0.09	0.13	
Available Phosphorus	%	0.04	0.05	0.07	
Orthophosphate	mg/kg	137	210	243	
Sulphate	mg/kg	187	176	210	
Cation Exchange Capacity	meq/100gm	18.7	10.6	13.7	
Calcium as Ca	mg/kg	483	312	632	
Magnesium as Mg	mg/kg	97	21	251	
Sodium as Na	mg/kg	56.9	63.7	85	
Potassium as K	mg/kg	8.12	32.6	10.3	
Chloride as Cl	mg/kg	32.6	36.2	21.7	
Bicarbonates	mg/kg	5.8	9.7	3.2	
Iron as Fe	%	0.23	0.94	0.74	
Zinc as Zn	mg/kg	0.65	ND	ND	
Copper as Cu	mg/kg	10.5	26.0	8.5	
Texture	Sand	%	78	81	76
	Silt	%	20	11	22
	Clay	%	2	8	2

ND – Not Detected. BDL – Below Detection Limit, MDL – Minimum Detection Limit

In India there is no standards for soil pollution. Analysis of the soil samples revealed no soil pollution in the vicinity of the planned route. During construction phase, spillage during refueling and faulty maintenance of construction machinery among other factors may possibly pollute the soil. Micro nutrients in the soils were low and hence the soil along the alignment and at the proposed stations is not suited for cultivation.

3.11 Biological Environment: Ecology and Biodiversity

The state harbours 5094 taxa under 1537 genera and 221 families of flowering plants (Sasidharan, 2012). A total of 1709 taxa that are endemic to Peninsular India are found in Kerala; of which 237 species distributed in 47 families are exclusively endemic to the present political boundary of the state (Nayaret *al.*, 2008). There are about 1170 species with established medicinal properties. The flowering plants of Kerala include 858 exotics that have been introduced as agriculture, forestry as well as accidentally entered species (Sasidharan, 2012); of which around 200 species have become naturalized in the state. Kerala with only 1.2% of India's landmass harbors 25.69% of flowering plant species and 26.59% of Pteridophytes recorded in India. Vertebrate diversity of Kerala is represented by 1,847 species in 330 families and 81 orders with Fishes (freshwater and marine) the most diverse group of vertebrates (905 species), followed by birds (500 species), reptiles (173 species), amphibians (151 species) and mammals (118 species). Out of 779 marine species, 93 per cent is not included in any Schedules of Wildlife Protection Act. The highest level of endemism (between 77-102 species per sub basin) and highest species richness (133-160 species per sub basin) is found in the west flowing rivers namely Chaliyar, Bharatapuzha, Chalakkudy, Periyar, and Pamba with point endemics in certain cases. The identification of flora/ fauna parallel to the corridor site and surrounding was done with personal observations along with review of secondary data.

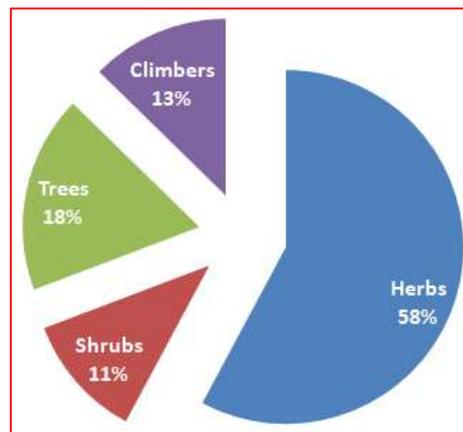
3.11.1 Flora

A preliminary field survey was carried out in November-December 2019 to provide detailed profile and baseline of the biological environment parallel to the proposed alignment. The vascular plants present in and around 15 m on both sides of the central line of the final alignment of the proposed semi highspeed railway provided by K-Rail. During one-time extensive field study along the area mentioned, identification of the plants on the spot for common species and taking photographs of the suspected species and confirmation by using referring various flora. The IUCN Red List were confirmed by Rdlisted species Version 2019-1 (<https://www.iucnredlist.org/>). The endemic plants were confirmed by referring Ahmedullah and Nayar (1987), Nayar et.al (2014) and Sasidharan (2012). The medicinal

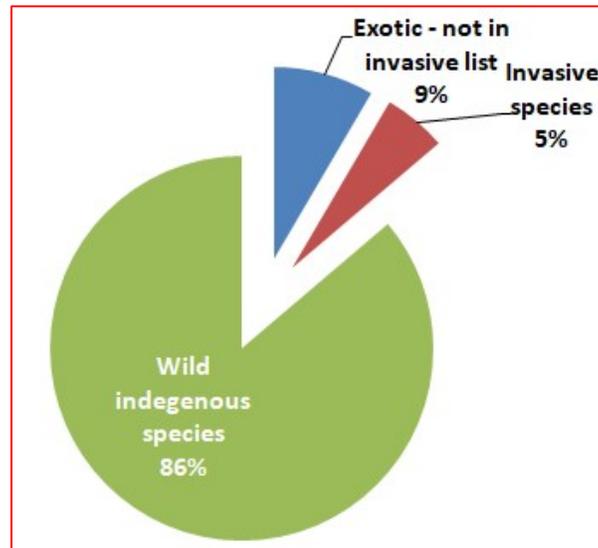
use status of the plants were arrived by the consulting the ENVIS website for medicinal plants by FRLHT (http://envis.frlht.org/bot_search).

The present study identified 806 species of vascular plants along and area close to the proposed alignment (**Annexure- 2**). Out of the 806 species, 575 are Dicotyledons, 223 Monocotyledons, 1 Gymnosperms and 7 Pteridophytes. The plants come under 124 families. The largest family is Fabaceae - 78 species followed by Poaceae (70), Cyperaceae (65), Euphorbiaceae (40), Scrophulariaceae (33), Asteraceae (32) and Rubiaceae (22, Acanthaceae and Convolvulaceae (21 each), Apocynaceae (18), Araceae (15), Amaranthaceae and Verbanaceae (14 each), (14), Eriocoulaceae (13), Moraceae (12), Lythraceae (11), Commelinaceae (10), Lentibulariaceae and Malvaceae (10 each). There are 50 families with only one species recorded.

Majority of the riparian flora recorded are herbs (466 - out of which 258 are annuals and 208 perennials.), followed by trees (146), climbers (102) and shrubs (92). Out of the 446 herbs, 247 are aquatic or semi aquatic with distribution restricted to the running/stagnant water or water logged/wet areas like marshes, paddy fields, ponds etc. 20 out of 146 tree species are true riparian species growing close to the water flowing areas -8 are mangrove species. 16 out of 92 shrubs identified 16 are restricted to the immediate boundary of the river -5 true mangrove species and 4 mangrove associates. 11 out of the 102 climbing plants identified are true riparian species -4 mangrove associates. All the 7 pteridophyte species are restricted to the riparian areas and one is mangrove associate. 66 out of the 806 species are cultivated species. 111 exotic species of which 43 species are included in the 82 invasive species of Kerala identified by Sankaran et.al. (2013).



Habit wise Distribution Pattern of Species



Distribution Pattern of Floristic Elements

3.11.2 Rare and Endangered Flora

Out of 806 species identified, 7 species are listed in the Red List Version 2019-1 (<https://www.iucnredlist.org/>); 50 species are Endemic to various regions of India viz. Peninsular India, Western Ghats, Southern Western Ghats, Kerala etc.; 297 species are used in various systems of medicine other than folk medicine; and 97 species having utility for local livelihood, capacity protect river banks. Purify polluted water etc.

Critically endangered (CR) Species

- *Vateria indica* (Sacred Grove, Edapal)

Endangered Species

- *Hopea ponga* (Chettipadi –Railway land)
- *Kingiodendron pinnatum* and (Sacred Grove-Edapal)
- *Limnopoamee boldii* (Kol lands-Near Muriyad)

Vulnerable Species

- *Dalbergia latifolia* (River banks- Vynthala)
- *Hydnocarpus pentandrus* (Madayipara)
- *Mallotus atrovirens* (River bank – Feroke)

Species Endemic to Kerala

- *Arundinellacannanorica* (Madayipara)
- *Bhideafischeri* (Madayipara)
- *Heliotropiumkeralense* (River sides and wet paddy fields, Malappuram and Thrissur districts)
- *Justicia ekakusuma* (Madayipara)
- *Lepidagathiskeralensis* (Madayipara)
- *Limnopoameeboldii* (Kol lands-Thrissur)
- *Linderniamanilaliana* (Near Kadalundi)
- *Nymphoideskrishnakesara* (Near Kadalundi)
- *Rotalamalabarica* (Madayipara)
- *Rotalamalampuzhensis* (Madayipara)

Species Endemic to Southern Western Ghats

- *Aponogetonappendiculatus* (Kol lands-Thrissur)
- *Artocarpushirsutus* (All districts)
- *Calamus travancoricus* (Sacred Grove-Edapal)
- *Cinnamomummalabratrum* (Homesteads – All districts)
- *Dalbergiahorrada* (Sacred Grove-Edapal)
- *Holigarnaarnottiana* (river banks almost all districts)
- *Hopeaponga* (Chettipadi –Railway land)
- *Hopea parviflora* (river banks almost all districts)
- *Kingiodendronpinnatum* (Sacred Grove-Edapal)
- *Mallotusatrovirens* (River bank – Feroke)
- *Memecylonranderianum* (Sacred Grove-Edapal)
- *Ochlandratravancorica* (River banks, Kottayam, Ernakulam & Thrissur districts)
- *Syzygiumcumini* var. *cumini* (Plains Malappuram and Thrissur districts)
- *Tabernaemontana alternifolia* (Sacred Grove-Edapal)

The magnificent 12-volume monumental treatise, “Hortus Indicus Malabaricus” by the Dutch explorer, Hendrik Adriaan van Rheedee tot Draakestein (1678–1703), was the first authentic account on the plants of Kerala. Since then, numerous publications dealing with the flora of various plant groups have been published. Some of the recent important

publications pertaining to the Flora of Kerala State are 'Biodiversity Documentation for Kerala: Flowering Plants' (Sasidharan, 2004), 'The Flora of Kerala' Volume 1 (Daniel, 2005), 'Flowering Plants of Kerala – A Handbook' (Nayar & al., 2006) and a DVD of 'Flowering Plants of Kerala' (Sasidharan, 2012). Kerala's floral biodiversity faces severe threat from 89 alien invasive species recorded from the State.

Majority of the area under the proposed rail corridor is paddy fields (cultivated and abandoned), open scrubland and homestead gardens with domestic trees / plantations of Coconut (*Cocos nucifera*), Areca nut (*Areca catechu*), Anjili (*Artocarpus hirsutus*), Mango (*Mangifera indica*), Jackfruit (*Artocarpus heterophyllus*), etc and monoculture plantations of Rubber.

Mangrove forests of Kerala are highly localized, found mainly in Kozhikode Kannur and Kasaragod districts and the species diversity of these mangroves and its associates are comparatively rich. Mangroves and associated species found in the region includes *Acanthus illicifolius*, *Acrostichum aureum*, *Aegiceras corniculatum*, *Avicennia officinalis*, *A. marina*, *Azmatetracantha*, *Bruguiera gymnorhiza*, *B. cylindrica*, *B. sexangula*, *Excoecaria agallocha*, *E. indica*, *Kandelia candel*, *Rhizophora apiculata*, *R. mucronata*, *Sonneratiacaseolaris*, *Calophyllum*, etc.

In general extinction or rarity of species is considered to be due to environmental factors, ecological substitutes, biological factors, pathological causes and habitat destruction. Out of the 159 rare, endangered vulnerable and threatened species 70 are herbs, 23 are climbers, 8 epiphytic 15 shrubs and 43 trees. There are 64 rare, 22 threatened (vulnerable), 50 endangered and 7 extinct. Out of the 300 rare, endangered and threatened species of WG, 68 are in low elevation evergreen, 85 in medium elevation evergreen, 52 in high elevation evergreen and 32 in montane grasslands and the remaining are found in moist deciduous and dry deciduous habitat. During our field visit, we observed 7 IUCN Red listed plant species that was present near proposed station site or near to the alignment.

3.11.3 Faunal Diversity

The Western Ghat's encompassing the forests of Kerala is one of the 34 Biodiversity hot spots in the World and Kerala has close to 90 % of its vertebrate fauna. Very high levels of species diversity and endemism provide importance to the faunal wealth of Kerala. A total of 285 species of Vertebrate are reported to be endemic to Western Ghats, which include 12 mammals, 16 birds, 89 reptiles, 87 amphibians, and 84 fresh water fishes. Among large mammals, no species is endemic to Kerala.

3.11.4 Birds

A detailed study by Praveen in 2015, listed 500 species of birds in 88 families and 22 orders from Kerala State, out of which 17 are endemic to Western Ghats (**Annexure- 3**). A total of 25 species fall under various threatened categories of IUCN, 32 are Near Threatened, 443 falls under one of the schedules of Wildlife (Protection) Act and 71 falls under one of the appendices of CITES. The SilverLine alignment passes through part of the *Kol* wetlands, one of three sites in Kerala that are listed under the Ramsar Convention on wetlands of international importance. The *Kol* wetlands, with an extent of 1,512 km², is fed by 10 rivers and typical of large estuarine systems on the western coast, is renowned for its clams and supporting the third largest waterfowl population in India during the winter months. A total of 233 species of birds have been reported from *Kol* wetlands, of which 90 species are resident and 50 species are migratory birds. For centuries this human-managed ecosystem has been used for cultivating rice, catching fish, rearing ducks and grazing livestock (only in the dry months).

3.11.5 Mammals

A total of 118 species of mammals are reported from Kerala (Nameer, 2015), out of which 15 are endemic to Western Ghats, 29 species fall under the various threatened categories of IUCN, and five are Near-threatened. Eighty-seven species fall under one of the schedules of Indian Wildlife (Protection) Act and 46 come under one of the appendices of CITES.

3.11.6 Insects and Reptiles

Insects: From the State of Kerala, 4027 species have been listed under 23 genera. Kerala is home to 330 butterfly species, 37 of these are endemic to the region. Nearly 135 species of dragonflies were also been recorded from the State.

Reptile Diversity: A total of 173 species under 24 families belonging to three orders are recorded from Kerala. Of these, 87 species are endemic to the Western Ghats, which include the 10 Kerala endemics. Of the 173 species, 23 are listed in the various threatened categories of IUCN.

3.11.7 Endangered Species

The State of Kerala has 1847 species of vertebrates in 330 families and 81 orders, of which 386 are endemic to the Western Ghats region (of the Western Ghats - Sri Lanka Hotspot), and 205 species are listed as threatened in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Among this, 23 are categorized as Critically Endangered, 90 are Endangered and 92 are Vulnerable. 680 species of vertebrates of

Kerala have been listed in the various schedules of the Indian Wildlife (Protection) Act, while 148 are listed in the different appendices of CITES.

3.11.8 Agro-biodiversity

The State grows 142 crop plants belonging to 104 genera and 43 families. The *Kuttanad* below sea level farming has been recognized as a Globally Important Agricultural Heritage System (GIAHS) considering the agricultural biodiversity, resilient ecosystems and varietal cultural heritage.

3.11.9 Domestic Fauna/Livestock

As per the Livestock Census 2012, the livestock population of Kerala is 27.35 lakh (Table 3.61), and there was a decline of a decline of 23.65% cattle and 27.94% goats (which form the majority share) as compared to 2007 census. Amongst the cattle, 12.51 lakh (94 per cent) are cross bred and only 77,000 are indigenous, the indigenous breed recording decline of 35.18 per cent as compared to the previous census. The poultry population of Kerala as per 2012 Livestock Census is 242.82 lakh, which accounts for 3.3 per cent of the total poultry population in the country. It registered 54 per cent increase over the previous Livestock Census.

Table 3.61 District wise Livestock Population, Kerala

Sl. No.	District	Livestock	Poultry
1	Alappuzha	137652	1532185
2	Ernakulam	248722	4270568
3	Idukki	206222	527015
4	Kannur	161706	798259
5	Kasaragod	120687	685297
6	Kollam	220402	1070243
7	Kottayam	189875	1509805
8	Kozhikode	155899	1122398
9	Malappuram	239112	3276239
10	Palakkad	293467	3512994
11	Pathanamthitta	119119	643571
12	Thiruvananthapuram	268870	1743232
13	Thrissur	256826	3185833
14	Wayanad	116603	404289
Total		2735162	24281928

3.11.10 Ecologically Sensitive Areas

The proposed SilverLine corridor is not a nationally or internationally recognized area for nature conservation. However, the Kerala State is known for its conservation and there are 7 national parks and 15 wildlife sanctuaries in the state. The alignment lay out has been very wise as it doesn't covers any protected areas like National Parks, Wildlife Sanctuary and Biosphere Reserves as per Wildlife Protection Act, 1972 along the both side of the alignment (10 km wider) of the proposed site or proposed station areas. No area or village along the alignment or proposed station falls under Western Ghats Notification, 2015. Hence, no ecologically sensitive areas were observed during our field survey and as per our secondary data review as per Kasturirangan and Gadgil Report on WGEEP. Eco-sensitive zones are shown in Table 3.62, Fig. 3.24 & Fig.3.25 and the proposed SilverLine activity is far away from such ecological sensitive areas.

Table 3.62 Environment Sensitive Locations in the Study Area

Sl. No.	Category	Name
1	Ramsar Sites	Ashtamudi Wetland (614 km ²), Sasthamkotta Lake (3.73 km ²) & Vembanad-Kol Wetland (1512.5 km ²)
2	CRZ 1 (No intervention areas)	Areas delineated as CRZ 1 in the Coastal Zone Management Plan of the state
3	Biosphere reserves	Nilgiri Biosphere Reserve (5,520 km ²) & Agasthyamalai Biosphere Reserve (3,500 km ²)
4	National Parks	Eravikulam National Park (97 km ²); Periyar National Park (350 km ²); Silent Valley National Park (89.52 km ²); Mathikettan Shola National Park (12.82 km ²); Anamudi Shola National Park (7.5 km ²); Pambadum Shola National Park (1.318 km ²) and Karimpuzha National Park (230 km ²)
5	Wildlife sanctuaries	Periyar Wildlife Sanctuary (427 km ²); Wayanad Wildlife Sanctuary (344.44 km ²); Parambikulam Wildlife Sanctuary (285 km ²); Neyyar Wildlife Sanctuary (128 km ²); PeechiVazhani Wildlife (125 km ²); Chimony Wildlife Sanctuary (85 km ²); Shendurony Wildlife Sanctuary (171 km ²); Chinnar Wildlife Sanctuary (90.44 km ²); Idukki Wildlife Sanctuary (70.0 km ²); Aralam Wildlife Sanctuary (55 km ²); Peppara Wildlife Sanctuary (53 km ²); Thattekadu Bird Sanctuary (25.16 km ²); Mangalavanam Bird Sanctuary (0.0274 km ²); Kurinjimala Sanctuary (~32 km ²) & Ranipuram Wildlife sanctuary (~80 km ²)
	Tiger Reserves	PeriyarTiger Reserve (777.54 km ²) & ParambikulamTiger Reserve (285 km ²)
	Reserve forests	Attappadi (249 km ²)
	Mangrove sites	Ernakulam & Mattancheri Channels (1.69 km ²); ChittariPuzha & Anela Puzha (0.34 km ²); Dharmadam-Edakkad (0.26 km ²); Dharmadam Puzha & Anjrakandi Puzha (2.46 km ²); Valapattanam estuary (0.99 km ²); Ramapuram Puzha (1.14 km ²) & Pazhayangadi estuary (4.62 km ²)

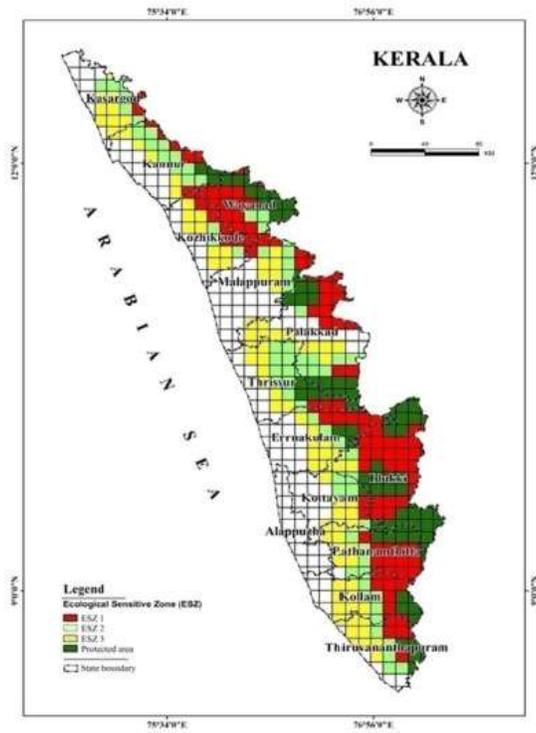


Fig. 3.24 Ecological Sensitive Zones as per Gadgil Report on WGEEP

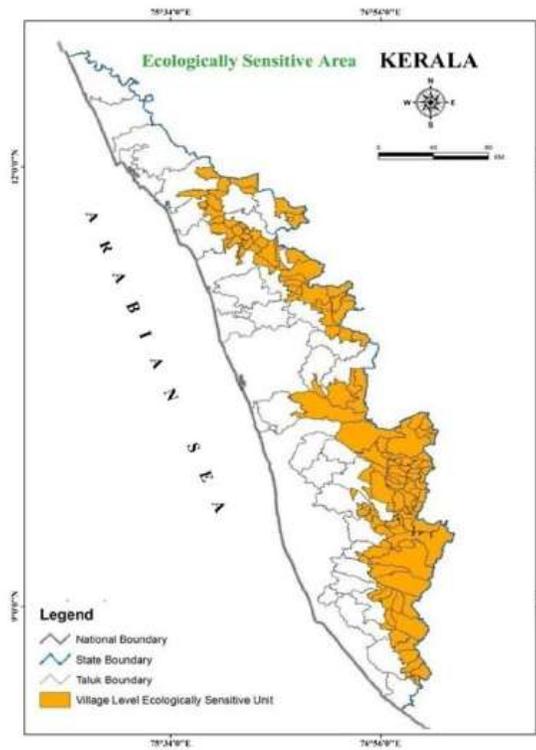


Fig. 3.25 Ecological Sensitive Units as per Kasturirangan Report on WGEEP

3.12 Human Environment: Socio-Economic Aspects

3.12.1 Demographic Profile

The demographic structure of the study area was derived primarily from 2011 Census records for the Kerala State (Table 3.63). Kerala consists of 14 districts spread over an area of 38861 km². Total population is about 33.4 million with about 48% male and 52% female population. Out of the total population, Scheduled Caste and Scheduled Tribes are 9.1% and 1.45% respectively. Population density is 860 persons/km² with rural and urban population density of 559 and 2097 persons/km² respectively. Literacy rate is more than 84%. Average family size is 4.25 persons per household. Sex ratio (female to male population) is 1.084.

Table 3.63 District-wise distribution of the population in different age groups, Kerala

	Unit	Numbers in Different Age Group in total District population			% of Different Age Group in total District population		
		0-14	15-59	60+	0-14	15-59	60+
1	Kasaragod	3,42,696	8,35,111	1,29,568	26	64	10
2	Kannur	5,94,411	16,06,593	3,21,999	23	64	13
3	Wayanadu	2,12,246	5,26,414	78,760	26	64	10
4	Kozhikode	7,49,692	19,72,762	3,63,839	24	64	12
5	Malappuram	12,41,491	25,26,407	3,45,022	30	61	9
6	Palakkadu	6,78,192	17,95,096	3,36,646	24	64	12
7	Thrissure	6,88,592	20,01,050	4,31,558	22	64	14
8	Ernakulam	6,93,215	21,35,689	4,53,484	21	65	14
9	Idukki	2,47,338	7,32,193	1,29,443	22	66	12
10	Kottayam	4,13,849	12,47,065	3,13,637	21	63	16
11	Alappuzha	4,46,279	13,57,100	3,24,410	21	64	15
12	Pathanamtitta	2,32,670	7,50,202	2,14,540	19	63	18
13	Kollam	5,83,023	17,00,534	3,51,818	22	65	13
14	Thiruvananthapuram	7,07,280	21,60,992	4,33,155	21	66	13
	Kerala	78,30,974	2,13,47,208	42,27,879	23	64	13

Source: Census 2011

3.12.2 Major Socio-Economic Activities

Industries (SSIs/MSMEs): As on September 17, 2015, the total number of working SSIs/MSMEs registered in Kerala are 2,57,466. Out of the total SSIs/MSMEs, 3.84 per cent were promoted by SC entrepreneurs, 0.72 per cent by STs and 24.97 per cent by women entrepreneurs. The total investment was 17,98,646.38 lakh while the total value of goods and services produced was 67,65,143.93 lakh and the total number of employments generated was 13,18,666 numbers.

Marine Fishing: The total fish production in Kerala in 2017-18 was 6.73 lakh tonnes, of which Marine fish landings were 4.84 lakh tonnes and Inland fish production was 1.89 lakh tonnes. As per records of Directorate of Fisheries, Government of Kerala, during 2014-15, marine fish landing in Kerala was 524000 tons, which comprised of more than 80 types of fishes. The most prominent species were oil sardine (27%), Indian mackerels (9.0%), non-penaeid prawns (6.9%) and scads (6.6%). The other prominent species were stolephorus, cuttlefish, ribbon fishes, thereadfin breams. Marine fish production has decreased from 5.24 lakh tonnes in 2014-15 to 5.17 lakh tonnes in 2015-16

Inland Fishing: Besides, 44 perennial rivers, there are large number of water bodies in Kerala, which act as fishing ground for local people. During 2015-16, the share of inland fish production in the total fish production of the state was 29 percent. Kerala has not utilized its potential in Inland fishing. Kerala has over 7 per cent of the water bodies in the country, but its share in Inland fishing is lower than that of many other states.

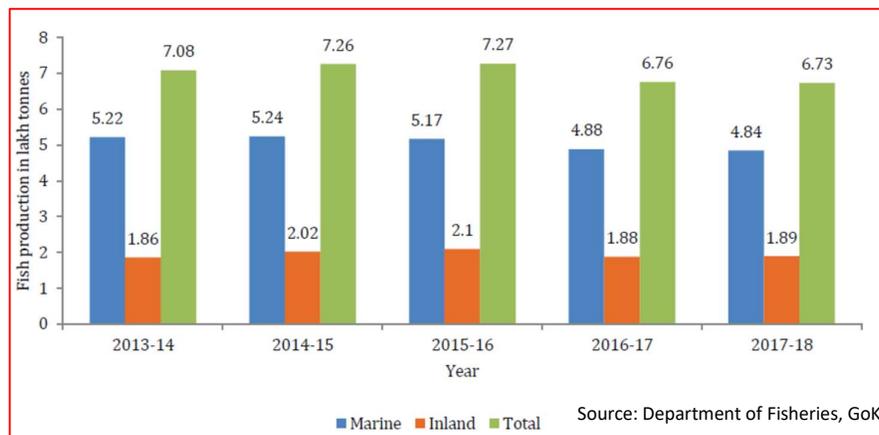


Fig. 3.26 Fish Production in Kerala 2013-14 to 2017-18

Agriculture: Kerala has unique and diverse agro-climatic specialities, which enable it to cultivate many types of crops. As per 2011 Census, about 9.2 lakh persons (males, 82.8% and 17.2% females) were engaged in agriculture activities. There has been a gradual shift from the food crops to cash crops and at present the cropping pattern in Kerala is dominated by cash crops. Food crops comprising rice, tapioca and pulses accounted for just 10.12 per cent of the total cropped area in 2017-18 while cash crops (cashew, rubber, pepper, coconut, cardamom, tea and coffee) constituted 61.6 per cent. Coconut occupies the largest area with 29.5 percent coverage followed by rubber with 21.4 percent. Rice comes third with 7.3 per cent of the total cropped area. Except for rice, pulses, banana, turmeric, tapioca and rubber, all other crops recorded a declining trend in area under cultivation (Table 3.64).

Table 3.64 Area, Production and Productivity of Principal Crops, Kerala

Sl. No.	Crops	Area (Ha)		Production (T)		Productivity (Kg/Ha)	
		2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
1	Rice	171398	189086	436483	521310	2547	2757
2	Pulses	1738	1992	1711	2045	984	1027
3	Pepper	85207	85141	34065	37955	400	446
4	Ginger	5151	4370	20478	18978	3976	4343
5	Turmeric	2632	2777	6506	8822	2472	3177
6	Cardamom	39080	39080	17147	18350	439	470
7	Arecanut	97696	94580	116839	108516	1196	1147
8	Banana	57158	62106	489322	565829	8561	9111
9	Other Plantations	57140	54455	395806	379683	6927	6972
10	Cashew	41661	39720	27944	25629	671	645
11	Tapioca	68664	70193	2529729	2697319	36842	38427
12	*Coconut	781496	760443	5384	5230	6889	6878
13	¹ Coffee	84976	84976	63476	66465	747	782
14	² Tea	30205	30205	61505	62230	2036	2060
15	³ Rubber	551050	551115	540400	540775	981	981
*Production in Million Nuts; Source: Directorate of Economics & Statistics, Kerala;							
¹ Coffe Board, ² Tea Board, ³ Rubber Board							

Tourism: Kerala, God's own country, an internationally recognized popular tourist destination, is known for its tourists' attractions, namely very long coastal line, lakes, backwaters, beaches as well tea gardens on hills and number of archaeological monuments and museums. Over 16.7 million tourists visited Kerala in 2018 as against 15.76 million the previous year, recording an increase of 5.93 per cent. Of the total footfalls, 1.09 million were foreign tourists (Table 3.65; Fig 3.27). The share of revenue from foreign visitors touched Rs 8,764.46 crore. Domestic tourism sector also gained during the period with visitors exceeding 15.6 million, showing an increase of 6.35 per cent (Table 3.66; Fig 3.28).

Table 3.65 Month-wise foreign tourist arrivals in India & Kerala in 2017

Sl.No.	Month	No. of FTAs in 2017	
		India	Kerala
1	January	964,109	150,808
2	February	931,025	135,089
3	March	885,936	107,141
4	April	717,899	82,633
5	May	622,408	49,073
6	June	663,470	44,040
7	July	779,309	72,552
8	August	719,129	73,736
9	September	719,964	54,700
10	October	866,976	79,957
11	November	997,738	107,028
12	December	1,167,840	135,113

Source: Ministry of Statistics, Gol & Department of Tourism, Kerala

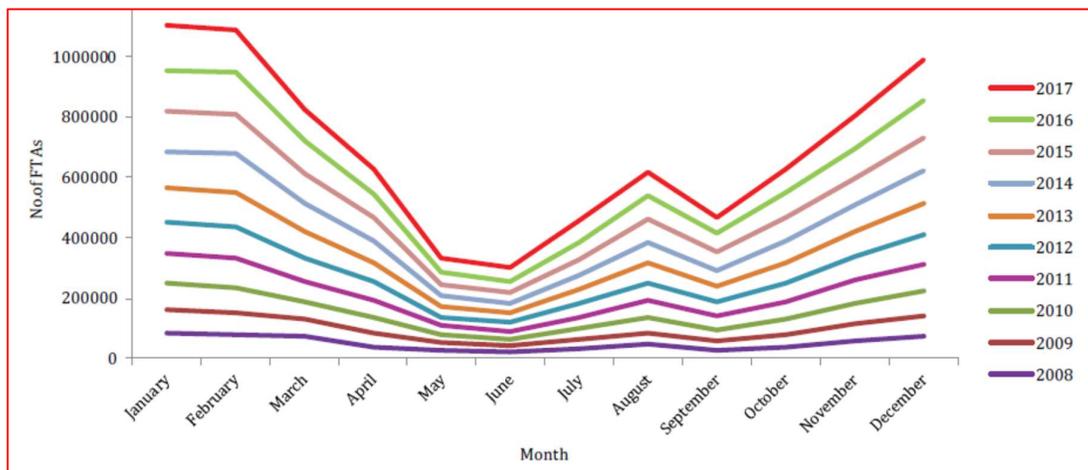


Fig. 3.27 Month wise comparison of foreign tourist arrival in Kerala from 2008 to 2017

Table 3.66 Month-wise domestic tourist arrivals in Kerala in 2016 and 2017

Sl. No.	Month	No. of Domestic Tourists Arrival	
		2016	2017
1	January	1,077,231	1,221,074
2	February	1,006,111	1,034,563
3	March	960,467	1,014,877
4	April	1,012,844	1,213,252
5	May	1,206,350	1,338,330
6	June	891,614	1,027,361
7	July	913,886	1,083,162
8	August	1,043,362	1,138,533
9	September	1,129,260	1,188,959
10	October	1,337,191	1,379,190
11	November	1,187,620	1,401,610
12	December	1,406,599	1,632,609
	Total	1,31,72,535	1,46,73,520

Source: Department of Tourism, Kerala

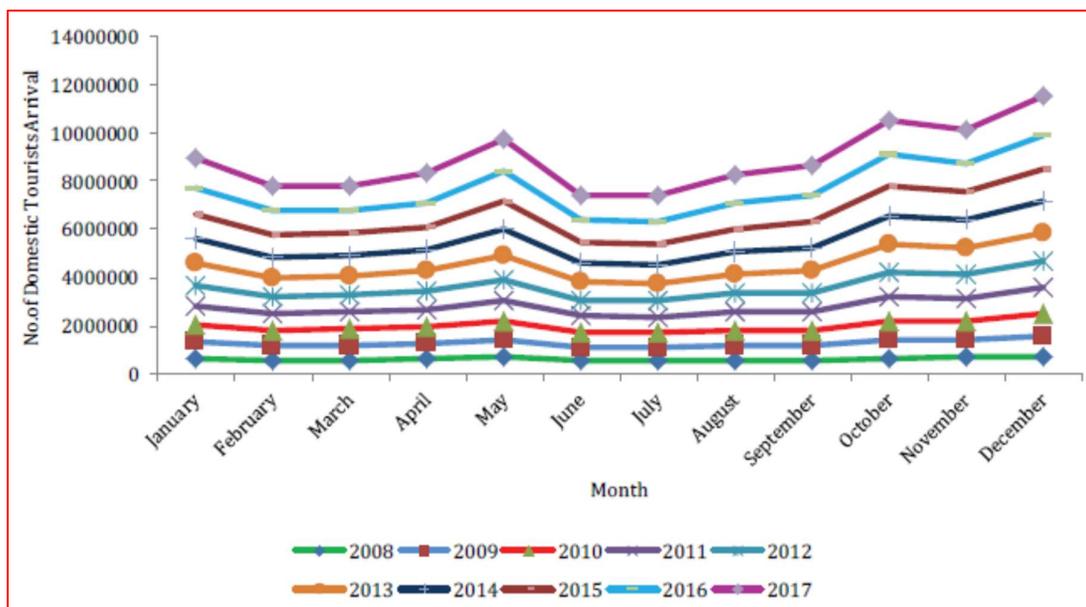


Fig. 3.28 Month wise comparison of domestic tourist arrival in Kerala from 2008 to 2017

3.12.3 Health Infrastructure & Diseases

Kerala has good health care facilities, and its Ayurvedic treatment centres are well known in the World and one of the major tourists' attractions. As on March 31, 2013, there were in total 1281 Govt. Allopathic Institutions, 19 speciality hospitals and 49 other institutions. The Govt. Allopathic Institutions include 233 Community Health Centres, 682 Primary Health Centres (PHCs), 173 round the clock PHCs. Diarrhoea is the most common disease of Kerala. Other communicable diseases are Hepatitis A & Hepatitis B, dengue fever, malaria, typhoid, leptospirosis, scrub typhus and chikungunya (Table 3.67).

Table 3.67 Prevalence of communicable diseases in Kerala

Disease	2014		2015		2016		2017		2018 (Up to October)		
	Cases	Death	Cases	Death	Cases	Death	Cases	Death	Cases	Death	
Dengue Fever	2,548	13	4,114	29	7,218	21	21,993	165	3,265	33	
Malaria	1,751	6	1,549	4	1,540	3	1,192	2	551	0	
Confirmed Chikungunya	264	0	152	0	124	0	54	0	37	0	
Japanese Encephalitis (JE)	3	2	0	0	1	0	1	0	5	2	
Leptospirosis	1,075	43	1,098	43	1,710	35	1,408	80	625	30	
Hepatitis-A	2,833	6	1,980	10	1,351	10	988	24	1,029	44	
Cholera	8	1	1	0	10	0	8	1	7	0	
Typhoid	1,955	0	1,772	0	1,668	2	3,144	1	98	0	
ADD (Diarrhoea)	442,109	5	467,102	4	493,973	14	463,368	8	355,218	10	
Scrub Typhus	433	6	1,149	15	633	3	340	5	115	0	
Kala Azar	1	0	4	0	2	0	0	0	3	0	
Kysanur Forest Disease	6	0	102	11	9	0	0	0	0	0	
H1N1	62	15	900	80	22	1	1411	76	15	0	
Fever	OP	2,655,507	29	2,676,842	26	2,641,311	18	3,417,968	76	1,786,250	33
	IP	85,959		96,189		80,049		109,974		38,202	
Diarrheal Diseases	-	-	-	-	326,517	10	-	-	-	-	
Enteric fever	-	-	-	-	1,192	0	-	-	-	-	
Measles	-	-	-	-	870	3	-	-	-	-	
Chickenpox	-	-	-	-	12,698	1	27,856	20	20,911	144	

Source: Directorate of Health Services, GoK

3.13 Historical / Archaeological Importance

3.13.1 Archaeological Locations in the Study Area

Kerala has number of important archaeological and museums, which are attraction to large number of domestic and foreign tourists. However, the SilverLine alignment is not passing through any of such Archaeological / Historical monuments. District-wise list of major archaeological monuments and museums of Kerala is given in Table 3.68.

Table 3.68 District-wise List of Archaeological Monuments & Museums of Kerala

Sl. No.	Districts	Archaeological Monuments and Museums of Kerala
1.	Alappuzha	Krishnapuram Palace, Narasimha Temple, Buddha Image
2.	Ernakulam	Pallipuram Fort, Mattanchery Palace, PareekshithuThampuran Museum, Hill Palace Museum, KottayilKovilakam, Chennamangalam, Vishnu Temple, Rock-Cut Temple
3.	Idukki	AnnamalaTheruvu Temple, Mangala Devi Temple, Marayoor Pre-Historic Paintings
4.	Kasargod	Poyyilikotta, Chandragiri Kotta
5.	Kollam	Numismatic Study Centre, KottarakkaraThampuran Museum, Chathanathu Temple, Kottukal Rock-Cut Temple
6.	Kottayam	Mural Art Centre, Pundarikapuram Vishnu Temple
7.	Kozhikode	Kunhalimarakkar's House, Arrival of Vasco-Da-Gama, Kappad, Pazhassiraja Museum
8.	Malappuram	Sukapuram Subramanya Temple
9.	Palakkad	Kattilmadam, Palakkad Fort
10.	Pathanamthitta	Folklore and Folk Art Centre, Kaviyoor Rock-Cut Temple, Megalithic Burial Site
11.	Thrissur	Rock-Cut Cave, Porkalam Dolmens, Tippu's Flag's Staff, Cremating Place of SakthanThampuran and Zamorin of Calicut, Thrikkur Rock-Cut Cave Temple, Cheramanparambu, Vadakkumnadha Temple, Siva Temple, Ariyannur Temple, Keezhathali Temple, Peruvanam Siva Temple, Idol of Siva in Bharathamala, Mukundapuram Temple, Archaeological Museum, Kottapuram Fort
12.	Thiruvananthap-uram	East Fort, Anjuthengu Fort, NedumangaduKoyikkal Fort, Irooppara rock Cut Cave Temple, Pandavanpara Cave, Perunkadavila, Ottur Vishnu Temple, Thrivikramangalam Temple, Parasurama Temple, Bhagavathi Temple, Rock Cut Cave Siva Temple, Aruvikkara Vishnu Temple, Padmanabhapuram Palace
13.	Waynad	Pazhassikudeeram (Tomp), Edakkal Cave.

3.13.2 World Heritage Site

The mountain chain of the Western Ghats represents geomorphic features of immense importance with unique biophysical and ecological processes has been included in the list of World Heritage sites by UNESCO. The areas of Western Ghats included in the World Heritage Site are given in Table 3.69.

Table 3.69 Areas of Western Ghats included in the World Heritage Site

Sl. No.	Sub Cluster Names	PA's/ RF/ Range/ Forest Division
1	Agasthyamalai	Shendurney Wildlife Sanctuary, Neyyar Wildlife Sanctuary, Peppara Wildlife Sanctuary, Kulathupuzha Range and Palode Range
2	Periyar	Periyar Tiger Reserve, Ranni Forest Division, Konni Forest Division and Achencovil Forest Division
3	Anamalai	Eravikulam National Park, Mankulam Division, Chinnar Wildlife Sanctuary, Mannavan Shola & Karian shola
4	Nilgiri	Silent Valley National Park, New Amarambalam Reserve Forests, Kalikavu Range and Attappady Reserve Forest
5	Thalakkavery	Aralam Wildlife Sanctuary

Source: Kerala Forest Department

The site also has an exceptionally high level of biological diversity and endemism. It is recognized as one of the world's eight "hottest hotspots" of biological diversity. The forests of the site include some of the best representatives of non-equatorial tropical evergreen forests anywhere and are home to at least 325 globally threatened flora, fauna, bird, amphibian, reptile and fish species. However, none of the above sites falls in the SilverLine corridor.

Chapter 4

ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

4.1 Introduction

The identification, evaluation and prediction of Impacts and suggesting mitigation measures is the most important step of an environmental impact assessment and this always depends on the nature and magnitude of the activity being undertaken and also on the type of pollution control measures that are envisaged as part of the proposal. The environmental impacts have been identified and evaluated based on severity, scale, reversibility and temporal basis. Superimposing predicted impacts over baseline environmental scenario provides an understanding of the resulting environmental impact scenarios. The quantitative prediction of impacts is vital to define pragmatic environmental management plan for implementation during the construction and operation phase for minimizing the adverse impacts on environmental quality. Accordingly, mitigation measures have been identified to avoid, minimize, control and manage the key environmental impacts.

The SilverLine alignment is not passing through any notified area such as National Park, Wildlife Sanctuaries, Biosphere Reserves and other Ecological Sensitive areas. However, the alignment is somewhat parallel to one of the Global Biodiversity Hotspots, the Western Ghats and hence impacts relating to biodiversity need to be carefully assessed. A number of households and establishments (shops, schools, temples and mosques, *etc.*) need to be displaced and rehabilitated where the alignment is passing through or over it. The social impacts are also assessed in detail by specific locations and mitigation measures suggested. There are many positive impacts and benefits due to the proposed SilverLine project such as technology transfer, safe, fast as well as energy efficient transport connectivity between Thiruvananthapuram and Kasaragod, improvement in productivity, generation of employment and promote a modal shift from private vehicles to SilverLine rail, resulting in relative reduction in air pollutants and greenhouse gas emissions.

This chapter deals with the assessment and prediction of potential impacts of the SilverLine project on the natural and biological environment and socio-economic environment as well as recommend mitigation measure and interventions in the design, construction and operation stages of the project.

The transportation projects like SilverLine project and its associated infrastructure may cause impacts in many ways on the Physical, Biological, Socio-economic and Cultural environment. The EIA will help to identify those negative impacts that are anticipated in the project under consideration and to suggest the mitigation measures to minimize the negative impacts. The assessment of potential impacts is being carried out during the following stages of the project planning and implementation:

- i. *Pre-Construction Impacts*: this includes impacts associated with alignment selection; impacts arising from project design including the technology used, scale of operations, standards, topographic survey, geotechnical survey, etc.; and impacts on environment and resettlement or livelihood related impacts on communities.
- ii. *Construction impacts*: Impacts resulting from construction activities including site clearance, earthworks, civil works, etc.; and
- iii. *Operation and Maintenance impacts*: Impacts associated with the operation and maintenance of the semi-high-speed rail and associated infrastructure built in the project.

The mitigation measures suggested in Environmental Management Plan (EMP) is based on field study and various standards notified by MoEFCC under the Environment Protection Act, 1986 and other relevant standards/ criteria published by Bureau of Indian Standards as well as other National and International agencies. Anticipated impacts due to various activities envisaged during construction and operation of SilverLine have been assessed and further mitigation measures have been suggested for each of the following environmental components.

- Land Environment (Impact on land use, soil fertility and agriculture)
- Water Environment ((Impact on ground water quality, surface water quality)
- Air Environment (Impact on Ambient air quality)
- Noise Environment (Impact on Ambient Noise & Vibration)
- Biological Environment (Impact on flora and fauna)
- Socio-economic Environment (Impact on other infrastructure, employment, public health and safety, cultural resources and aesthetics)

Based on a recognisance survey and review of previous studies, within 500 m on both side of the SilverLine alignment is expected to be affected by (i) the activities pertaining to site preparation and construction of the proposed SilverLine and ancillary component works; (ii) the operation and maintenance of the semi high-speed railway system; and (iii) the growth of population and economic activity in the surrounding areas due to the project. As a first step, land use land cover of the entire SilverLine corridor (500 m on both sides of the

alignment) has been studied in detail using Google Earth Image. The entire stretch has been surveyed by experts and the probable potential impacts of each of these activities on various sectors of environment have been identified and listed. The impacts further have been classified as short-term or long-term impacts, reversible or irreversible impacts.

4.2 Land Environment

4.2.1 Land Environment: Impact during Construction Phase

There will be a change in topography and land use of the corridor due to acquisition of agricultural land, commercial and/ or residential land for the proposed SilverLine alignment. During construction phase, the existing land use characteristics of the acquired land will be changed to transportation land including rail lines, stations, parking areas, rest areas, etc. This will lead to loss of productive soil and agriculture land. Cutting of trees that falls within formation width of 18 to 25 m may reduce the ecological balance of the area and also trees and bushes will be cleared for the construction of associated infrastructure. No forest area exists along the project alignment or its corridor. The impact on land use characteristics during construction phase also include impact to ancillary sites such as borrow areas, quarry areas, labour camps, contractors' camps, etc. Large quantity of quarry material will be required for the construction of project infrastructure. In all newly opened Quarries, borrow area, labour camps, etc. there will be land use changes on a temporary basis. Loss of productive agricultural land may result from the establishment of construction camps, batch mix plant and hot mix plant, quarry and borrow area. This results in minor change in agricultural yield due to project activities. Land selected for borrow and quarry area will change the land use pattern permanently. Topographic changes and visual impact may occur during site preparation and construction activities.

Table 4.1 Identification of Construction Activities & its Impacts on Land Environment

Activities	Potential Impacts	Permanent/Temporary
Site clearing and Levelling (cutting, stripping, excavation, earth movement, compaction)	<ul style="list-style-type: none"> • Change in Land use pattern • Change in the local topography • Loss of fertile top soil • Loss of agricultural produce 	Permanent
Transportation and Storage of Construction Material/ Equipment	<ul style="list-style-type: none"> • Deposition of spilled construction material on soil 	Temporary
Civil Construction Activities	<ul style="list-style-type: none"> • Change in Land use pattern 	Permanent
Mechanical and Electrical Works	<ul style="list-style-type: none"> • Deposition of spilled construction material on soil 	Temporary
Influx of Labour & Construction of Temporary Houses/ Camps	<ul style="list-style-type: none"> • Change in Land use pattern of the area due to labour camps 	Temporary
Transportation and Disposal of Construction & Demolition Waste	<ul style="list-style-type: none"> • Spillage/Spread/Deposition of debris • Conversion of land into waste land 	Temporary

There will be 'Cuttings' for a length 101.74 km and embankment with total length of 292.73 km. The embankment will be constructed using the excavate from the cutting and remaining quantity will be utilized without damaging the environment. Further there will be a 24.79 km length of cut and cover section and the excavate will be used along the route. The filled area will be developed as recreational area or other usable area in consultation and with support of local administration. Thus, most of the excavate will be suitably used without affecting the environment. Detailed analysis, based on actual ground levels and width of water logged area, need to be separately carried out to estimate the exact quantity of filling with pre-determined height of filling. Viaducts will be constructed for a length of 88.41 km, rail / road crossings (bridges) for 12.99 km and tunnels for 11.53 km length respectively. During construction of embankment, loose soil for embankment preparation could result in silt run-off if exposed to wind or rain and appropriate compaction or stabilization measures are not adopted immediately. Loss of productive soil may result from uncontrolled opening up of borrow pits. Loosening of top soil and loss of vegetative cover from the ROW section due to excavation, land cut and back filling could lead to soil erosion.

4.2.2 Land Environment: Impact during Operational Stage

During operational stage, there will be induced impacts on the land use, immediately bordering the available corridor. The locations where the stations and maintenance depots shall be constructed will bring permanent change in the physiographic and land use of the area. Major landuse along the proposed stations and depots areas are agriculture / abandoned paddy field / barren land and thus less impact on landuse pattern of the region.

Table 4.2 Identification of O&M Activities & its Impacts on Land Environment

Activities	Potential Impacts	Permanent / Temporary
Running of Semi High Speed Train	<ul style="list-style-type: none"> • Discharge of untreated sanitary effluents from the station • Increased traffic volume and density 	Temporary
Withdrawal of Water	<ul style="list-style-type: none"> • Scarcity of water 	Temporary
Maintenance (Cleaning, Overhaul, Oil Change, Lubrication etc.)	<ul style="list-style-type: none"> • Spillage of spent oils from the workshops and depot 	Temporary
Domestic Use of Water at Stations and Maintenance Depot	<ul style="list-style-type: none"> • Scarcity of water 	Temporary

4.2.3 Mitigation measures on Land Environment

Mitigation measures include careful planning, timing of operations and re-vegetation. Following measures are suggested to mitigate adverse impacts on land environment during construction and operation phases.

- Embankment slopes made from earthen material as well as exposed surfaces of hills should be protected from low cost bio-engineering products for preventing soil erosion in areas which have high soil erodibility or high intensity rainfall.
- As far as practicable, top soil removed from the construction sites should be used for construction of embankment to enhance growth of vegetation on the embankment surface and its consolidation.
- Adequate temporary or permanent drainage should be provided before slope construction begins with lagoons to allow silt to settle out.
- Top soils of the borrow pit sites should be conserved and restored after excavation is over.
- Stockpiles of construction materials should be located away from rivers, streams, fertile agricultural lands, recorded forest lands or inhabited area.
- Appropriate measures should be installed around stockpiles to retain runoff water and any silt it contains.
- Use of fly ash as a substitute to top soil in construction of embankment, roads should be done but only after careful analysis of site conditions such as ground water level, soil texture, infiltration rate *etc.* The usage of the fly ash in different forms such as fly ash mix cement, fly ash bricks, ready-mix concrete *etc.* during construction phase should be enhanced to comply with relevant laws.
- Earth dikes and contour trenching should be provided for the soil dump area.
- Temporary seeding should be adopted to reduce erosion and sedimentation from disturbed areas that will not be stabilized for long period and where permanent plant growth is not appropriate.
- Precaution needs to be taken to avoid spillage on soils to protect soil microbiology in the project area
- Construction activities should be avoided during rainy season to prevent soil erosion
- Excavated soil should be properly used later to reinstate the land after completing the construction activities
- Before the start of construction activities, suitable disposal sites should be identified for solid waste, construction and demolition waste likely to be generated from the construction activities

- The construction camps, stockpiles, etc., should be located on open areas/ barren land, devoid of vegetation
- Construction and demolition waste should be processed as per existing law
- Standard national and international construction norms should be implemented to ensure that the impact on surface drainage pattern and soil erosion is kept minimal
- The stone aggregate should be sourced from licensed quarries only and shall be transported in the covered trucks to the construction yards
- Regular maintenance of equipment / machinery and vehicles should be made mandatory as per CPCB norms
- All Solid waste disposal sites should be secured away from human settlements, water bodies/ wetlands, and archaeological and historical monuments
- Hazardous waste management as per existing law
- All stations should follow green protocol during the operation phase and there should be adequate provision of correctly marked waste containers made available at convenient locations for the disposal of wastes

4.3 Water Environment

The proposed semi-high-speed rail alignment is running through various land uses including wetlands/ paddy fields and many times will cross rivers and drains. The impacts predicted due to the semi-high-speed rail corridor on water environment could be attributed to pre-construction (location, design, etc.), construction and operation phases of project.

4.3.1 Water Environment: Impact during Construction Phase

The semi-high-speed rail corridor are crossing rivers, canals and streams on their way and are abutting water bodies like lakes, ponds and tanks, wells, etc. Disposal of construction debris near the vicinity of water bodies may cause stagnation/ diversion of natural drainage. During construction, exposure of soil will occur due to foundation works for elevated bridges, Cutting, and Embankment. This will temporary to involve drilling the river bottom which will cause muddy water to spread within the river. During construction, there could be impact to the surface water bodies due to the various construction activities including topsoil, temporary or permanent storage of waste material and other related construction activities. Ancillary construction site such as quarries, borrow areas would also affect water bodies.

Drawing of water for construction camps for domestic use from local water sources may disturb water supply use for the local inhabitants. Provision of site offices and workers' camps during construction will cause production of domestic sewage and waste water

including urine and faeces. If directly discharged into nearby bodies of water without treatment, water contamination will occur. The water requirement for construction work will be met from various sources of surface water such as the rivers, streams, lakes, etc.

The impact on the surface and ground water quality during the construction phase may be expected from the following activities viz., Effluent discharge from the construction camp; Sludge from the construction activities; Breeding of mosquitoes due to stagnant pool of water; Surface runoff from the unpaved road; Soil compaction as a result of construction activities; Discharge of untreated sewage from camp office, labour camps; Increase of sediment load in the runoff from construction sites would increase in turbidity in receiving streams/water bodies; Slight change in hydrology and geomorphology of the stretch of water course directly affected by the temporary works at the site; Water quality of nearby water bodies due to spillage and uncontrolled release of construction and toxic materials such as cement, concrete, oil, fuel and paints; and Run-off of silt and spilled materials into the river water may arise from earth works, exposed ground, water collecting in excavations, stockpiled materials and site roads, etc.

The water demand for the construction activities shall be met through piped water supply wherever available and in the absence of piped supply, surface water in the vicinity or ground water as available will be used. Considering massive water requirement for civil works, constant supervision would be required on part of the Contractor to prevent over exploitation of surface water sources and adequate water is available for use by local communities.

Table 4.3 Identification of Construction Activities & its Impacts on Water Environment

Activities	Potential Impacts	Permanent / Temporary
Site clearing and Levelling (cutting, stripping, excavation, earth movement, compaction)	<ul style="list-style-type: none"> • Run-off from vegetation stripped areas and erosion • Domestic effluent discharge from the labour and construction camps • Natural drainage pattern changes • Seepage of wastewater into the groundwater table 	Temporary
Transportation and Storage of Construction Material/ Equipment	<ul style="list-style-type: none"> • Spillage of construction material and flow into streams particularly during the monsoon months • Run-off from Storage areas 	Temporary
Civil Construction Activities	<ul style="list-style-type: none"> • Run-off from Construction Areas during curing & 	Temporary

Activities	Potential Impacts	Permanent / Temporary
	<p>from the storage area of the construction materials</p> <ul style="list-style-type: none"> • Seepage of wastewater into surface water and the groundwater table, where groundwater level is shallow 	
Mechanical and Electrical Works	<ul style="list-style-type: none"> • Run-off from erection areas containing spent oils, Paints, etc. 	Temporary
Influx of Labour & Construction of Temporary Houses/ Camps	<ul style="list-style-type: none"> • Sanitary effluents from labour colonies/ camps 	Temporary
Transportation and Disposal of Construction & Demolition Waste	<ul style="list-style-type: none"> • Spillage/ spread of debris material and flow into streams • Run-off from Disposal Areas • Leaching effect from the debris disposal area 	Temporary

4.3.2 Water Environment: Possible Impact during Operational Stage

The operational stage impacts will be minimum due to the overall measures adopted by the project to contain the direct, indirect and long-term impacts. Lack of proper drainage arrangement may result in soil erosion, subsequently leading to turbidity and siltation of nearby natural water bodies. Spillage of edible oil, crude oil, lubricants and other hazardous chemicals close to natural drainage will cause alterations in water quality. During operation phase, maintenance gangways from depots will maintain and repair track, catenary and other elements. This work could pollute river water with residual oil, grease, iron fillings etc. Besides this, some other impacts on the surface water environment would occur as a result of Increase in the volume of surface water run-off caused by an increase in impermeable surface associated with the new bridge/ crossing; Impacts associated with maintenance and repair of bridge which may include sediment aggravation and works on the watercourse banks; and increase in the possibility of flood risk.

Eleven stations and two maintenance depots have been proposed for the SilverLine project. The demand at stations shall be met through piped water supply since the stations are in the urban or sub-urban area. For maintenance depots through piped water supply as well as the raw water sources like ground water developed during construction phase. It is advisable to inform the Kerala Water Authority of high requirement and apply for sanction of supply for the project life cycle at the earliest to enable them to take necessary action to ensure continuous and uninterrupted supply to the project.

Table 4.4 Identification of O&M Activities & its Impacts on Water Environment

Activities	Potential Impacts	Permanent / Temporary
Running of Semi High Speed Train	<ul style="list-style-type: none"> • Discharge of untreated sanitary effluents from the station into local sewers • Spillage of spent oils from the workshops and depot • Increased water demand • Scarcity of water to the competing and downstream users 	Temporary
Withdrawal of Water	<ul style="list-style-type: none"> • Reduced availability to downstream users • Reduced flow in downstream direction/ change in regime in case of drawl of surface water • Ground water depletion nearby the station and maintenance depot areas 	Temporary
Maintenance (Cleaning, Overhaul, Oil Change, Lubrication, etc.)	<ul style="list-style-type: none"> • Generation of effluents containing oil/ chemicals from the Workshop and Maintenance Depot 	Temporary
Domestic Use of Water at Stations and Maintenance Depot	<ul style="list-style-type: none"> • Scarcity of water • Generation of sewage 	Temporary

4.3.3 Mitigation measures on Water Environment

Following measures are suggested to mitigate adverse impacts on water environment during construction and operation phases.

- Identification of water sources should include a quick assessment to identify capacities to maintain water requirement of competing users;
- All necessary statutory approvals should be secured from local authorities (Irrigation department for rivers / lakes and LSGs for wells);
- All applicable water quality standards should be complied with, at all construction sites along the proposed alignment route during the entire period of construction activity;
- It should be ensured that no liquid is discharged from any construction site/activity without treatment;
- Stockpiled soil and other loose material should be covered with secure tarpaulins;
- As far as possible, all parking, repair and fuel storage areas should be located away from water bodies;

- Effective storm water drainage system should be provided in every bridge to eliminate / reduce the chance of discharge of untreated storm water directly into the river;
- Measures should be adopted to avoid contact between water and machinery when construction work is conducted in rivers, streams and canals;
- All hazardous materials on-site should be stored in areas with concrete floors enclosed by concrete bunds;
- Oil catch pit/ oil trap may be erected along drain channel from construction site to prevent oily water to flow into any water body;
- Greening of the excavated area to prevent erosion of soil is one of the mitigation measures on the content;
- Silt fencing may be provided near water bodies;
- Proper sanitation facilities shall be provided at the construction site to prevent health related problems due to water contamination.
- Where there is no possibility for getting surface water for the construction, the ground water will be tapped after obtaining necessary permission from the authorities concerned such as Central Ground Water Authority (CGWA).
- The water course should not be blocked while constructing the corridor, but suitable culverts and drains should be provided for the free flow of water.
- Implement suitable measures to minimize usage of water as well as reduce wastage.
- To reduce the fresh water demand, recycle mechanism shall be adopted.
- Treated water from STP shall be used for construction

4.4 Air Environment

The air environment in the proposed SilverLine corridor will be affected by various factors including the design, process technology, raw materials used, transportation of raw materials and products, storage facilities and material handling, and operation and maintenance practices.

4.4.1 Air Environment: Impact during Construction Phase

During the construction phase, the impact on ambient air quality is envisaged due to fugitive dust emission coming out of the construction site. However, this impact would be of temporary nature and will be localized. The SilverLine corridor is relatively clean, and no major source of air pollution is reported along the route. The major pollutant in the construction phase is dust / PM₁₀ being air-borne due to various construction activities. Various construction activities that may contribute to air pollution during construction phase are dust generation due to earth moving and construction work; transportation of

construction materials; Dust generation at burrow areas; quarrying activities; construction machinery viz., DG sets, Concrete mixers, etc. The vehicular movement generates pollutants such as NO_x, CO and HC. Emissions from vehicles and machinery could also impact quality of air in and around construction sites.

Table 4.5 Identification of Construction Activities & its Impacts on Air Environment

Activities	Potential Impacts	Permanent / Temporary
Site clearing and Levelling (cutting, stripping, excavation, earth movement, compaction)	<ul style="list-style-type: none"> Fugitive Dust (PM10 and PM2.5) Emissions causing health concerns to local community and workers Air Emissions from construction equipment and machinery and backup power generation 	Temporary
Transportation and Storage of Construction Material/ Equipment	<ul style="list-style-type: none"> Gaseous emissions from vehicles Fugitive Dust Emissions due to Traffic Movement Fugitive emissions from construction materials (cement, paints and varnishes) 	Temporary
Civil Construction Activities	<ul style="list-style-type: none"> Gaseous Emissions from Construction Machinery Fugitive Dust (PM10 and PM2.5) Emissions due to Movement of Traffic on the unpaved way Fugitive dust (PM10 and PM2.5) emission from the batching, mixing and concreting plant 	Temporary
Mechanical and Electrical Works	<ul style="list-style-type: none"> Air emissions from running of construction machineries due to fuel 	Temporary
Influx of Labour & Construction of Temporary Houses/ Camps	<ul style="list-style-type: none"> Dust generation from labour colonies/ camps 	Temporary
Transportation and Disposal of Construction & Demolition Waste	<ul style="list-style-type: none"> Noise and Air Emissions from Transport Vehicles Fugitive Dust Emissions due to Movement of Traffic on the unpaved access roads Spillage and fugitive emissions during handling of C&D waste Fugitive emission from the pile of C&D waste 	Temporary

4.4.2 Air Environment: Possible Impact during Operational Stage

No major adverse impact on air quality is envisaged in the operation phase except corridor effect on air movement along the SilverLine alignment due to semi-high-speed train movement. The adverse impact on air quality is envisaged from the station and maintenance depot in the form of gaseous and particulate emission from DG set. Air pollution in the vicinity of stations can be expected due to movement of vehicles coming/going out of the station. Ambient Air quality in the vicinity of the stations needs to be monitored on regular basis during operation phase for PM₁₀, PM_{2.5}, SO₂, NO₂ and CO.

4.4.3 Mitigation measures on Air Environment

- Maintain all construction vehicles to minimize vehicle emissions.
- Payload area of the trucks or dumpers should be covered by tarpaulin when transporting soil and crush in order to prevent fall out of fines and emissions of dust.
- Spray water on the stones while unloading from the truck/dumper, at the primary crusher feeder chute and the transfer points from one belt conveyor to another, etc.
- Facility for regular cleaning and wetting of the unpaved roads and exposed soil on construction sites should be provided in dry weather.
- Trees should be planted to develop a green belt within and along the boundary of the yards and corridor.
- Concrete batching plant or other machinery liable to generate dust should be kept away at safer distance from residential areas and should not be in predominant upwind direction of these areas.
- Ensure that all major construction machineries including batching plant placed on construction sites are inbuilt with appropriate dust reduction measures.
- The haul freight corridors inside the quarry should be properly watered to arrest the dust arising out of it.
- Conduct periodic monitoring of ambient air quality as per NAAQS, 2009
- Provide adequate height of the stack of DG set to have wider dispersion of the gaseous emission and also to attain the mixing height.

4.5 Noise and Vibration

Noise and vibration are among the major concerns with regard to the effects of a semi-high-speed railway project on the surrounding community. A field review of the existing and proposed land uses within 500 m on either side of the proposed alignment and construction sites was undertaken for identifying the nature and location of sensitive receptors. For noise and vibration assessment purposes, all residential receivers are considered to be of a

sensitive nature. Other sensitive receptors include commercial receptors, educational facilities, schools, *Anganwadis*, places of worship and hospitals.

4.5.1 Noise: Impact during Construction Phase

During construction phase, noise is generated due to activities such as Truck and vehicle movements, Excavation machinery, Demolition, Piling, Hand held tools such as grinders, drills, etc. The major noise generating sources are DG sets, crusher, excavators, crane, concrete mixer, etc.

Table 4.6 Identification of Construction Activities & its Impacts on Noise Environment

Activities	Potential Impacts	Permanent / Temporary
Site clearing and Levelling (cutting, stripping, excavation, earth movement, compaction)	<ul style="list-style-type: none"> • Increase in noise levels due to running of heavy construction equipment • Noise & Vibration due to demolition, underground tunnelling and compaction work for viaduct • Noise propagation due to plying of heavy construction vehicles 	Temporary
Transportation and Storage of Construction Material/ Equipment	<ul style="list-style-type: none"> • Noise propagation due to plying of heavy construction vehicles at the sites 	Temporary
Civil Construction Activities	<ul style="list-style-type: none"> • High noise emitting from the construction equipment • Noise generated from the running of heavy vehicles deployed in the construction activities 	Temporary
Mechanical and Electrical Works	<ul style="list-style-type: none"> • Induced vibration may be experienced due to erection activities • Noise generated from running of heavy mechanical & electrical equipment 	Temporary
Influx of Labour & Construction of Temporary Houses/ Camps	<ul style="list-style-type: none"> • Noise propagation from the camps 	Temporary
Transportation and Disposal of Construction & Demolition Waste	<ul style="list-style-type: none"> • Noise and Air Emissions from Transport Vehicles 	Temporary

Construction Noise: Table 4.7 shows the Federal Transit Administration (FTA) noise assessment criteria for construction. Day-night sound level, L_{dn} , is used to assess impacts in residential areas and 24-hr L_{eq} is used in commercial and industrial areas. The 8-hr L_{eq} and the 30-day average L_{dn} noise exposure from construction noise calculations use the noise emission levels of the construction equipment, their location, and operating hours.

Table 4.7 Construction Noise Assessment Criteria

Land Use	8-Hour L_{eq} dBA		Noise Exposure, L_{dn} dBA
	Day	Night	30-day Average
Residential	80	70	75*
Commercial	85	85	80**
Industrial	90	90	85**

Source: FTA (2006)

*In urban areas with very high ambient noise levels (L_{dn} greater than 65 dB), L_{dn} from construction operations should not exceed existing ambient noise levels + 10 dB.

**Twenty-four-hour L_{eq} , not L_{dn} .

Construction Equipment Noise: By using the FTA criteria provided in Table 4.8 and the noise projections prepared by the Federal Railroad Administration (FRA), and assuming that construction noise reduces by 6 dB(A) for each doubling of distance from the centre of the site, it is possible to estimate the screening distances for potential construction noise impact.

Table 4.8 Typical Equipment Noise for Rail Construction

Equipment Item	Typical Maximum Sound Level at 50 Feet dB(A)	Equipment Utilization Factor (%)	L_{eq} dB(A)
Air Compressor	81	50	78
Backhoe	80	40	76
Crane, Derrick	88	10	78
Bulldozer	85	40	81
Generator	81	80	80
Loader	85	40	81
Jackhammer	88	4	74
Shovel	82	40	78
Dump Truck	88	16	80
Total Workday L_{eq} at 50 feet (8-hour workday)			89

Source: (FRA 2012)

Noise Caused by New Austrian Tunnelling Method (NATM): NATM shall be used for construction of tunnel which is only 11.53 km (2.17%) of the total length of the route. Actual noise level caused by NATM is not significant in studies elsewhere. Therefore, impact of noise caused by NATM is considered insignificant.

Blasting Noise: Noise level was predicted using following equation.

$$LA = A + 16 \log W - 16 \log D - 20 \log R + \Delta L$$

where: LA: Noise level (dB); W: Explosive volume (kg); D: Distance inside of pit; R: Distance outside of pit; A: in case of DS detonation cap: 130; In case of Ms detonation cap: 136; and ΔL : Correction value (dB) for directivity, noise barrier, obstacles

4.5.2 Noise: Impact during Operational Stage

The frequent train movements would generate a certain level of noise and the generated noise may cause sleep disturbance and mental instabilities of the residents living adjacent to the proposed alignment. In addition, careful attentions should be paid on noise impacts on sensitive receptors (SRs) located near the proposed alignment such as educational institution, hospitals and religious institutions. In absence of the Indian Guidelines for assessment of impacts of Noise and Vibration due to running of Semi High Speed Train, the available guidance manual of Federal Transit Administration (FTA) and Federal Railroad Administration (FRA) on noise and vibration has been used for the assessment of impacts of noise and vibration due to operation of the SilverLine.

The standard environment values (the strictest value) as equivalent noise level on scale A which is relatable to human hearing- LA_{eq} in various countries are around LA_{eq} 60–65 dB during daytime and LA_{eq} 50-55 dB during night time. In Japan, the equivalent noise level value is set at LA_{eq} 60 dB during daytime and LA_{eq} 55 dB at night time as the guideline value when a new railway or large-scale improvement for existing railways are constructed. The predicted values for standard railway level of 15m with 2.0m noise barrier vary between 73dB and 75dB, showing the same level of actual measurement in Japan. There is considerable evidence that increased annoyance is likely to occur for train noise events with rapid onset rates. Because of this, the relationship of speed and distance was used to define locations where the onset rate for the SilverLine operations may cause surprise according to the FRA guidance manual (FRA 2005). The potential for increased annoyance for the most part is confined to an area very close to the tracks. In operation phase, there will be significant movement of vehicles at the stations for passengers, and continuous movement of vehicles will be a source of noise generation. The public needs to be made aware about the noise generation and various possible options for mitigation of the same.

4.5.3 Noise: Mitigation Measures

- Notify the local people prior to undertake the construction activities associating with higher noise level such as blasting operations
- Locate the quarry sites away from the residential areas and sensitive receptors
- Avoid night time construction in residential neighbourhoods
- Use low-noise designed; Machinery and vehicles should be maintained regularly, with particular attention to silencers and mufflers, to keep construction noise levels to minimum
- Re-route construction-related truck traffic along roadways that will cause the least disturbance to residents.
- Prohibit aboveground jack hammering and impact pile driving during night time hours near residential areas
- Use high-grade engine exhaust silencers and engine-casing sound insulation
- Protection devices (ear plugs or ear muffs) should be provided to the workers operating in the vicinity of high noise generating machines
- Expanding the right of way (buffer zone) is recommended method of reducing the noise impact and a vegetative barrier in the buffer zone will be help to reduce the noise impact
- Noise barriers should be erected at appropriate locations such as residential areas and sensitive receptors which are adjacent to the corridor

4.5.4 Vibration: Impact during Construction Phase

Guidelines in the FTA guidance manual (FTA 2006) provide the basis for the construction vibration assessment. FTA provides construction vibration criteria designed primarily to prevent building damage, and to assess whether vibration might interfere with vibration sensitive building activities or temporarily annoy building occupants during the construction period.

Table 4.9 Construction Vibration Damage Criteria

Building Category	PPV (inch/sec)	Approximate Lv ^a
Reinforced concrete, steel, or timber (no plaster)	0.5	102
Engineered concrete and masonry (no plaster)	0.3	98
Non-engineered timber and masonry buildings	0.2	94
Buildings extremely susceptible to vibration damage	0.12	90

Source: FTA (2006)

^a:An RMS vibration velocity level in VdB relative to 1 micro-inch/second.

During construction, some equipment may cause ground-borne vibration, most notably piledriving equipment. Construction equipment can produce vibration levels at 25 feet (7.62 m) that range from 58 VdB for a small bulldozer to 112 VdB for a pile driver. Table 4.10 provides the approximate distances within which receivers could experience construction related vibration effects.

Table 4.10 Approximate Distances to Vibration Criterion – Level Contours

Land Use Category	Vibration Criterion Level (VdB)	Approximate Vibration Contour Distance (feet)
Tracts of land where silence is an essential element	65	175 (53.35 m)
Residences and buildings where people normally sleep	72	130 (39.624 m)
Institutional land uses with primarily day time and evening use	70	70 (21.336 m)

Source: FTA (2006)

4.5.5 Vibration: Impact during Operational Stage

Ground-borne vibration impacts from the SilverLine operations inside vibration-sensitive buildings are defined by the vibration velocity level, expressed in terms of VdB, and the number of vibration events per day of the same kind of source. Desktop reviews revealed that measurement on actual vibration levels when *Shinkansen* passes with the speed over 300km/h in Japan do not exceed the guideline value in Japan. As similar construction technique and measures are introduced to the planning of the SilverLine, the impact caused by vibration will be within the standard limit.

4.5.6 Vibration: Mitigation Measures

Building damage from construction vibration is only anticipated from pile diving at very close distances to buildings. When a construction scenario has been established, preconstruction surveys will be conducted at locations within 15.24 m of piling to document the existing condition of buildings in case damage is reported during or after construction. Damaged buildings would be repaired, or compensation paid to the owners. The operation time shall be limited between 6:00 to 18:00. Although the vibration level caused by blasting is theoretically controlled within the threshold value, continuous monitoring is necessary during the construction for both NATM and blasting. Notify the local people prior to undertake the construction activities associating with higher vibration level such as activities using vibrating rollers. The vibrations should be reduced considerably by ensuring and keeping correct track geometry by advanced measurement. Expanding the right of way (buffer zone) is sometimes the easiest method of reducing the vibration impact.

4.6 Biological Environment

4.6.1 Flora: Impact during Construction Phase

The major impact in this project on flora involves the removal of trees growing within the ROW (on both private and public lands) for efficient construction workmanship and to provide clear zone for safety of the users. Trees, herbs and shrubs in the ROW will be felled along the alignment route could adversely affect vegetation cover and local landscape.

4.6.2 Flora: Impact during Operation Phase

Improper post-plantation care/ maintenance as well as illegal felling of plantation along the track will offset all positive efforts by the project.

4.6.3 Flora: Mitigation Measures

- Appropriate compensatory plantation using suitable native species or pollution tolerant species should be initiated to compensate for the vegetation loss due to felling of trees during site clearing
- For trees to be felled in private land, compensation for trees based on fruit yield value, timber value and other economic value should be given to the owners
- Transplantation of trees/poles should be carried out wherever possible
- For mangrove felling, permission from the State Forest Department shall be secured. Compensatory mangrove plantation shall be taken up at the identified location in consultation with the Forest Department.
- Plantation along the ROW should be maintained properly (in terms of proper inspection/ pruning, water and nutrition requirements) as well as protected from illegal felling

4.6.4 Fauna: Impact during Construction Phase

Terrestrial, aquatic and avifauna may be affected in the construction phase by noise and vibration due to construction equipment and machinery as well as movement of construction bound vehicles. Removal of trees along the proposed alignment route will lead to the destruction of faunal habitats such as bird nests, breeding sites, *etc.* Increased sediment loads into water bodies during bridge construction work may impact aquatic fauna due to temporary loss of habitat and reduced water quality and flow.

4.6.5 Fauna: Impact during Operation Phase

Proposed SilverLine which may divide the natural habitats in certain landscape that could possibly affect faunal population range and distribution, ability to mate, connectivity between populations. Impact on aquatic fauna in case of accidental oil spill and toxic chemicals release find its way into the water bodies. The noise and vibration generated by the SilverLine project may disturb the fauna including domestic livestock especially in the night time. There is a potential of direct impact of SilverLine trains hitting avifauna since the trains will be running at a speed of 200 km/h on viaduct at a height of 10m-15 m.

4.6.6 Fauna: Mitigation Measures

- Noise and vibration at the construction site should be minimized and all major noise producing construction equipment/ machineries should be fitted with acoustic control measures
- Soil compaction for embankment work should be done immediately to avoid erosion and consequently increase in sediment loads to the water bodies.
- Major earth work during construction of important bridges should be done during the dry period.
- Immediate actions should be taken for speedy cleaning up of oil spills, fuel and toxic chemicals in the event of accidents.
- Crossing structures should be constructed at regular interval and the location, frequency, basic design and number of crossing structures need to be finalised in consultation with various stakeholders.

4.6.7 Mangroves: Impact during Construction Phase

The SilverLine alignment passes through a number of mangrove patches especially in the northern Districts of Kerala. Mangrove area with dominant species of *Avicennia sp.* having conservation value will be affected by construction of SilverLine project. Mangrove Fauna may be impacted by destruction of water holes and habitats such as bird nest and breeding sites along the new alignment route.

4.6.8 Mangroves: Mitigation measures

- The loss of mangrove vegetation should be compensated by replanting at with ratio of 1:5 at other identified sites so that there is no net overall loss of this important habitat.
- Incorporate into the design underpasses, pipe culverts and/ or other structures as needed to allow wildlife to cross line safely.

4.7 Microclimate

4.7.1 Impacts

During construction phase, the impact on local micro-climate is envisaged from activities including clearing of vegetative cover may also lead to rise in the local temperatures over long term, operation of large number of heavy construction machineries, and Continuous running of power back up DG set at the construction camp, etc. The removal of trees on both private and public lands may result in changes in micro-climatic effects for the local communities. The construction and operation of the proposed project is not expected to lead to any changes in the precipitation (rainfall) over the region. During operation phase, greenhouse gas emission due to running of air conditioning system and DG set at station areas and maintenance depot can contribute to climate change.

4.7.2 Mitigation measures

- Solar PV cell should be installed on roof top of all station buildings and maintenance depot to trap the solar energy
- Design buildings in compliance to the Energy Conservation Building Code 2017
- Minimal use of air conditioning system in the station and maintenance depots

4.8 Flood and Landslides

4.8.1 Impacts

The SilverLine intersects both perennial and non-perennial drainage system through out the State which has the potential to directly affect the drainage conditions of the area. During construction phase, flood and landslides may occur if drainage channels are blocked. Increased incidence and duration of floods may happen due to obstruction of natural drainage courses by the embankment. No major impact is envisaged during the operation phase of the project.

4.8.2 Mitigation measures

- No construction materials or wastes should be dumped into natural drains or block, impede or alter drainage channels
- Adequate cross drainage channels (longitudinal and median drains) should be provided along SilverLine route for the smooth passage of the surface run-off to prevent flooding
- Longitudinal drains of sufficient capacity should be provided on both sides of the maintenance road to accommodate increased run-off. The outfall of these drains should be in the nearby culverts/ bridges on canals/rivers/drains

4.9 Impacts on Hydrology

4.9.1 Impacts on Hydrologically Fragile Zones: Construction Phase

The project is a linear one/ crossing all the west flowing rivers, streams of Kerala and also agriculture fields/ flood plains are crossed or runs along. Large quantity of earthwork involved affects Hydrological environment. Embankments cause Inundation/ obstruct easy flow downstream, increase silt flow, etc. Increase in soil erosion hampers the water quality /increased siltation. Reduced infiltration resulting in increase in surface flow and resultant flood. Obstruction of flow due to banking also result in ground water fluctuation and water logging. This has been described in detail in Chapter 6. Construction phase activities and its impacts on hydrologically fragile zones are given in Tables 4.11 to 4.14.

Table 4.11 Construction phase activities - Hydrologically fragile zones

Viaduct	Bridge	Banking	Cutting	Cut & Cover	Tunnel
HEIZ-(11nos) & other viaducts	HEIZ-(52nos) & other bridges	HEIZ-(101nos) & all banking	All	All	All
Vegetation clearance	Vegetation clearance	Vegetation clearance	Vegetation clearance	Vegetation clearance	
Earthwork and spillage stacking	Earthwork and spillage stacking	Earthwork	Earthwork	Earth work	Earth, rock or muck removal
Foundation / pile driving	Foundation / pile driving	Earth stacking	Earth /rock stacking & disposal (short time)	Earth /rock stacking (longer period)	Earth, rock or muck stacking
Drawing water for construction	Drawing water for construction	Drawing water for construction	Drawing water for construction	Drawing water for construction	Drawing water for construction
Stacking construction materials	Stacking construction materials	Stacking construction materials	Stacking construction materials	Stacking construction materials	Stacking construction materials
Vehicle movement/ Temporary roads	Vehicle movement Temporary roads	Vehicle movement Temporary roads	Vehicle movement Temporary roads	Vehicle movement Temporary roads	Vehicle movement Temporary roads
Storing fuels, cement, chemicals	Storing fuels, cement, chemicals	Storing fuels, cement, chemicals	Storing fuels, cement, chemicals	Storing fuels, cement, chemicals	Storing fuels, cement, chemicals

Equipments /machinery Working	Equipments /machinery Working	Road rollers Soil stabilization	Equipments /machinery Working	Equipments /machinery Working	Equipments /machinery Working
Construction of service roads	Construction of service roads	Construction of service roads	Construction of service roads	Construction of service roads	
Camp shed/toilets/waste water	Camp shed/toilets/waste water	Camp shed/toilets/waste water	Camp shed/toilets/waste water	Camp shed/toilets/waste water	Camp shed/toilets/waste water

Table 4.12 Construction phase activities– Hydrologically fragile additional zones

I VERY HIGH Kollam station and two yards	II HIGH Kottayam, Chengannur and Kochi Airport stations	III MODERATE Thiruvananthapuram, Ernakulam, Thrissur, Tirur, Kozhikode, Kannur, Kasaragod stations
Large scale earth filling	Large scale earth filing	Earth filling/ Elevated/ under ground station construction
Sensitive Flood Plain reduction	Sensitive Flood Plain reduction	Floodplain reduction/ existing station
Station building, parking area, public amenities	Station building, parking area, public amenities	Station building, parking area, public amenities
Water supply/septic tanks	Water supply /septic tanks	Water supply/ septic tanks
Deviation of existing water course, culverts, fencing, roads etc.	culverts, fencing, roads etc.	culverts, fencing, roads etc.
Storing cement, materials, fuel, etc.	Storing cement, materials, fuel, etc.	Storing cement, materials, fuel, etc.
Heavy machinery, Equipment working & movements	Heavy machinery, Equipment working & movements	Heavy machinery, Equipment working & movements
Camp shed, Toilets, Foul water disposal	Camp shed, Toilets, Foul water disposal	Camp shed, Toilets, Foul water disposal

Table 4.13 Expected Impacts, Construction Phase – Hydrologically fragile zones

VIADUCT	BRIDGE	BANKING	CUTTING	CUT&COVER	TUNNEL
HEIZ-(11nos) & other viaducts	HEIZ-(52nos) & other bridges	HEIZ-(101nos) & all banking	All	All	All
High flood damage	High flood damage	High flood damage	Land slides	Stacked earth slides	Stacked rock, muck/ earth slides
Soil erosion	Soil erosion	Soil erosion	Soil erosion	Soil erosion	Soil erosion
Sediment laden flow	Sediment laden flow	Sediment laden flow	Sediment laden flow	Sediment laden flow	Sediment laden flow
Contamination of surface / ground water	Contamination of surface / ground water	Contamination of surface / ground water	Contamination of surface/ ground water	Contamination of surface/ ground water	Contamination of surface/ ground water
Piling may impact on aquifer	Piling may impact on aquifer	Sub soil strata consolidation-sand or stone piles- impact on aquifer	Cutting water table and resultant water leakage	Cutting water table and resultant water leakage	Cutting water table and resultant water leakage
Flood plains obstruction	Reduction in water way	Flood plains obstruction			
		Water logging			
		Streams, rain water paths obstruction			
Fuel, cement, waste spillage	Fuel, cement, waste spillage	Fuel, cement, waste spillage	Fuel, cement, waste spillage	Fuel, cement, waste spillage	Fuel, cement, waste spillage
Camp sheds-waste water, septic tank leaks impact water sources	Camp sheds-waste water, septic tank leaks impact water sources	Camp sheds-waste water, septic tank leaks impact water sources	Camp sheds-waste water, septic tank leaks impact water sources	Camp sheds-waste water, septic tank leaks impact water sources	Camp sheds-waste water, septic tank leaks impact water sources
Impact on domestic dug wells	Impact on domestic dug wells	Impact on domestic dug wells	Impact on domestic dug wells	Impact on domestic dug wells	Muck stack /leaching impact water quality
Dry season-dust generated impact-air/water	Dry season-dust generated impact-air/water	Dry season-dust generated impact-air/water	Dry season-dust generated impact-air/water	Dry season-dust generated impact-air/water	Dry season-dust generated impact-air/water
			Rock blasting impact	Rock blasting impact	Rock blasting impact
		Impact due to dust creation	Impact due to dust creation	Impact due to dust creation	

Table 4.14 Expected Impacts, Construction Phase – Hydrologically fragile additional zones

I VERY HIGH Kollam station and two yards	II HIGH Kottayam, Chengannur and Kochi Airport stations	III MODERATE Thiruvananthapuram, Ernakulam, Thrissur, Tirur, Kozhikode, Kannur, Kasaragod stations
Reduction in Flood Plains-Flood Havoc	Flood /water logging	
Soil Erosion-Contamination of water body	Soil Erosion-Contamination of water body	Soil Erosion-Contamination of water body
Reduction in infiltration- increase in runoff	Reduction in infiltration-increase in runoff	Reduction in infiltration-increase in runoff
Geomorphologic changes- Thodu deviations/changes in flood plains – drastic changes in hydrological environment	TS canal deviation/ thodu deviation-affect hydrological environment	
Spillage of oil, diesel, cement and chemicals- contamination of water body	Spillage of oil, diesel, cement and chemicals-contamination of water body	Spillage of oil, diesel, cement and chemicals-contamination of water body
Sub soil strata consolidation-sand or stone piles impact on aquifer	Sub soil strata consolidation-sand or stone piles impact on aquifer	
Water logging		
Impact due to soil piping zone		
Impact due to flood surge zone		
Labour camp waste spills	Labour camp waste spills	Labour camp waste spills
Rise in water table		
Impact due to dust creation	Impact due to dust creation	Impact due to dust creation

4.9.2 Impacts on Hydrologically Fragile Zones: Operation Phase

Operation phase activities and its impacts on hydrologically fragile zones are given in Tables 4.15 to 4.16.

Table 4.15 Expected Impacts, Operation Phase – Hydrologically fragile zones

VIADUCT	BRIDGE	BANKING	CUTTING	CUT&COVER	TUNNEL
HEIZ-(11nos) & other viaducts	HEIZ-(52nos) & other bridges	HEIZ-(101nos) & all banking	All	All	All
No significant impact	No significant impact	High flood damage	Landslides/ soil erosion	No significant impact	No significant impact
		Soil erosion from slopes	In monsoon Eruption of new springs	Soil erosion from refilled earth	Erosion and leaching of stacked muck
		Water logging	Water table rising –water logging		
		Local floods			
		Surface/ ground water contamination			
		Impact on downstream water supply scheme			

Table 4.16 Expected Impacts, Operation Phase – Hydrologically fragile additional zones

I VERY HIGH	II HIGH	III MODERATE
Kollam station and two yards	Kottayam, Chengannur and Kochi Airport stations	Thiruvananthapuram, Ernakulam, Thrissur, Tirur, Kozhikode, Kannur, Kasaragod stations
Flood risk/storm surge	Flood risk	No significant impact
Water logging		
Soil erosion		
Soil piping		
Tsunami invasion		

4.9.3 Hydrologically Fragile Zones: Mitigation Measures

Construction phase impact can be contained or minimized if proper mitigation measures are taken. As for as 'bridges' and river crossing, 'viaducts' are concerned proper design flood calculation is needed and the levels fixed accordingly or else vent increased by providing additional span. In the case of Embankments where the maximum impact will be experienced care must be taken to minimize it. In 'Cuttings' and 'cut & covers', the earth work involved is huge and there for the impact will be maximum during construction phase. This can be overcome by adopting precautionary measures to minimize impacts.

- Adequate discharge VENT has to be provided for Bridges/Viaducts
- Some banking proposal may be changed to VIADUCT to overcome High Flood water risk
- Severe hydrological impact zones have to be subject to detailed study
- Suitable Irrigation canal crossing structures shall be designed
- In Kollam and Kasargod (station/yard) diversion of thodu shall be done after comprehensive hydrological study.
- Banking shall be with adequate cross drainage to avoid water logging
- During construction, a combination of temporary and permanent detention basins, notched weirs, swales and vegetative strips would be used to limit off-site stormwater runoff.

Mitigation measures suggested for Hydrologically fragile zones of the SilverLine project is given in Tables 4.17 and 4.20.

Table 4.17 Mitigation Measures, Construction Phase – Hydrologically fragile zones

VIADUCT	BRIDGE	BANKING	CUTTING	CUT&COVER	TUNNEL
HEIZ-(11nos) & other viaducts	HEIZ-(52nos) & other bridges	HEIZ-(101nos) & all banking	All	All	All
Storing and handling fuel, cement, chemicals, etc. without causing spillage	Storing and handling fuel, cement, chemicals, etc. without causing spillage	Storing and handling fuel, cement, chemicals, etc. without causing spillage	Storing and handling fuel, cement, chemicals, etc. without causing spillage	Storing and handling fuel, cement, chemicals, etc. without causing spillage	Storing and handling fuel, cement, chemicals, etc. without causing spillage
Earth spoil debris stacked without causing spillage-can be disposed early	Earth spoil debris stacked without causing spillage-can be disposed early	Earth spoil debris stacked without causing spillage-can be disposed early	Earth spoil debris stacked without causing spillage-can be disposed early	Earth spoil debris stacked without causing spillage-can be disposed early	Earth/muck spoil debris stacked without causing spillage-can be disposed early

VIADUCT	BRIDGE	BANKING	CUTTING	CUT&COVER	TUNNEL
Construction materials stacked within barriers	Construction materials stacked within barriers	Construction materials stacked within barriers	Construction materials stacked within barriers	Construction materials stacked within barriers	Construction materials stacked within barriers
Level of rail and span designed as per design flood discharge	Level of rail and span designed as per design flood discharge	Adequate vent shall be given for rain water to drain off	Trial borings taken to ensure water table position; precaution taken	Trial borings taken to ensure water table position; precaution taken	
River crossings the pile cap coming inside river to be kept below bed level	Pile cap top level kept below bed level-to avoid obstruction of easy flood water flow	Care shall be exercised in case of flood plains that the flood waters allowed to pass easily through vents and fill up & drain off as existed early.			
		Filling and draining off of flood plains shall not be obstructed			
		Sheet piles shall be used to stack materials likely to spill			
		Watering periodically to contain dust	Watering periodically to contain dust	Watering periodically to contain dust	
		Banking slopes may be protected with coir matting and grass			
Regular monitoring of surface /ground water	Regular monitoring of surface /ground water	Regular monitoring of surface /ground water	Regular monitoring of surface /ground water		
Designing proper drainage with silt settlement pits	Designing proper drainage with silt settlement pits	Designing proper drainage with silt settlement pits	Designing proper drainage with silt settlement pits	Designing proper drainage with silt settlement pits	Designing proper drainage with silt settlement pits
Spans to be inclusive of river banks-extra spans	Spans to be inclusive of river banks-extra spans				
			In soil piping region precautionary		

VIADUCT	BRIDGE	BANKING	CUTTING	CUT&COVER	TUNNEL
			measures to be taken/change to C&C		

Table 4.18 Mitigation Measures, Construction Phase – Hydrologically fragile additional zones

I VERY HIGH Kollam station and two yards	II HIGH Kottayam, Chengannur and Kochi Airport stations	III MODERATE Thiruvananthapuram, Ernakulam, Thrissur, Tirur, Kozhikode, Kannur, Kasaragod stations
Watching hydrological events-storm surge-tsunami-flood, etc.-precautionary measures to divert flood waters- designed drains	Watching hydrological events- designed drains	Watching hydrological events- designed drains
Storing materials/ fuel, chemicals, etc., within enclosed barriers	Storing materials/ fuel chemicals, etc., within enclosed barriers	Storing materials/ fuel, chemicals, etc., within enclosed barriers
Providing preventive measures for soil piping; slips	Alignment not to affect TS canal development works- Inland Navigation	Alignment not to affect TS canal development works- Inland Navigation
Keep rail level above anticipated flood/surge level	Keep rail level above anticipate flood	Keep rail level above anticipated flood/surge level
Adequately designed infrastructure for ensuring safe waste water, septic tank discharge - adopt treated water recycling	Adequately designed infrastructure for ensuring safe - waste water septic tank discharge - adopt treated water recycling	Adequately designed infrastructure for ensuring safe - waste water septic tank discharge - adopt treated water recycling
Rain water harvesting - recharging aquifer	Rain water harvesting – recharging aquifer	Rain water harvesting – recharging aquifer
Creating compensatory flood plain for the anticipated flood		
Rail levels to be kept beyond the reach of tsunami inundation- viaducts preferred		Rail levels to be kept beyond the reach of tsunami inundation- viaducts preferred
Peripheral drainage system with recharging pits at intervals	Peripheral drainage system with recharging pits at intervals	Peripheral drainage system with recharging pits at intervals
Watering periodically to contain dust	Watering periodically to contain dust	Watering periodically to contain dust

Table 4.19 Mitigation Measures, Operation Phase – Hydrologically fragile zones

VIADUCT	BRIDGE	BANKING	CUTTING	CUT&COVER	TUNNEL
HEIZ-(11nos) & other viaducts	HEIZ-(52nos) & other bridges	HEIZ-(101nos) & all banking	All	All	All
Monitoring hydrological events	Monitoring hydrological events	Monitoring hydrological events	Monitoring hydrological events		

VIADUCT	BRIDGE	BANKING	CUTTING	CUT&COVER	TUNNEL
While crossing rivers/ thodu- same measures as of bridge	Vent way designed to discharge predicted high flood	Proper de silting of drain periodically	In cutting slopes- provide protection-adopt advance-eco friendly methods	Re filled earth protection	Tunnel mouth, air vents- protection
Periodical debris removal	Periodical debris removal	Protection of embankment slope & maintenance		Proper drainage for rain water- seepage	Proper drainage for rain water- seepage
		Vent way clearance for flood flow			

Table 4.20 Mitigation Measures, Operation Phase – Hydrologically fragile additional zones

I VERY HIGH Kollam station and two yards	II HIGH Kottayam, Chengannur and Kochi Airport stations	III MODERATE Thiruvananthapuram, Ernakulam, Thrissur, Tirur, Kozhikode, Kannur, Kasaragod stations
Watching hydrological events and taking precautionary measures	Watching hydrological events and taking precautionary measures	
Maintaining all drains debris free, clearing obstructions in the natural /deviated thodu or drains	Maintaining all drains debris free and clearing obstructions	Maintaining all drains debris free and clearing obstructions
Maintaining drains and recharge pits regularly	Maintaining drains and recharge pits regularly	Maintaining drains and recharge pits regularly
Timely diversion of flood waters	Timely diversion of flood waters	

4.10 Socio-economic Environment

A socio- economic survey was carried out in the SilverLine corridor as part of the project to identify the perception/ attitude of the people towards the project. The survey was conducted along the alignment, around 30 m from the centre line of the alignment. The survey was conducted through consultation and disclosing the project details to the project affected people in the grama panchayats and urban local bodies through which the SilverLine is passing. The details and analysis reports are included in chapter 6.

Environmental and Social Impact Matrix

	Attributes	Construction Phase	Operation Phase	Remarks
Environment Impact	Land Environment	Medium	Low	Topographic and land use changes occur during construction phase
	Water Environment	Medium	Low	Contamination of natural water course envisaged during the construction phase
	Air Environment	High	Low	Fugitive dust emission is expected during the construction phase
	Noise and Vibration	High	Medium	Noise and vibration envisaged due construction activities & running of train
	Biological Environment			
	Flora	Medium	Negligible	Trees, herbs and shrubs in the ROW will be felled during the construction phase
	Mangroves	Medium	Negligible	Removal of mangroves within the ROW envisaged during the construction phase
	Fauna	Medium	Low	Removal of trees will lead to the destruction of faunal habitats such as bird nests, breeding sites, etc.
	Microclimate	Medium	Low	Removal of trees, construction activities may impact the microclimate of the region
	Flood and Landslides	Medium	Low	During construction phase, flood and landslides may occur if drainage channels are blocked.
Hydrology	High	Low	Embankments cause Inundation/ obstruct easy flow downstream, increase silt flow, etc.	
Social Impact	Resettlement	High	Negligible	Detailed Rehabilitation and Resettlement (R&R) plan will be prepared to compensate the owners of the affected structures, trees and other agricultural land
	Water use	High	Low	High Water demand during the construction phase
	Livelihood	Positive	Positive	Large number of employment opportunities during construction and operation phase is envisaged
	Cultural Heritage	Medium	Low	Mixing of different culture may expect especially during construction phase
	Public health & safety	Medium	Low	Periodic health checkup to the construction workers and adequate sanitary facilities within every camp shall be provided by the construction contractor
	Aesthetics	Medium	Low	Green belt will be developed for the proposed site this will ensure proper aesthetics
	Ethnic minorities and Indigenous people	Medium	Low	Land acquisition may affect their domestic and agricultur land holding.

Chapter 5

ANALYSIS OF ALTERNATIVES - PROJECT ALIGNMENT AND TECHNOLOGY

5.1 Introduction

Analysis of Alternatives (AoA) aims to identify alternate project options and should be conducted during project design and planning stage in order to identify cost-effective alternatives, reduce adverse impacts and risks, improve performance and validate the appropriateness of the selected option. The proposed SilverLine connects the State Capital, Thiruvananthapuram to the northern most district, Kasaragod. The SilverLine passes through the entire length of the State and the environmental and socio-economic aspects influence the route alignment, construction methods, rollingstock, traction technology, type of carriageway, materials and services, *etc.* This chapter presents a comparative analysis between several alternatives considered to avoid or minimize environmental and social impacts.

With or Without Project Scenario

The 'with' or 'without' project scenarios are a major consideration of the cost-benefit analysis of a project. Providing better and faster connectivity across the State will ensure that goods and people can move in and out of the areas more efficiently. The project is expected to spin off increased trade and commerce activity throughout the State as the project has been designed to connect the various urban economic growth centers within the state. Without this project, it is expected that there will be an increase in air pollution, due to slow moving traffic and congestion. Travel will take longer thus impacting productivity and reducing the economic growth of the area. Overloading of existing transport infrastructure will also affect safety and lead to loss of human life due to increase in accidents. Benefits of the SilverLine over the other mode of transportation are presented in Table 5.1.

Table 5.1 Benefits of SilverLine over the other mode of transportation

Parameters	SilverLine	Other mode of Transportation (Railway/ Road/ Air/ Water way)
Land use	<p>The SilverLine is more efficient on landuse – an average SilverLine uses ~2.4 ha per km.</p> <p>Land impacts significantly reduced as alignment from Tirur to Kasaragod are parallel to the existing railway line.</p> <p>Elevated alignment will again reduce the land impacts</p>	<p>For widening of the road to meet the requirement, 6.1 ha per km land need to be acquired</p> <p>The land requirement for construction of 6 lane highway to cater same amount of traffic is 3 times more</p>
Travel Time	<p>Time savings from the SilverLine are significant.</p> <p>4 hours after the start of SilverLine service between Thiruvananthapuram and Kasaragod.</p> <p>As an alternative against air travel, SilverLine offers convenience through better connectivity to local transport infrastructure.</p>	<p>More time due to slow speed. 10 to 12 hours depending upon the speed of train.</p> <p>By air it takes 1 hour to travel between Thiruvananthapuram and Kannur. Access to the airport is not convenient in all the cities and not connected to local city transport.</p>
GHG Emissions	<p>Due to higher energy efficiency of the SilverLine operations, net GHG emissions are expected to be lower.</p> <p>Annual average emissions reduction of about 2,87,994 Tonnes CO₂e/year</p>	<p>The GHG emission has been estimated to be 31,20,328 Tonnes CO₂e in 2019 and it will be 45,84,786 Tonnes CO₂e in year 2024, without SilverLine operation</p>
Fuel Consumption	<p>Significant reduction in fuel consumption</p>	<p>Higher fuel consumption due to increased number of private vehicles</p>

5.2 Alternative Scenarios for SilverLine

This section deals with the rationales behind preferred choice of taking the Embankment Route Vs the No-SilverLine/ Business as Usual evaluation Vs Express Highway and comparison of impacts.

5.2.1 Alternative 1 - SilverLine with Embankment, Cuttings and viaducts with minimal cut and cover, Tunnels and Bridges

More than 60% of the alignment is on embankment, 19% on cuttings, 11% on viaducts and less than 10% of the alignment is on cut and cover, bridges and Tunnel. Although the foot print area of this alternative is comparatively high due to embankment, the cost of construction is low compared to Alternative 2.

5.2.2 Alternative 2 - No SilverLine - Business-as-Usual

In the absence of SilverLine, the passenger travel choices will continue to operate on the existing modes including road, rail and air. In addition, growing ownership of private vehicles will result in significant number of trips being served by cars. Road are predicted to continue to dominate, especially short trips between intermediate cities along the SilverLine corridor. Thus, there may be an increase in private vehicles at the expense of public transport like Rail, which shall have serious effect on the GHG emissions.

5.2.3 Alternative 3 – Express Highway

Construction of a new express highway requires more land acquisition and may have high social and environmental impacts. The land requirement for construction of Express highway to cater same amount of traffic is 3 times more.

5.3 Comparison of Alternatives

It is evident from the above sections that all the three alternatives have some advantage and disadvantage in terms of cumulative impact-environmental, social, etc. On assessment of the advantages and disadvantages of the three alternatives and certain limitation, it is considered that Alternative 1 is the most preferred option. The comprehensive comparison of three alternatives is summarized and presented in Table 5.2.

Table 5.2 The comprehensive comparison of three alternatives

Parameters	Alternative 1- <i>SilverLine with Embankment, Cuttings & viaducts with minimal cut & cover, Tunnels & Bridges</i>	Alternative 2 - No SilverLine - Business-as-Usual	Alternative 3 – Express Highway
Land use	The foot print area of this alternative is high; uses ~2.8 ha/ km.	For widening of road, 6.1 ha/ km land need to be acquired	Land requirement to cater same amount of traffic is 3 times more
Travel Time	Time savings from SilverLine are significant. 4 h between Thiruvananthapuram and Kasaragod	More time due to slow speed. 10 to 12 h depending upon the speed	More time due to slow speed. 6 to 8 h depending upon the speed
GHG Emissions	Due to higher energy efficiency, net GHG emissions are expected to be lower. Annual average emissions reduction of about 2,87,994 Tonnes CO ₂ e/year	GHG emission estimated to be 31,20,328 Tonnes CO ₂ e/year	GHG emission estimated to be 31,20,328 Tonnes CO ₂ e/year
Fuel Consumption	Significant reduction in fuel consumption	Higher fuel consumption	Higher fuel consumption
Safety	High safety and efficiency kept	Low safety and efficiency kept	Moderate safety & efficiency kept
Cost	Length of viaduct is less to economise the cost.	High Cost	High Cost
Environment	Low impact on environment. Overall economical & will have less cost of construction. This is the most desirable plan	High impact on environment. This plan is inferior to ALT1.	High impact on environment. This plan is inferior to ALT1 and ALT2.

Chapter 6

ADDITIONAL STUDIES AND ACTIVITIES

6.1 Hydrological Environment Impact Assessment

Kerala is the southernmost state of India receiving an average annual rainfall of 3000mm. In Kerala there is need for hydrological EIA because of the highly dense population and due to occurrence of rains throughout the year except for a short period of summer. Going through the records of high flood events occurred in last hundred years' shows that devastating flood and damage occurred in July 1925 and August 2018. Floods of varying magnitude and its damage occurred to a lesser extent in between the above period apart from the floods that occur annually. Floods occurring during the monsoons also to be reckoned as they also cause damages to a considerable extent. In the 2018 flood it can be seen that almost all the small and medium dams had spilled due to storage of previous storms. Even the big dams like Idukki, Kakki, Pamba, etc., had almost reached top level. This created a worst situation, as the CWC report reveals, leaving no room for any kind of flood attenuation possible. There for in this study the flood peak computed are compared with the high flood peak occurred in 2018.

6.1.1 Study Area

The SilverLine starts from Thiruvananthapuram "Kochuveli" station and terminates at "Kasaragod". Up to Kadinamkulam kayal the proposed alignment runs near and parallel on the Eastern side to the present railway line. It takes East- Northerly deviation and cross the NH-66 at three points. The alignment then reaches the proposed station location "Kollam" and then to "Chengannur", "Kottayam", "Eranakulam" and "Thrissur". After Eranakulam from Chowara to Angamali again it runs parallel to existing rail line and crosses it to W/side of existing line at Angamali. From Thirunavaya/Tirur reach the alignment again runs parallel and close to the existing railway line till it reaches the destination point Kasaragod. Thus, traversing the entire length of Kerala, the proposed line crosses all major rivers except a few in Southern and Northern parts of Kerala. The alignment needs to cross several streams, 'Thodus' and Irrigation canals. The proposed rail line passes through embankment and Viaducts for a considerable length and through open cutting for a shorter length and remaining major length of cutting as 'Cut & Cover' and Tunnels. Hydrological Impact significance attributes primarily to embankment, river, stream and thodu crossings. However, its impact due to bridges, Viaducts, cutting, cut & cover and tunnels also need to be assessed and addressed.

The terrain traversed by the proposed alignment in most of the part is closer to coast and only a portion runs along the midlands. The soil types are riverine alluvium, lateritic soil, brown hydromorphic soil and coastal alluvium. In the midland portion is the topography consists of a cluster of lateritic hills with numerous valleys in between. These valleys are called *elas*, which are essentially paddy fields. Now a days they are kept as barren land which in turn serve the purpose of flood pains. The ground water regime of Kerala along the places of interest in this study is basically unconfined aquifers and semi-confined aquifers. Tapping of ground water is done by open wells and by bore wells. In the aquifers in alluvial formations the depth to water ranges from less than a meter to 25m in coastal region and that in crystalline formations in midlands ranges from 3m to 16m.

6.1.2 Methodology

Desktop inspection of alignment in the Google earth platform and identification and marking of hydrological environment impact Zones (HEIZ). Watershed map along the proposed line is drawn using GIS platform (DEM) and the hydrological parameters like area of watershed, length of stream, gradient of stream, etc. are calculated and peak stream flood flow calculated using 'Rational' method and compared it with empirical formulae. This is done to assess the flood risk impact. This study mostly depends on secondary data collected from Internet and Departments. However, as Kerala had experienced an un precedential Flood havoc in 2018, primary data collection of HFL during ground truthing is also done. In this study CWC report on the 2018 August flood havoc published is also taken into account (secondary data). The project area crosses almost all the water sources of Kerala, thereby prone to contamination due to spills, silt loads, obstructions, etc. Regular monitoring of quality of water is necessary to ascertain the impact. Furthermore, in this study during site walk over data of domestic wells are also taken to monitor the impact. Table 6.1 shows water depth in the nearby wells of the SilverLine corridor.

The hydrological environment impact assessed for flood risk, pollution of surface and ground water during construction and operation phases. The hydrological environmental impact zones are marked as HEIZ (164nos) in the Google earth map. The linear alignment is classified according to the construction mode as Banking, Bridges, Cutting, Viaducts, Cut & cover and Tunnel for assessment. In the selected most vulnerable zones' watershed are drawn with indicative contour level marking of the area up to the level of banking/ MFL for visualizing the flood impact (4nos) (see Annexure 3). Further the Station areas and Yard development are also taken as separate zones for assessment (12nos). Google Map Showing Watershed of HEIZ (Google Map Screen Shots) are given in **Annexure 4**.

Table 6.1 Water depth in the nearby wells of the SilverLine corridor

Sampling location code	Latitude	Longitude	Place	Depth to water level from ground (m)	Depth of well (m)
GW1	8° 30' 44.8" N	76° 53' 52.43"E	Kochuveli	2.0	3.90
GW2	8° 53' 40.5"N	76° 39' 27.09"E	Kollam	6.0	7.6
GW3	9°20' 19.8"N	76° 38' 37.9"E	Chengannur	5.1	6.6
GW4	9° 34' 39.8"N	76° 32' 22.5"E	Kottayam	2.0	3.7
GW5	10° 00' 27.3"N	76° 22' 42.4"E	Ernakulam	2.0	3.5
GW6	10° 30' 34.4"N	76° 12' 20.6"E	Thrissur	3.2	3.7
GW7	10° 55'42.9"N	75° 54'52.0"E	Tirur	2.8	7.0
GW8	11° 14'45.5"N	75° 46'49.4"E	Kozhikode	1.5	5.6
GW9	11° 35'22.2"N	75° 37'17.2"E	Badagra	5.0	7.2
GW10	11° 52'57.7"N	75° 21'47.3"E	Kannur	2.5	6.2
GW11	12° 09'13.3"N	75° 10'31.3"E	Vadamkumkad	1.8	5.0
GW12	12° 29'31.6"N	74° 59'11.3"E	Kasragod	6.0	7.4

6.1.3 Rainfall Data

Annual rain fall in Kerala is about 3000mm per annum. But Kerala has witnessed two major flood havocs in 1924 and in 2018. The report on the study conducted by CWC for the 2018 flood has been adopted for optimizing the constant 'C' in Ryve's formula and 'I' intensity to be used in rational formula and these values are applied to the watersheds. In a study report about the intensity of rainfall, the values of hourly maximum recorded intensity in Kerala at Kozhikode, Thiruvananthapuram and nearby area Mangalapuram as part of the whole Indian terrain, are seen as 8.7, 7.7 and 9.3cm/hr respectively (secondary data from the study report-International journal of Climatology-3/6/2011). This is very high intensity rain occurred for short duration recorded on those station gauges. The values are given only to emphasize the need for further hydrological study for the present project situated in the state of Kerala.

In this study, rainfall intensity is required for calculating the flood discharge in each catchment by rational method. As the data availability is not forthcoming, an indirect method of finding the optimized value of intensity of rainfall based on the recorded flood flow

(secondary data) has been adopted. The flood peak thus found will indicate the flood risk at that point. Analysis of rainfall data for past several years and flood peak discharge using unit hydrograph or rainfall runoff model study does not come under the purview of this study but that may be used in the detailed hydrological study of areas wherever it is warranted.

Kerala receives monsoon rains from June to December in two spells as South-West and North-East. Apart from the monsoon rains it also receives flash floods due to low pressures/depression or cyclonic storms in Bay of Bengal and Arabian Sea. Also, the Kerala coast had experienced the fury of Tsunami waves recently. The rail line proposed is running almost nearer to the coast for the considerable part of the alignment. However, this rapid EIA does not cover the **Tsunami/ Tidal** effects in detail, it is imperative to consider the same during the comprehensive EIA. It is also noteworthy that no such events had caused any considerable damages to the existing rail line so far. The Kerala disaster management authority has published map showing vulnerable areas of flood, sand piping and tsunami/storm surge. Maps showing the tsunami inundation areas, storm surge and soil piping areas with the alignment centre line drawn in it is also made for indicating and assessing areas of its impact. On verifying the area with the proposed alignment, it can be seen that the alignment is passing through flood prone area throughout and sand piping prone area in Kasaragod taluk. And storm surge/tsunami inundation area in Malapuram, Kozhikkod and Kasaragod districts. Sufficient design parameters shall be included to overcome any eventuality of STORM SURGE DAMAGE OR DAMAGE DUE TO TSUNAMI INUNDATION.

It is pertinent to notice that the new deviation of alignment particularly the portions which traverse West side of existing rail line is passing through the **STORM SURGE AND TSUNAMI INUNDATION AREAS** as per the published map of Kerala Disaster Management Authority. Due consideration in this regard is essential to overcome any potential damage that may cause due to any natural calamity in future.

In the Google earth map the hydrological impact zones are marked along the proposed alignment. Embankments, Rivers, thodus, valleys etc., which divide the land to be subjected to hydrological verification for the following aspects.

- Topography or land slope including watershed area.
- Previous history of Flood plain/Inundation level/field visits.
- Expected maximum discharge calculation (only for Impact assessment)
- Field visits for GW levels in nearby wells.
- Flood level markings in the 2018 flood.

For calculation of maximum possible flood discharge for assessment purpose rational method has been adopted with cross checking with Ryve's method. The 'I' value was taken for rational method by optimizing the recorded runoff (secondary data-cwc report) at Bharthapuzha, Chalakudy, Periyar, Manimala and Pamba basins using the Rational formula by changing 'I' values and keeping all other constants same. The value that gives the nearest result is adopted. It is to be noticed that the odd values highlighted in red are ignored. Similarly, 'C' values for Ryve's equation were obtained by optimization method. The optimized values are given in Table 6.2.

Table 6.2 Maximum possible flood discharge in selected rivers

RIVER	RYVE'S C	RATIONAL I cm/hr (C=0.25)	CWC Qmax m3/s recorded	RYVE'S/ RATIONAL Qmax m3/s	ADOPTED VALUE
Bharathapuzha	20	1.65	6400	6662/6972	C=21 for RYVE'S
Chalakudy	22	2.60	2900	2918/3028	
Periyar	30	2.5	8800	8893/8868	
Manimala	16	2.3	1280	1393/1298	I=2.38cm/hr
Pamba	19	2.1	2900	3050/2969	For RATIONAL
Average	21.4/5(21.75/4)	2.23/5(2.38/4)			

6.1.4 Hydrological Environment Impact Zones (HEIZ)

On scrutinizing the proposed alignment on Google earth, the HEI Zones were identified. A total of 164 zone points are marked along the alignment and screen shots are taken (see Annexure - 2). The zones that affect the alignment are identified and its catchment area up to the HEIZ points is calculated. The maximum probable flood discharge is also calculated using rational and Ryve's methods. Table 6.3 shows the HEI Zones which were highly prone to flooding with a stream or thodu crossing. It is recommended to consider these points and provide appropriate cross drainage to avoid flood risk.

Table 6.3 HEI Zones highly prone to flooding with a stream or thodu crossing

Zones	Place	Watershed Area(km ²)	Flood Discharge (m ³ /sec)	Recommended Proposal
HEIZ 3 *	Murukumpuzha	3.18	5.00	Bridge/Culvert
HEIZ 5*	Eala near Mudapuram	0.60	1.00	Bridge/Culvert
HEIZ 12 ***	Parakkulam	10.00	17.00	Bridge/VD
HEIZ 20 **	Meenadu	4.00	7.00	Bridge/Culvert
HEIZ 26 **	Maruthoor	11.00	18.00	Bridge/VD
HEIZ 30 **	Thottuva	18.00	30.00	Bridge/VD
HEIZ 31 *	Kallappanchira	18.48	31.00	Bridge
HEIZ 37 ***	Kurichimuttam	23.61	39.00	Bridge
HEIZ 39 *	Koipuram	3.91	6.00	Culvert
HEIZ 46 **	Vakathanam	4.00	7.00	Culvert
HEIZ 47***	Pathyapally	2.33	4.00	Bridge/Culvert
HEIZ 53 ***	Vadakunnampuzha	2.39	4.00	Bridge/Culvert
HEIZ 61 ***	Chottanikkara-Kadambayar/3 croses	43.00	71.00	River deviation/Bridges
HEIZ 80 ***	Edayattoor	48.00	79.00	Bridge
HEIZ 87 **	Kaduppassery	11.00	18.00	Bridge
HEIZ 96 **	Thannikudam River	91.00	151.00	Bridge
HEIZ 97 **	Peramangalam	58.00	96.00	Bridge
HEIZ 102 **	Eranallur	1.78	3.00	Culvert
HEIZ 106 **	Panthalloor-Near Viaduct	6.60	11.00	Extend VD
HEIZ 108 **	Porkulam	2.00	3.00	Culvert
HEIZ 109***	Othallur west	73.00	121.00	Bridge
HEIZ 113 ***	Kolathara	13.00	6.00	Bridge/Culvert
HEIZ 114 ***	Maravanchery	13.00	22.00	Bridge
HEIZ 118 **	Thirunavaya	28.00	46.00	Bridge
HEIZ 120 **	Kattachira-Upstream Bridge /Old rail line	49.00	81.00	Bridge

6.1.5. Hydrologic Impact Assessment of Additional Zones

All the eleven station areas and two-yard areas are to be assessed as separate impact zones. The impact in these areas are classified as very high, high and moderate (Table 6.4). It is observed that the Kollam station and yard is proposed in a flood plain. The Ayathil thodu with a catchment area of 15.3 km² and flood discharge of 25m³/sec is running along the rail line. The 'thodu' is required to be re aligned and diverted for the development works. It is there for seen as the most vulnerable place of hydrological impact.

Table 6.4 Other vulnerable place of hydrological impact

SI. No.	HEIZ No.	Name of Station/ Yard	Features	Impact	Land Type	Remarks
1	1	Thiruvananthapuram	Elevated, Nearby TS-canal	Moderate	Flood Plain	Inland Navigation Clearance
2	23	Kollam	Banking	Very High	Flood Plain	More Study Required
3	38	Chengannur	Banking	High	Flood Plain	
4	49	Kottayam	Banking	High	Flood Plain	
5	66	Ernakulam	Elevated	Moderate	Flood Plain	More Study Required
6	95	Thrissur	Elevated	Moderate		
7	121	Tirur	Banking	Moderate		
8	126	Kozhikkode	Elevated	Moderate		
9	142	Kannur	Under ground	Moderate		
10	160	Kasargod	Banking	Moderate		
11	23 & 24	Kollam Yard	Banking	Very High	Flood Plain	More Study Required
12	160 & 160A	Kasaragod Yard	Banking	Very High	Flood Plain	More Study Required

The most vulnerable place identified in this study is the Kollam station and Yard. Similarly, Kasaragod yard also is in flood plains. A study on Kollam station & yard and Kasaragod yard on GIS platform reveals the following points (Fig 6.1 & 6.2).

The proposed station and yard area are paddy field and flood plain. A Thodu named 'AYATHIL' is running close and parallel and discharging flood waters from its catchment area of 32.73km². The flood discharge for 2.68cm/hr rainfall intensity calculated at station point HEIZ23, works out to 25m³/sec. If the proposal is to be realized the said thodu and its tributaries are to be deviated through the boundary with adequate dimensions to convey the flood waters. For this a detailed hydrological study is necessary. In this rough study, it can be seen that the water spread area (see Fig. 6.1) indicated in dark blue is that occurred during the recent flood havoc in 2018.

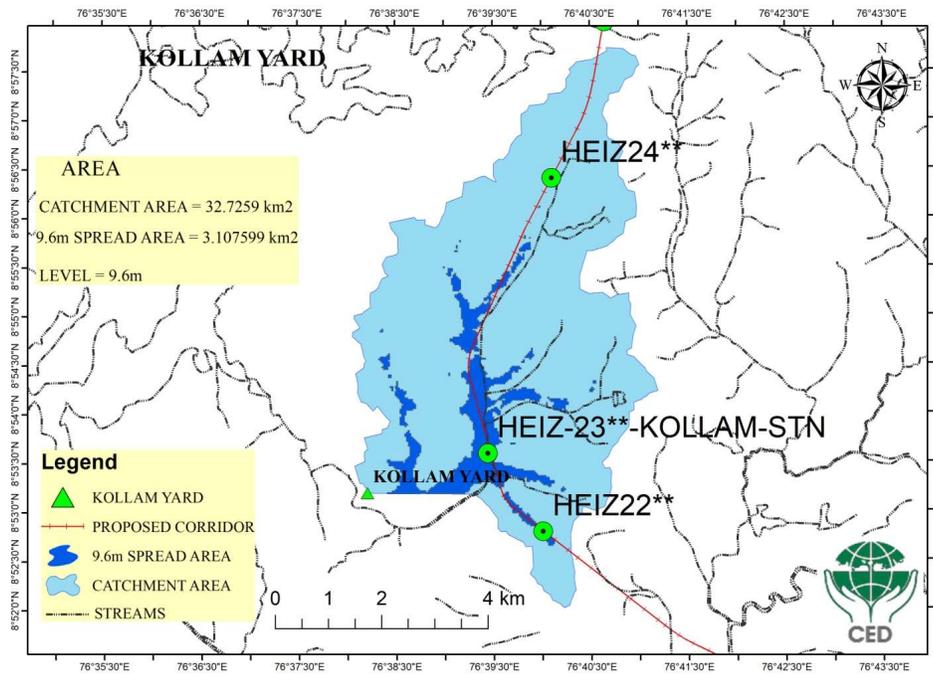


Fig. 6.1 Kollam Station & Yard and its catchment area

The area is 3.11km² in extent, for the flood level marking of 9.60m (data obtained from the local community). It can also be seen that from point HEIZ 22 to HEIZ 24 the flood havoc in 2018 has filled up water. Therefore, this area needs a detailed study to divert floods and to provide flood plain for the natural process of filling and draining.

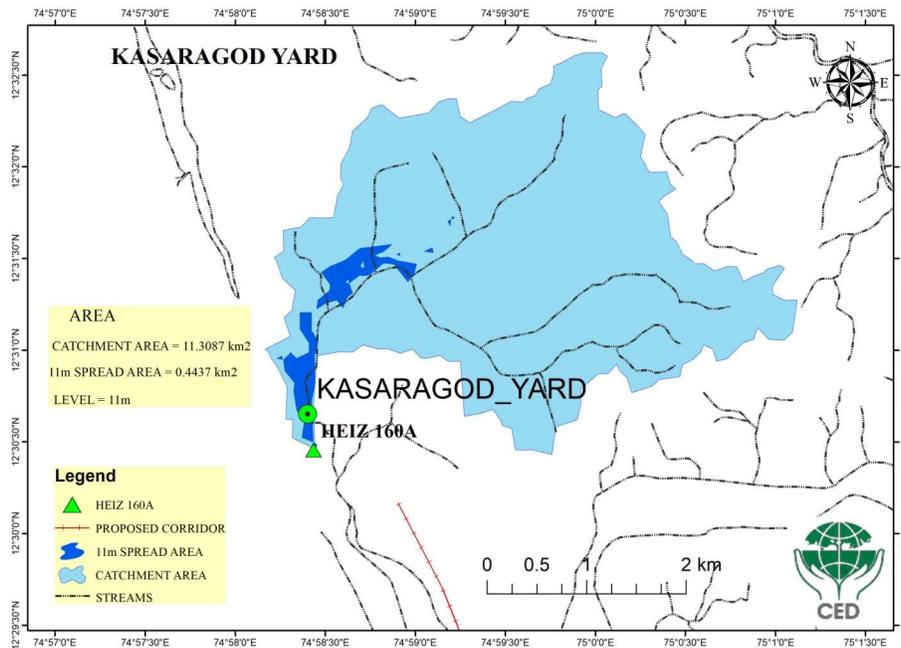


Fig. 6.2 Kasaragod yard and its catchment area

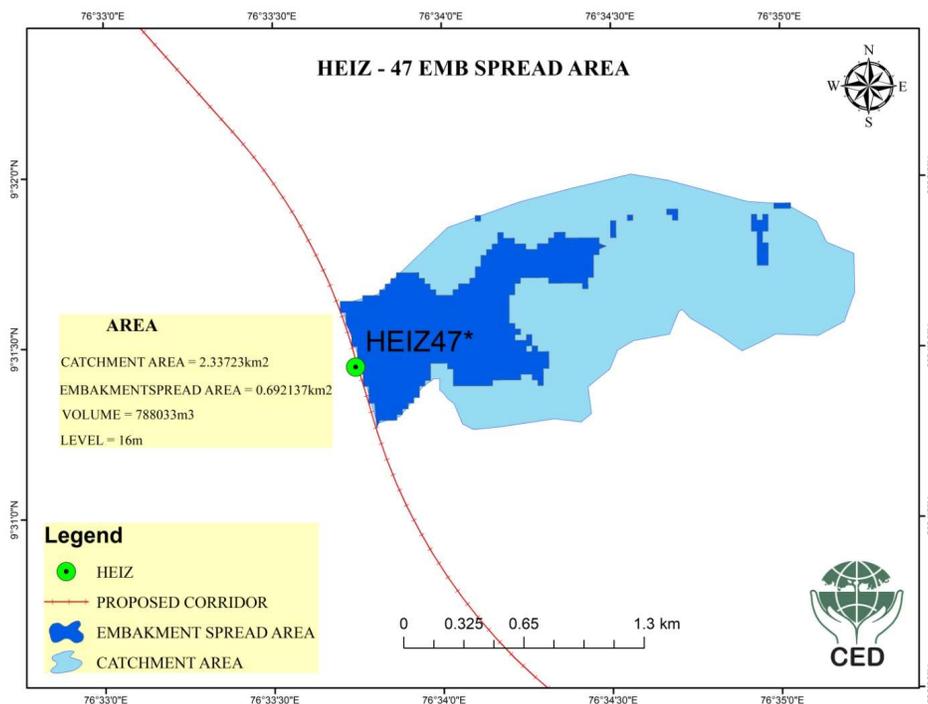
Fig 6.2 shows the Kasaragod yard and its catchment area. It can be seen that the thodu and its tributaries discharge through the point HEIZ160A. The catchment area is 11.31km². And the discharge for rain fall intensity of 2.68cm/sec is 19m³/sec. The dark blue in the figure shows the spread area for 11m contour. The adopted level for this study is the land level at the point considered-160A. It can be seen that the area proposed as Yard is actually a flood plain so if development in this area is carried out alternate flood plain is to be necessarily created. The maximum intensity of rainfall recorded in Mangalore, a nearby place is 9.7cm/hr. This indicate a possibility of flooding even for short duration storms.

6.1.6 Important Hydrological Environment Impact Zones (HEIZ)

Selected HEIZ with countour level and watershed are described below.

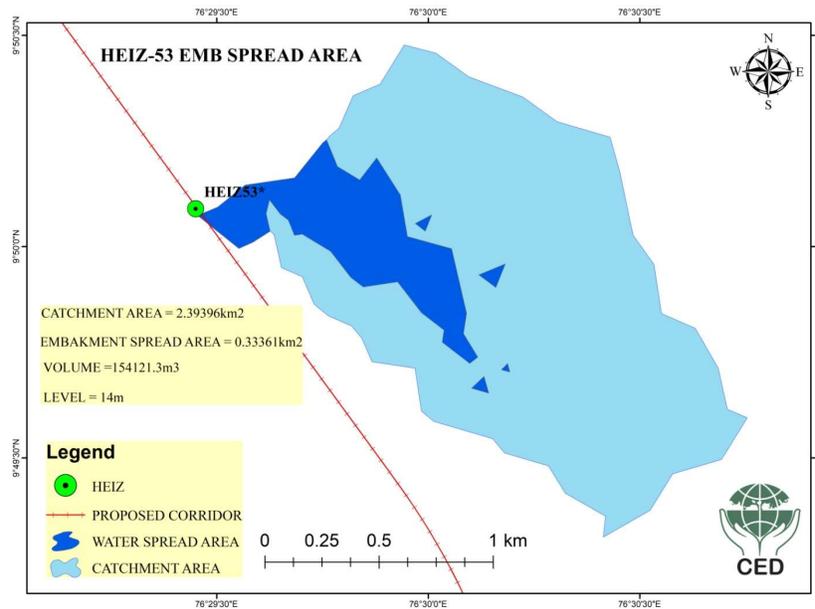
HEIZ 47

Here the alignment is proposed as banking with a rail formation level of 15.659 meters above sea level. In the study it is revealed that the catchment that discharges the flood waters to the point is 2.34km². In order to ascertain the spread area of the level of formation of banking ie, 16m above sea level, GIS tool was used. An area of 0.692km² was obtained and that is shown as dark blue shade in the map in the Appendix-3. The flood discharge for 2.38cm/hr intensity rain over the above catchment gives the value of 4m³/sec. This shows the high flood risk at this place. Proper drainage vents are to be provided for easing out the flood risk.



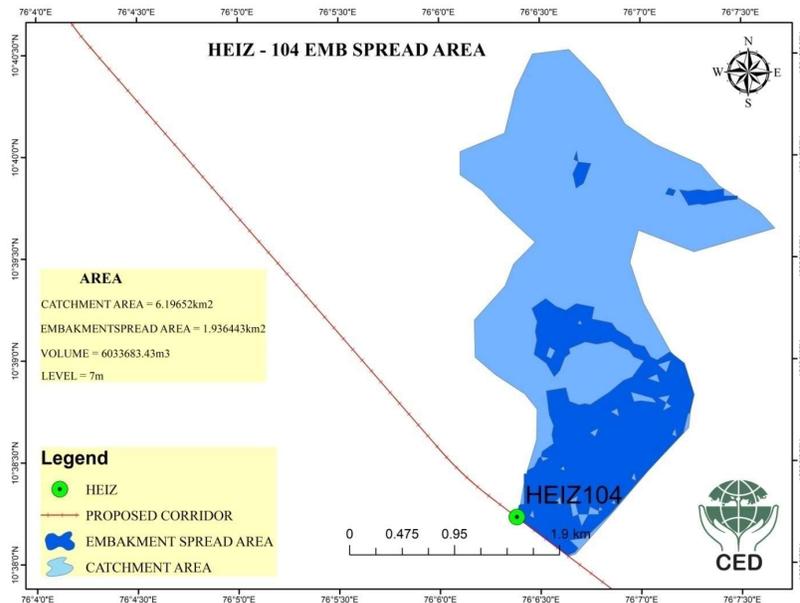
HEIZ 53

Here the alignment is proposed as banking with a rail formation level of 14.583m above the sea level. In the GIS study it is revealed that the catchment that discharges the flood waters to the point is 2.39km². Using GIS tools and applying the formation level of 14m the spread area of 0.333km² was obtained. On scrutiny of the above details and observing the figure in which dark blue shade is given for the above spread area, it can be seen that the flood risk involved can be eased out by providing proper vent drains of design flood capacity. For the above catchment with rainfall intensity of 2.38cm/hr gives a flood discharge of 4m³/sec.



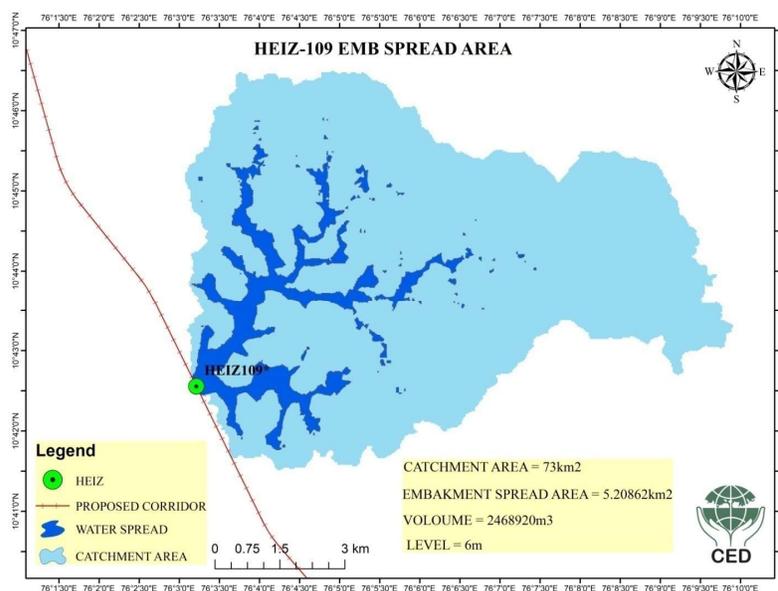
HEIZ 104

In this case the proposed alignment again is banking. The proposed rail level is 7.287m above sea level. The GIS study using tools and applying the formation level of 7m gave a catchment area of 6.20km² and spread area for 7m contour as 1.94km². In the figure the spread area is shown in dark blue shade. For the above catchment with rainfall intensity of 2.38cm/hr gives a flood discharge of 6m³/sec. It can be seen that the flood risk involved can be eased out only by providing proper vent drains of design flood capacity.



HEIZ 109

Here again the alignment is proposed as banking. The proposed rail level is 5.999m above sea level. The GIS study tools and applying the formation level of 6m resulted in a catchment area of 73km² and spread area for 7m contour as 5.21km². Here it can be seen that the catchment area is very large resulting in high design flood. On applying the same intensity of rainfall of 2.38cm/hr over the above catchment resulted in a flood discharge of 121m³/sec. This flood discharge being very high a culvert or drain pipes will not be sufficient. Therefore, it is suggested that this portion may be converted as a viaduct or a bridge provided.



The study reveals that more detailed analysis is required for a comprehensive impact assessment. It is observed that while embankment area divides the watershed, in some zones the water flow is towards Eastern side and all other places it is westward. There for due consideration is necessary to provide proper drainage in banking portions to avoid water logging. Kollam yard, if possible, may be relocated or effective compensatory flood plain created along with diversion of the Ayathil thodu to convey projected design flood waters. Kasaragod yard area also need comprehensive hydrological study before filling up the area for yard development. Here also three 'thodus' are seen passing through the area. All the mitigation measures and EMP shall be made as part of the bid document and DPR of the project. Observing all the above measures the project can be implemented without compromising or jeopardizing the hydrological environment and its impact.

6.2 Study on Socio-Economic Environment

A socio-economic survey was done as part of the project. The survey was conducted along the alignment. The survey was conducted through consultation and disclosing the project details to the project affected people in the grama panchayats and urban local bodies through which the SilverLine is passing. A structured schedule was designed to collect information from the residents staying within 30 m of the proposed alignment. The grama panchayats and urban local bodies where the alignment passes through are randomly selected for the study. Further a cluster sample method was used for identifying the households to be interviewed. Demographic and economic data were collected from the respondents. Information regarding land availability, land use and structure of the same is also collected. Availability of basic amenities like schools, hospitals, etc were asked to assess the infrastructure need of the population after materializing the proposed rail line. The attitude of the people towards the project will reveal their expectations and apprehension based on rumors and misconceptions. Such information is also collected during the field work. The schedule was tested with a limited sample and modified. The data collection was done by trained staff with mode of communication as Malayalam. The outcome of the data analyzed are provided in Tables 6.5 to 6.10. and Fig. 6.3 to 6.4.

Table 6.5 Background information of the respondent

Household information	Description	Percentage
Sex of the respondent	<i>Male</i>	78.6
Religion	<i>Hindu</i>	62.2
	<i>Muslim</i>	19.3
	<i>Christian</i>	18.5

Ownership of House	<i>Own</i>	89.0
Type of House	<i>Concrete</i>	80.8
Current status of house	<i>Work completed</i>	90.6
Toilet facility	Yes	99.6
Electricity	Yes	99.1
Piped water	Yes	54.1
Availability of two-wheeler	Yes	69.7
Availability of four-wheeler	Yes	43.0
Total		481

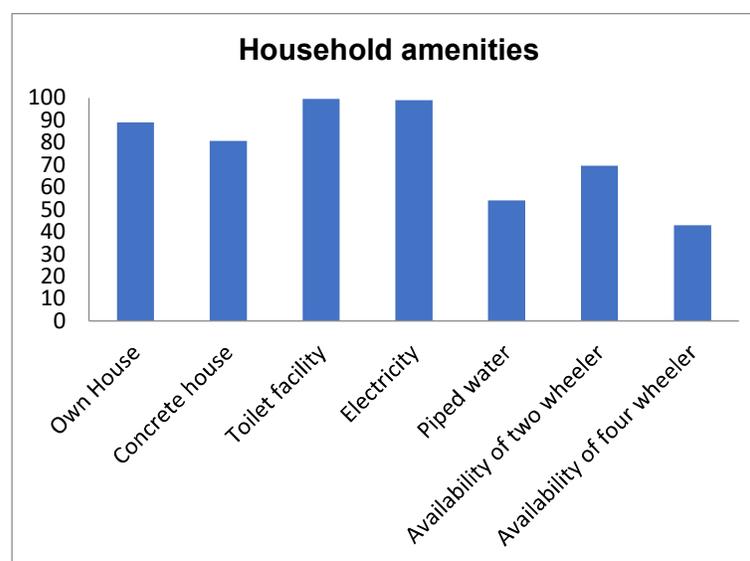


Fig. 6.3 Graphical representation of household amenities

A total of 481 data were analyzed for the final report. The interviewer tried to meet the head of the household for accurate information. In the absence of that person, the next senior member was interviewed. 78.6 percent of the respondents were male. More than three fifth of the households were Hindus. Percentage share of Muslims and Christians hovered around 19 percent. It is almost similar to the religious composition exist in the state. However, a large proportion of Hindus are residing within 30 meters of the proposed rail line. The basic amenities available in the house are also collected. 89 percent of the respondents own their house. Nearly 11 percent are staying in rented houses. Majority of the houses (90.6) are fully constructed. Concrete houses form 81 percent of the total constructed houses. Availability of electricity and toilet are almost universal. However, only 54 percent of the houses are using piped water for drinking. Others mainly depend on well.

Presence of household amenities like Television, Refrigerator is also universal. 70 percent of the houses have a two-wheeler, while that reduces to 43 percent for four wheelers.

Information about family and income were collected for the study. As the State has already explored the benefits of nuclear family structure, only 29.6 percent of the households are following joint family system. 67.7percent of the houses in the area are nuclear families and 2.7 percent of the interviewers stay single. 47.6 percent of the houses have only a single male member and another 2.6 percent have no male members. At the same time, only one percent of the houses have no female members. Presence of 2 or more female members is reported in 53.5 percent of the houses. Surprisingly, 31 percent of the households have no children. This can be coincided with the current low-fertility regime in the State having TFR of 1.8. 37 percent of the households have two children and households with more than 2 children are only 8.7.

Table 6.6 Family and economic situation of the household

Variables	Description	Percentage
Type of family	<i>Joint family</i>	29.6
No. of male members	<i>None</i>	2.6
	<i>Single</i>	47.6
	<i>2 or more</i>	49.8
No. of female members	<i>None</i>	1.2
	<i>Single</i>	45.3
	<i>2 or more</i>	53.5
No. of children	<i>None</i>	30.7
	<i>Single</i>	23.9
	<i>2 Children</i>	36.6
	<i>More than 2</i>	8.7
Monthly income of the family	<i>Less than 1000</i>	49.6
	<i>1000 to 10000</i>	36.0
	<i>More than10000</i>	14.4
Monthly expenditure	<i>Less than 5000</i>	44.0
	<i>5000-10000</i>	40.5
	<i>More than10000</i>	15.5
Main source of income	<i>Salary</i>	38.9
	<i>Agriculture</i>	16.8
	<i>Business</i>	19.6
	<i>Manual &others</i>	24.7
Additional source of income	<i>Yes</i>	20.4
Type of ration card	<i>white</i>	29.5

	<i>blue</i>	32.4
	<i>pink</i>	23.3
	<i>yellow</i>	5.8
	<i>No Card</i>	9.0
No. of earning members	<i>Nobody</i>	4.3
	<i>Single</i>	71.2
	<i>2 or more</i>	24.5
No. of dependents	<i>Nobody</i>	3.2
	<i>1dependent</i>	33.4
	<i>2or more</i>	63.4
Total		481

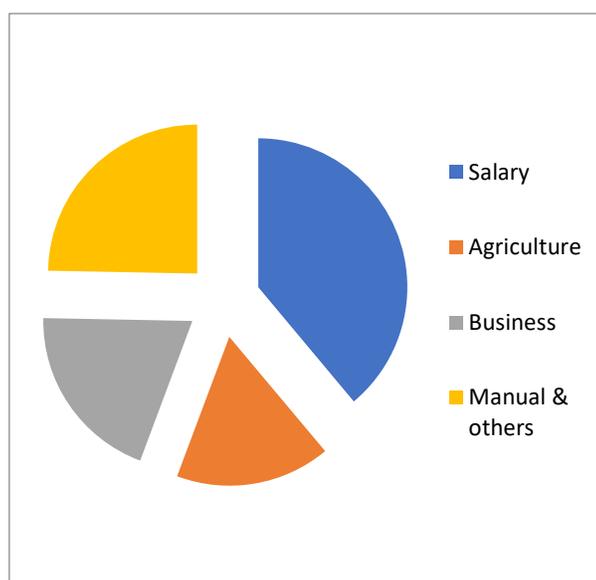


Fig 6.4 Graphical representation of main source of income

There is a tendency not to reveal the income of the household in surveys in India. Here also 50 percent of the houses reported their monthly income below Rs. 1000/- which is not reliable. At the same time, only 20 percent of the households reported their expenditure below Rs. 1000/-. Expenditure based analysis reveals that another 24 percent of them are spending about Rs. 5000/- to meet their monthly consumption. About 40 percent of the households spent between Rs. 5000 to 10000 in a month. About 39 percent of the households reported monthly salary from Government jobs or private as their main source of income. Another one fourth is involved in manual labor. Agriculture is the main source of income for 17 percent of the households. 20 percent of the entire households have reported additional source of income. 14 percent of them are getting additional income from

agriculture activities. In total, about 31 percent of the entire households are engaged in agriculture activities beside the proposed rail line. The colour of the Ration card is also asked to verify their financial status. About 60 percent of the households hold either white or blue ration cards. It revealed that 23 percent have Pink colored Ration card and another 5.8 percent is having Yellow, which comes under special subsidized categories. It is worrying that nine percent of the households have not obtained a ration card for them. Nearly three quarter of the households have single earning member and 25 percent have two or more earning members. 63 percent of the household have 2 or more dependants and 33 percent have one dependant. As the number of dependants increase their monthly consumption on education and treatments of elderly will also increase. Only 3 percent of the households are left without dependent population.

Table 6.7 Details of basic amenities near the house

Presence of Institutions	Description	Percentage
Anganwadi	Yes	32.7
Aided Schools	Yes	28.6
Government Schools	Yes	72.7
Unaided Schools	Yes	3.3
Higher education institutes	Yes	25.5
Private Hospital	Yes	48.0
Government hospital	Yes	68.1
Place of Institution	<i>Other side</i>	30.1
	<i>Same side</i>	69.9

Availability of schools, hospitals, play schools or Anganwadi are essential for village dwellers and Kerala is an example for availability of such community based basic infrastructure amenities in the nearby areas of every villages. When a new project is proposed in the area, people will think about losing the easy accessibility to such basic amenities. However, the system has to develop equal amenities in the other side to compensate such losses. Nearly three fourth of the respondents had reported availability of Government schools in their area. Anganwadi or play school is available nearby in 32.7 percent of the selected households. Sixty eight percent of them reported easiness to reach a Government hospital from their house. It includes Primary Health Centre to District Hospital. 48 percent of the households have easy accessibility to private hospitals or clinics. 70% of the households have all the Institutions in the same side and no need to cross the proposed line to access them. It will be the peculiarity of Kerala, where basic amenities are available irrespective of rural-urban differences.

Table 6.8 Awareness and Impact of the project

Variables	Description	Percent
Aware of the project	Yes	73.8
Source of information	<i>Print Media</i>	91.1
	<i>Internet/ Social media</i>	4.0
	<i>Other People</i>	4.8
Intensity of acquisition	<i>Completely</i>	64.2
	<i>Partially</i>	28.1
	<i>Don't know</i>	7.7
Re-usability of land after the project	Yes	17.8
Source of income affected	Yes	28.0
Affects agriculture land	Yes	31.0

Information regarding awareness and impact of the project was asked to assess people's attitude towards the proposed rail line. 73.8 percent of the households are aware of the project in their area, but are not completely aware of the alignment. 91 percent of them got the information through print media. Share of social media in providing the information is however, just 4 percent among the community. 64 percent of them pointed that their land will be completely acquired for the project. 28 percent have the idea that they will lose only a portion of their land. It is to be noted that among those who are aware of the project, about 8 percent have no idea about the alignment. Information regarding the project needed to be provided both in print and social media platforms. Based on their knowledge, nearly 18 percent of them believe that they can reuse the property and 56 percent are sure that they can't re-use the same. More than one third of the households informed that the project will affect the main source of income. 31 percent reported that their agriculture land will be affected if the project is implemented. Based on their information the trees need to be cut down in their land ranges from 3 to 170.

Table 6.9 Anticipation and apprehension of the project

Variables	Description	Percent
Opinion	<i>Good</i>	64.9
	<i>Bad</i>	20.8
	<i>No Opinion</i>	14.3
Land Acquisition	<i>Helpful</i>	45.2
Benefits	<i>Easiness of travel</i>	60.6
	<i>Accessibility of fruits & vegetables</i>	50.0
	<i>Advanced travel facilities</i>	70.0
	<i>Better living status</i>	63.8

	<i>Better employment opportunities</i>	83.7
Demerits	<i>Divide the village</i>	13.0
	<i>Social isolation</i>	16.2
	<i>Less land availability for future</i>	14.1
	<i>High cost of living</i>	17.5

General opinion of the respondent was taken about the project. 70 percent of the households positively welcomed the project, provided with good compensation for their land. 30 percent had expressed their anxiety over the execution of the project. Major concern of the people is regarding land acquisition activities. It is to be noted that only 45 percent of the respondents were rated the land acquisition activities as a helpful one. When the project was explained to the households, they pointed several advantages of it. Better employment opportunities (84 percent), advanced travel facilities (70 percent) and better living status (64 percent) were the major benefits pointed out by them. At the same time, a small portion of them criticized the work by pointing that it will divide the village (13 percent), socially isolate the villagers (16 percent), remain less land availability for them (14 percent) and increase the living cost (17.5 percent) in the area.

Table 6.10 Compensation and opportunities

Variables	Description	Percent
Financial Compensation	Yes	92.3
Selling articles in Railway station	Yes	0.6
Job in railway	Yes	25.4
House and land by Govt.	Yes	59.8
Commercial value for the land	Yes	58.2
Reasons for not providing land	Don't like the Project	14.2
	Not believe in Compensation	3.4
	Delayed Compensation	4.7
	bitter experience in previous land acquisition	2.0

Expected compensation were asked to the respondents. Majority of them would like to get financial compensation. Commercial value of the land was raised by 58 percent of them. Providing job in railway was asked by 25 percent of the households. About 60 percent of them raised the demand of house and adequate land in other places. Nearly 148 households (30 percent) expressed their disagreement with the proposed rail line through their land by raising different reasons. Though they are welcoming the project, but not interested to provide the land. Dislike the project (14 percent), delayed compensation (4.7

percent), and bitter experience in previous land acquisition (2 percent) were pointed by them. Though negligible in percent, delayed or foul play by Government in distributing compensation was also raised by them. Except twelve percent (58 in number), all the respondents are interested in the project in general hoping that it will provide development in their area. Environmental (6 persons), and financial issues (5 persons) were the reasons for them to completely oppose the rail line. In total, the household survey revealed positive attitude of the population in the area of alignment. Proper awareness of the project needs to be provided through different media and clarity is necessary in the land acquisition process. The positive attitude and expectation of the area is very high as they expect a better living arrangement with advanced travel facility and employment opportunities by implementing the project in their area.

6.3 Risk Assessment

This section identifies risks associated with the project's implementation and a description of the specific risk mitigation measures and management approaches

i) Cost and Schedule: The current cost estimating system is based on static inputs, such as unit prices and inflation. Thus, a risk exists that projected costs and schedule could fluctuate as these underlying inputs are modified in response to world markets, over the construction period and operational stages. The possible risks include Delay or inability to complete the project; Escalation of construction and operations costs; Loss of stakeholder acceptance and support; etc. Realizing that increases to costs and schedule are a risk to the project, the mitigation measures, including the following: Including significant contingencies, inflation estimates, and schedule extension in the financial plan; Continuing to review and validate construction cost estimates, including the underlying cost (e.g., unit prices); Developing a schedule for the entire project based—and highly dependent—on funding availability; etc.

ii) Staffing and Organizational Structure: Implementation of SilverLine is a complex undertaking. The scale, size, and technical complexities necessitate a robust internal project management team, complemented by external resources, with the specific skills and expertise necessary to manage this unique project. The possible risks include Delay in critical management decision making; Loss of stakeholder support; Delay or inability to complete the project; Escalation in staffing / HR costs, etc. K-rail need to place a sound human resource procurement process along with supporting HR policies to address all key issues and should implement measures aimed at mitigating and managing risk related to staffing and organizational structure.

Acquisition of Right-of-Way (RoW): Acquiring right-of-way (RoW) for a project of this nature is normally the responsibility of the procuring authority. A risk exists with regard to the estimated cost and schedule of acquiring RoW. The possible risks include Delay or inability to complete the project; Increase in project costs; Schedule delays; Loss of political support; etc.

The mitigation measures, including the following: Engaging qualified ROW firms with significant experience and Developing a ROW acquisition plan for timeline for acquisition.

The general risk identification and management of the same in the SilverLine is detailed in Table 6.11.

Table 6.11. The general risk identification and management, SilverLine

Thematic Area of Risk	Primary Risk	Short Description of Potential Risks	Probability of Occurrence	Proposed Risk Management Actions
Geophysical	Earthquake Mass movement of earth materials	The entire project alignment of Silverline falls in Seismic Zone III. Kerala continues to be the most earthquake-free zone compared to other southern states. Mass movement of earth materials, usually down slopes	Low	Structures should be seismicity proof design as per statutory provisions Periodic conduct of Mock Drills Emergency Evacuation (Site Workers & Staff) along the alignment
	Tsunami	A series of high energy waves that are generated by a displacement of massive amounts of water	Low	Emergency Evacuation (Site Workers & Staff) along the alignment
Hydrogeological	Floods / water inundation Landslides / unstable slopes	Heavy rainfall in a short time that produce immediate runoff, creating flooding conditions within minutes or a few hours during or after the rainfall	Medium	Information from Early Warning Systems of local authorities Emergency Evacuation (Site Workers and Staff) along the alignment Slope stabilisation in the case of tunnels (entry and exits)
	Hazard caused by short term, micro- to meso scale extreme weather and atmospheric conditions	Cyclone, Storm Surge, Heavy Rain	Medium	Emergency Evacuation (Site Workers and Staff) along the alignment

Thematic Area of Risk	Primary Risk	Short Description of Potential Risks	Probability of Occurrence	Proposed Risk Management Actions
Climate Change	Extreme weather conditions related to long-lived, meso scale atmospheric processes ranging from intraseasonal to multi-decadal (long-term) climate variability	Extreme variations in weather	Medium	Suitable protection as per the EHS to be followed
Biological	Exposure to infection (eg. Covid 19) and toxic substances	Epidemics: viral, bacterial, parasitic, fungal, or prion infections Insect infestations	Medium to high	Emergency Evacuation (Site Workers and Staff) along the alignment at stations and maintenance depots Need to take care of any airborne pathogens
Accidents	Accidents	Interruption to operations Asset loss	Low	Ensure that proper design is adopted to suit the local requirements. Emergency evacuation plan
Tunnel Construction	Safety in Excavation of Tunnel	Chances of cave-ins and injuries during excavation in tunnel	Low to Medium	Tunneling technology should be based on requirements of safety.
	Ventilation in Tunnels	Health impact / fatality due to insufficient supply of fresh air Health impacts / Fatalities due to exposure to dust / smoke and noxious gases		Fresh air must be supplied to all underground work areas in sufficient amounts
	Underground tunneling work	Health impact / illnesses due to high working temperatures		Emergency Evacuation (Site Workers and Staff)
	Temperature in Working Environment	Injuries / Fatalities) due to electric shock, short circuits or break down of power supply		Workers in areas with a wet bulb temperature in excess of 27 ° C should be provided with control measures.
	Power Supply			Ensure availability of proper backup power
During Construction	Accidents	Accidents during construction of Road and Bridges/Via-duct/Tunnels	Low to Medium	Formulation of Safety Policy and strict implementation of the

Thematic Area of Risk	Primary Risk	Short Description of Potential Risks	Probability of Occurrence	Proposed Risk Management Actions
				same during construction phase Provision of First Aid at Work sites Arrangement with nearest hospitals for emergency treatment in case of accidents Provision of Ambulances at the work sites
	Noise and Vibration	Mechanical Equipment Permanent consequences up to chronic diseases (hearing loss, etc.)	Medium	Noise/vibration analysis and level evaluation Use of PPE Periodical medical check
	Environmental /hazards	Weather, high ambient temperature Heat stress to personnel Personnel injury	Low to Medium	Restricted working hours during peak summer for field work. Potable water (cold water during summers). First aid medical facility
	Electricity	Voltage >50V to 440 V in cables, Possible fire Personal Injury/fatality	Medium	Permit to Work Certified electrical equipment Trained and competent personnel Inspection and maintenance of electrical apparatus
	Dust and Debris	Poor visibility Dust respiration	Low	Cleaning procedures Use of appropriate PPE
	Lack of Barrier & Signs	Lack of information concerning hazards Danger area not identified	Medium	Periodical inspections Minimum HSE requirements, including Subcontractors Safe Working Practices
Operation Phase	Maintenance	Unskilled Manpower Personnel injury and potential equipment damage	Medium	Certified & approved contactors First aid medical facility

6.4 Disaster Management Plan

6.4.1 Recommendations of High-Level Committee on Disaster Management for Existing Indian Railway System

Various committees have been appointed on the Indian Railways to review Preparedness to handle disasters in railway operations. The latest Disaster Management Review Committee was appointed on 27.02.07 under the Chairmanship of Mr. G. Narayan, an Ex. IPS officer, to audit the current preparedness of all types of disasters/hazards for prevention, mitigation, rescue, relief and rehabilitation; integration of disaster reduction concept into development planning; and to recommend areas of multi-stakeholder partnership and citizen participation to establish a coordinated mechanism for disaster reduction, response and rehabilitation *etc.* Comptroller Auditor General of India (CAG) in its Report No 13 of 2016 on Indian Railways (Chapter 6) has emphasized the need of revamping and modernization of Disaster Management Plan.

6.4.2 Legal Framework in India

The Disaster Management Act, 2005 (hereinafter referred to as the Act), enacted by the Parliament was notified in the Gazette of India on 26th December 2005. The Act provides for the legal and institutional framework for the effective management of disasters. The Act mandates creation of new institutions and assignment of specific roles for Central, State and Local Governments. It is the central legislation on Disaster Management around which all the Disaster Management related activities revolve since its enactment. It legislates a holistic approach to Disaster Management; from mere responding to disasters to greater attention to prevention and mitigation, capacity building and preparedness. Based on the definition of the 'Disaster' in the Disaster Management Act 2005, different types of disasters are as follows:

Natural Disaster- Earthquake, Floods, Cyclones, Landslides, Tsunami (addressed in the previous section on Risk Assessment), along with risks during construction.

Train Accident Related Disaster- Collision, Train Marooned, Derailment, Tunnel Collapse, Fire Explosion in train etc. and

Man-made Disaster - Act of Terrorism and Sabotage Disaster Management means a continuous and integrated process of planning, organizing, coordinating and implementing measures which are necessary or expedient for prevention of danger or threat of any disaster; mitigation or reduction of risk of any disaster or its severity or consequences; capacity-building; preparedness to deal with any disaster; prompt response to any

threatening disaster situation or disaster; assessing the severity or magnitude of effects of any disaster; evacuation, rescue and relief; rehabilitation and reconstruction.

6.4.3 National Policy on Disaster Management

Under the provisions of the Act, the National Disaster Management Authority (NDMA) has been established under the chairmanship of the Hon. Prime Minister and a National Executive Committee (NEC) of Secretaries has been created to assist the NDMA in the performance of its functions. At the State level, a State Disaster Management Authority has been created under the chairmanship of Chief Minister, which has been assisted by a State Executive Committee. At the District level, District Disaster Management Authorities have been created.

The responsibility of laying down the policies on disaster management, approving the National Policy on Disaster Management (NPDM) and laying down the guidelines on Disaster Management has been given to NDMA under the Act. The NDMA accordingly prepared a draft of the National Policy on Disaster Management in consultation with the Home Ministry and submitted the same for approval of the Government.

6.4.4 Definition of Disaster Management in the Context of SilverLine

Railway Disaster is a serious train accident or an untoward event of grave nature, either on railway premises or arising out of railway activity, due to natural or man-made causes, that may lead to loss of many lives and/or grievous injuries to a large number of people, and/or severe disruption of traffic *etc.*, necessitating large scale help from other Government/ Non-government and Private Organizations.

6.4.5 Potential Disasters along / on SilverLine Alignment

Safe and stable transport is the prime objective of SilverLine. The natural conditions along the SilverLine alignment between Thiruvananthapuram and Kasaragod feature heavy rains in the monsoon. Although the SilverLine shall have the dedicated track, the collision and train accidents cannot be ruled out due to human and mechanical errors. Keeping in view the geological structure, soil stability, flooding, *etc.* following disaster may be kept in mind while designing the structure and operational system.

- Train accidents, train collision Collisions (with a huge number of casualties), Train marooned (flash floods), derailments at a bridge over a river, and coaches falling down; train washed away in cyclone, derailment of a train, tunnel collapse on a train, fire or explosion in trains, and other miscellaneous cases *etc.*

-
- Natural Disaster like flood, cyclone, Landslide, Tsunami, ground subsidence *etc.*
 - Manmade disasters like Acts of Terrorism and Sabotage, i.e. causing deliberate loss of life and/or damage to property, which includes Setting fire to a Train, Railway installations, *etc.*, bomb blast at Railway Station/Train, Chemical (Terrorism) Disaster, Biological and Nuclear Disaster.

K-Rail shall nominate and delegate adequate authority for declaring an untoward incident as Disaster. With the adoption of the above definition of railway disaster, it needs to be appreciated that not only a serious train accident may turn into a railway disaster, if not handled and managed properly, there may be many more railway related events which may not even involve human lives but may turn into disasters for which necessary prevention and mitigation measures are to be taken by the K-Rail beforehand. It will ensure that prevention, mitigation, preparedness, rescue and relief related issues covering all types of disasters affecting railway system are addressed and their details are also appropriately incorporated in their Disaster Management plans.

6.5 Disaster Management Plan for SilverLine

In SilverLine, trains run at a speed over 200 km/h, signalling and the mechanism to prevent train collisions, or a train safety system, are different from those of existing railways in terms of concept and contents. The safety mechanism in SilverLine is constituted based on the concept described below:

- Adopt facilities and rolling stock to cope with high-speed operation and establish a comprehensively harmonized modern mechanism.
- Minimize the elements relying on attentiveness to eliminate troubles due to human errors.
- Adopt multi-redundant systems for important safety equipment/facilities to improve reliability and make the concept of “fail-safe” thoroughly prevail.
- Take measures to avoid the effect of windstorms, floods, earthquakes and other damages caused by natural phenomena as far as possible.
- Introduce equipment/facilities to minimize automobile falling accidents and other troubles and institute legal/regulatory measures against deeds to compromise the safety of train operation.

6.5.1 Prevention of Train Accidents in Operational Phase

a) Prevention of collision between Trains: In view of their long braking distance, it is not possible to protect SilverLine trains by using fuses or special flash signals used for

existing railways. SilverLine need introduced a protection mechanism, therefore, to quickly protect trains by using ATC.

- b) Prevention of Obstacles on the SilverLine ROW:** To prevent people and impeding obstacles from entering the right of way (RoW), SilverLine shall install no entry fences along the boundary against external areas and No Jettisoning fences along the flyovers across SilverLine. Level crossings with roads are totally eliminated. Grade-separated crossings completely wipe off the possibility of invasion by cars or pedestrians, with only those concerned having a certificate allowed to enter the right of way of SilverLine while others totally shut out by law.
- c) Separation of the time zones for Train Operation and Maintenance Work:** In view of the above features, a maintenance work time zone when trains don't run is specified in advance, in which an interval between two trains dedicated to maintenance work called the 'maintenance time zone', with overall maintenance control centralized by the maintenance work dispatcher. After the completion of maintenance work, a maintenance car is run as a pilot car to confirm that the permanent way is free from obstacles that would impede train operation.
- d) Prevention of Accidents on Platforms:** Platform width has been designed to cope with the demand sufficiently for 30 years after commencement of operation to prevent passenger falling accidents and contacting trains. Furthermore, fixed fences are installed for all platforms to prevent passengers from falling onto the track pushed by the train draft. Also, the space for installing platform screen doors is reserved for the future.

6.5.2 Disaster Preventing System

In structure designing, it is important not only to guarantee earthquake resistant performance and strength against rains but also to make arrangements to quickly catch meteorological information to prevent occurrence of disaster or minimize damage there from, thereby protecting running trains against damage due to natural phenomena. Therefore, introducing a disaster preventing system into this project to automatically collect disaster preventive data is recommended. Terminals of the disaster preventing system will be installed at the operation centre and each maintenance depot aiming at establishing a communication system that makes it possible to renew data at a stretch from the operation control centre in charge of train operation to field organizations. About rainfall, wind speed and rail temperature, check the situation from Disaster Detection and Warning System (DWS), order restriction speed to train drivers and directly send command to high-speed trains.

Table 6.12 Installation Plan for Disaster Detecting Equipment

Disaster	Disaster Detecting Devices	Installation Policy
Earthquake	Earthquake resistant train protection device	Wayside detecting point (set at approx. 50 km intervals).
Tsunami	Tsunami alarming device	Coast/inland areas detecting points (each set at approx. 100 km intervals)
Rain	Rainfall alarming device	Cuts, tunnel entrance / exit and other places requiring attention
Wind	Wind direction / speed monitoring device	Areas where winds concentrate and places subject to gusts
Landslide	Landslide alarming device	Places subject to landslides
Rail Temperature	Rail temperature alarming device	Points requiring attention in sections subject to deformation due to temperature change.

Earthquake / Tsunami: The entire project alignment of Silverline falls in Seismic Zone III. Kerala continues to be the most earthquake-free zone compared to other southern states. However, the Tsunami happened during December, 2004 has damaged the entire coastal regions of the state. To minimize the damage due to earthquake / Tsunami when trains are running, SilverLine require an earthquake/ Tsunami damage preventive system to immediately decelerate trains at earthquake.

Rain: Kerala witnessed heavy rain during the 2018 and 2019 and caused heavy casualty / damage to life and properties. As the effect of rainfall is closely linked with track structure, geology and topography, the criteria on train operation control shall be determined based on the short-time amount of rainfall (amount per hour) and the long-time amount of rainfall (amount per 24 hours) for particular sections. To lift train operation control, return train speed to the normal level or resume train operation after inspecting tracks to confirm safety. Application of rain disaster preventive measures at the tunnel entrance near a slope to minimize the section for train operation control will lead to raising passenger safety level.

Wind: Wind speed should be continuously observed with the anemometers installed along the track and perform operation control in case the wind speed has exceeded a regulatory value. Automatic Weather Station fitted with data logger can used for recording the meteorological parameters like temperature, humidity, wind speed and direction, rainfall, solar radiation, etc. For operation control, stepwise regulatory values shall be set according to the condition of windbreak fence installation. When the wind speed hasn't exceeded a

regulatory value for 30 minutes or over, operation control relevant to the regulatory value will be relaxed step by step.

Landslides: Kerala witnessed landslides associated with heavy rain fall during the 2018 and 2019. Landslide alarming devices need to be installed in places subjected to landslides and monitored especially during monsoon season.

Rail Temperature: Long-rails shall be laid at the temperature to prevent both jutting (at high temperature) and rupture (at low temperature) of the rail. Therefore, a proximity limit values shall be set against the anticipated maximum temperature and the anticipated minimum temperature.

Flood: Floods have been a recurrent phenomenon in Kerala for the last two years and cause huge losses to lives, properties, livelihood systems, infrastructure and public utilities. Eighty percent of the precipitation takes place in the monsoon months from June to September. The rivers bring heavy sediment load from the catchments. These, coupled with inadequate carrying capacity of the rivers are responsible for causing floods, drainage congestion and erosion of river- banks. Cyclones, cyclonic circulations and cloud bursts cause flash floods and lead to huge losses. Recently during last two years during the monsoon period the Kerala state witnessed unprecedented flood causing loss of lives and properties. The proposed SilverLine passes through the flood prone area of Kerala. As per the constitutional provision, Flood Management (FM) is a state subject and as such the primary responsibility for flood management lies with the states. The IMD established in 1875, is responsible for the National Meteorological Services and the principal government agency in all matters relating to meteorology, seismology and allied subjects. The IMD is mandated as follows: To warn against severe weather phenomena like tropical cyclones, north-westerly dust storms, heavy rains and snow, cold and heat waves etc., which cause destruction of life and property.

The following Action Plan should be followed by the K-Rail

- Flood/weather forecasting in consultation with IMD and other agencies like SDMA, State Government, local bodies *etc.*
- Development of system of collecting data using modern techniques, monitoring of landslides, flood danger to bridges, bridge approaches causing interruption to traffic.
- Identification of flood prone areas and information prone to erosion and marking them on map. Monitoring of behaviour of rivers which pose danger to railway embankment.
- Documentation of records of flood and breaches.

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- Mechanism for coordination with State Government and other Central Agencies on flood control and erosion *etc.*
 - Sanction and execution of Anti Erosion works of track, formations, bridges, *etc.*
 - Improvement to water ways of bridges in track formation (if necessary) including sanction and execution of works.
 - Development of Flood Shelters for staff and passenger at suitable locations in the areas prone to repeated floods.
 - Implementation of Bye-laws for buildings in flood prone areas
 - Study of silting pattern resulting in reduction in reservoir/Dam's water holding capacity over years to forecast and extrapolate future impact on track due to over flow and need of additional waterway.
 - Study of changed water catchment area due to construction

Biological Disaster: Biological disasters might be caused by epidemics, accidental release of virulent microorganism(s) or Bioterrorism with the use of biological agents such as anthrax, Corona, *etc.* As our society is in a state of flux, novel pathogens emerge to pose challenges not only at the point of primary contact but in far removed locations. The increased interaction between humans and animals has increased the possibilities of zoonotic diseases emerging in epidemic form. The essential protection against natural and artificial outbreaks of disease (bio-terrorism) will include the development of mechanisms for prompt detection of incipient outbreaks, isolation of the infected persons and the people they have been in contact with and mobilisation of investigational and therapeutic countermeasures. In the case of deliberately generated outbreaks (bio-terrorism) the spectrum of possible pathogens is narrow, while natural outbreaks can have a wide range of organisms. The mechanism required however, to face both can be similar if the service providers are adequately sensitized.

Chemical (Terrorist) Disaster: A terrorist attack involving chemical agents differs from a normal terrorist attack as it results in specific effects on health and can cause fatal injuries, create panic, and affect the morale of the community. The targets of terrorists include market places, densely populated areas, public functions, important dignitaries, water and electricity supplies, restaurants/food plazas, malls, places of entertainment, busy railway stations in metros and critical and sensitive military, civil and economic institutions. The possibility of a chemical terrorism attack can be minimized by spreading general awareness and building the capacity of the community, institutions, and governmental and non-governmental organisations. Preparedness for an emergency response at the incident site requires protection, detection, and decontamination. RPF and the Medical Department

have a role to play in the relief and mitigation efforts. A well-orchestrated medical response to CTD will be possible only by having a command and control function at the divisional level by the Medical Department.

6.5.3 Conduct of Mock Drills

In terms of instructions issued by Railway Board vide letter No. No. 2008/Safety (A&R)/14/4 New Delhi, dated 18 February 2009, conducting mock drills is very important for checking the preparedness of HQ and Regional HQ as well as concerned staff. The mock drills have to be organized at regular interval of six months (twice in a year) in coordination with the Station Managers of all SilverLine stations.

6.6 Capacity Building to Handle Disaster

6.6.1 Disaster Management to be Inbuilt in Development Plans

As per the policy, NDMA will ensure mainstreaming of disaster risk reduction in developmental agenda in all existing and new developmental programmes and projects shall incorporate disaster resilient specifications in the design and construction. The K-Rail will give due weightage to these factors while allocating resources.

6.6.2 Responsibilities of the Departments

The different divisions of K-Rail shall prepare location/ site specific DM Plans and it will be approved by the concerned authority. The role and responsibilities of the individuals and the divisions shall be spelt out in detail.

6.6.3 Disaster Response and Mitigation Fund

As per the National Disaster Policy, as mandated by the Act, the National Disaster Mitigation Fund (NDMF) should be created for projects exclusively for the purpose of mitigation. NDMF shall be applied by the NDMA and shall be as recommended by the Finance Commission from time to time.

6.6.4 Modernization of Rescue / Mitigation during Disaster

Helicopter based relief rescue missions on par with similar arrangements existing in western world can also be used extensively for Mass Casualty Evacuation and for providing relief where required. For Railways own Disaster situation like a major train accident where the site is not approachable by rail or by other road vehicles this would be the only means of relief. All Station Managers may obtain details of Government and Private Helicopter

service and the contact numbers of their operators to be contacted in advance. The Disaster Management Plan of Station should make a mention of the helicopter service providers.

6.6.5 Crowd Management / Control during Festivals at the Stations

We should prescribe preventive protocols, when laid down footfalls defined separately for important stations become extraordinarily high, as during festivals (*Melas*) or other exceptional situations. Security personnel deployed on each platform will monitor crowds and rush build up in the circulating areas, booking windows, station platforms. One of the intelligent video analytics to be incorporated in the Integrated Security System is related to signal for crowd density within station premises when it exceeds the prescribed limit. This will enable RPF personnel and railway authorities to get timely information when heavy crowd builds up within station premises and plan follow-up action. Pictures stored on CCTV system will be of immense help in identifying miscreants and in ensuring effective legal action.

6.6.6 Medical Preparedness

The K-Rail shall establish network system capable of handling train accidents along with emergency medical response and casualty evacuation. The system shall be based on an infrastructure consisting of Accident Relief medical Vans (ARMV) – Scale I (Unit of accident relief trains situated at an average distance of every 75 km. Accident Relief Medical Equipment (ARME) – Scale II (to be established at every 120-150 km on either side of ARMV – Scale I) and consisting of three sets of Portable Medical Kit of Accidents (POMKA). Trained manpower of medical and all other departments of the K-Rail shall provide first aid, immediate and necessary emergency medical treatment to save the life and limbs of persons involved in train accidents and arrange rapid evacuation to the nearest government/private hospital by the first available means of transport.

6.7 Communication for Disaster Management

A comprehensive Communication System on the Railways to encompass all requirements of the Railways Disaster Management is required to be set up. Railways have their own extensive communication systems which would be used for Disaster Management too. However, SilverLine need to have back-ups specially to ensure 100% communication availability in case of any type of man- made or natural disasters.

Chapter 7

PROJECT BENIFITS

The Thiruvananthapuram - Kasaragod Semi High-speed Rail Project (popularly known as the SilverLine) is a visionary project which will create a new era of safety, speed and service for the people of Kerala. The SilverLine project brings with it several promising prospects as detailed in the subsequent sections of this chapter.

7.1 Technology

Unlike other areas, for high speed, country is getting a cutting-edge technology in totality. The project is set to provide reliable and comfortable service with high standards of safety. The technology regarding disaster predictions and preventions will also be acquired as a part of the project. Such safety systems ensure that the train operation safety is maintained in case of any natural calamity. With the presence and availability of this technology, India will be leapfrog to the cutting edge of latest train developments with passengers able to reach their destination faster and safely. As the engineering staff learns the latest technology it will also help in developing the same in India.

The construction sector in Kerala will also get a big boost not only in terms of investment but also with respect to new technology and work culture. This project is likely to generate employment opportunities during the construction phase, who will be trained specially to take up construction of such projects. Some of the new areas where construction skills would be developed are ballast-less track, etc.

7.2 High Speed Connectivity

The SilverLine train running between Thiruvananthapuram and Kasaragod will cover the distance of 529.45 km within four hours. The project is supposed to connect all bustling economic corridors in Kerala. This will facilitate economic growth. Smaller cities along the way can also be connected with high-speed transit facility to these economic centres through the SilverLine network. Transit oriented development will take place along the route.

The travel time by flight maybe less between Thiruvananthapuram to Kannur, but most airlines require a minimum of at least 1-hour pre-check-in time and since airports are located in the edges of cities, travel to and from the airports would also add to the total

travel time. Whereas most of the train terminals are located in the city centre and there is no need for check-in.

7.3 Expansion of Urban Area

Out of 11 proposed SilverLine stations on the route, 8 are located on the outskirts of the main city which will result in creation of new urban area and contribute to growth. This will again shift the pressure of urbanisation from the existing urban centres.

7.4 Potential Industries

New avenues for business will be opened up with the establishment of the fastest mode of surface transportation infrastructure. The understanding of advantages of Indian low-cost high-quality manufacturing will surely deepen with such projects coming up. It may be another stint of take-off for Indian industry like the ones with Indian IT industry.

7.5 Employment Generation

The SilverLine project will bring speed and employment. The SilverLine project is expected to create a large number of direct job opportunities, along with indirect jobs. A large number of construction workers will also be employed during the construction phase of SilverLine Project.

7.6 Boost to Economy

SilverLine project can help in regenerating the economy and building new townships and smart cities. An individual travelling 100 km on work can commute in just about 30 to 45 minutes. A new economic system will be developed along the SilverLine corridor, and the entire area would become a single economic zone. The SilverLine would boost economic growth and lead to higher Gross State Development Product (GSDP) for Kerala. Wherever in India Roads, Highways and Metro's are built, the corridor started having Trade as Transportation is made easier. So, while the SilverLine will get developed area surrounding will change into Industrial Hub generating business and Revenues and providing Jobs to the youths.

The SilverLine corridor will also boost economic growth by giving an impetus to the industrial sector while creating more jobs. This SilverLine project will cut down the travel time between Thiruvananthapuram to Kasaragod to less than four hours. There will be tremendous boost to tourism sector due to availability of the fastest mode of surface transport.

7.7 Environmental Aspects

Semi-high-speed efficient rail transport has accrued environmental benefits in terms of fuel consumption, emissions, productivity, time, *etc.* The adverse environmental impacts due to the land use, alignment, construction and operation of SilverLine, can be offset by smarter planning, better mitigation measures and a sound environmental management plan.

Green Energy: It is planned to use 100 percentage of power from renewable sources like solar by in-house production and purchase of renewable power from KSEBL and other renewable supply company to make the project as a green and Sustainable Transport System.

7.8 Reduction in Green House Gas (GHG) Emissions

Further, SilverLine is an environment friendly system that contributes to emission reduction due to diverted road traffic and reduced congestion on existing roads. As per an estimate, a high-speed electric train emits an eight and a fifth of carbon dioxide as against automobiles and airplanes per passenger km, respectively.

Over and above, the introduction of SilverLine would also result in a lot of travel demand shifting from modes such as automobiles, airlines, buses and conventional trains to semi high-speed trains. This would result in completely changing the energy demand for transport along this corridor. Due to higher energy efficiency of the SilverLine operations, net GHG emissions are expected to be lower. Annual average emissions reduction of about 2,87,994 Tonnes CO₂e/year is expected during the year 2025-26.

Chapter 8

ENVIRONMENT MANAGEMENT PLAN

8.1 Introduction

The Environmental Management Plan (EMP) addresses the pre-construction, construction, and operation and maintenance phases of each component of the SilverLine project. The EMP identifies the key environmental issues across the project and provides strategies and plans for managing them effectively. While it was not possible to avoid or reverse all of the adverse impacts of the proposed project, an effort has been made to address some of the significant impacts, by careful consideration and selection of project alternatives. This chapter presents an Environmental Management and Monitoring Plan based on the significant environmental impacts and mitigation measures. Further, suitable measures to minimize, control and manage the residual environmental impacts have been identified and described in the EMP in this chapter.

The EMP has been prepared based on a hierarchy of impact avoidance, minimization, mitigation and control of residual impacts, for both, construction and operation phases for all the relevant environmental attributes. It describes administrative aspects of ensuring that mitigatory measures are implemented and their effectiveness is monitored over the life of the project. Mitigation measures have been identified along Institutional arrangements, human resource requirements, their role and responsibilities; budgetary estimates of financial resources required; and performance indicators for tracking mitigation measures for effective implementation of the proposed EMP.

8.2 Environment Management Plan

The Thiruvananthapuram - Kasaragod SilverLine Project will be executed in a phased manner, viz., Pre-construction phase (Planning and Design stage), Construction Phase and Operation & Management (O&M) Phase. Based on feasibility study carried out by M/s Systra, the preferred alignment was finalized along with decision on traction technology, track design and other technical aspects. An Environment & Social Impact Assessment (ESIA) has been carried out. In the Construction stage, the location for the borrow areas, quarry sites and waste disposal sites should be identified before commencement of the construction activities. The Operational stage includes running the SilverLine trains and operating stations and maintenance activities. The EMP provides guidance on how the

project activities are to be planned, implemented and monitored in order to minimize and manage environmental and social impacts.

EMP has been developed based on the assessment of potential impacts of the project based on the review of secondary information, substantiated by field surveys and measurements, public consultation, household surveys and discussions with concerned authorities. The implementation of the EMP requires the Implementation of the mitigation measures; Monitoring the implementation program; Allocation of budget for the mitigation measures; Organizational structures for the implementation of the mitigation measures; and Establishment of the EMP.

EMP deals with the management measures and implementation procedure of the guidelines along with enhancement measures recommended to avoid, minimize and mitigate foreseen environmental impacts of the project. For each mitigation measure to be taken, its location, timeframe, implementation and overseeing/ supervising responsibilities are listed in the EMP. The generic environmental parameters that need to be monitored during pre-construction, construction and operation phases of the project are summarized in Tables 8.1, 8.2 and 8.3 respectively.

Table 8.1 Environmental Management Plan for Pre-Construction Stage

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
1	Land acquisition and Resettlement	The acquisition of land should be carried out in accordance with the RAP	Parties should be determined in a separate RAP Study	K-Rail
2	Consents, permits, clearances, no objection certificate (NOC), etc.	All the applicable consents, permits, clearances, NOCs, etc. shall be obtained before the commencement of the construction work	Design Consultant and K-Rail	K-Rail
3	Tree / Mangrove Cutting & Afforestation	Avoidance of non-essential tree-cutting Planting of native tree species should be taken up Green belt development at the sensitive locations along the alignment	Design Consultant and Contractor	K-Rail

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
		Compensatory Mangrove Afforestation should be taken up		
4	Crushers & Concrete Batching Plants	<p>All construction yards should be sited at least 500m away from settlements</p> <p>Arrangements to control dust pollution through provision of wind screens, water sprinklers, and dust suppressant and extraction systems should be provided at all such sites</p> <p>Specifications for crushers, and concrete batching plants should be designed to comply with the requirements of the relevant emission control legislation at the State level</p> <p>Consent for the establishment and operation from Kerala State Pollution Control Board should be obtained before establishment and operation of work sites</p>	Design Consultant and Contractor	K-Rail
5	Construction camps site, and locations of material storage areas, sanitation facilities	<p>The construction camps should be located at least 200m away from habitations at identified sites near alignment</p> <p>Location for stockyards of construction materials should be identified at least 500 m away from water bodies</p> <p>The sewage and solid waste treatment and management for the camp should be designed, built and operated</p>	Design Consultant and Contractor	K-Rail

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
		<p>All sites used for camps should be adequately drained</p> <p>The labour camp/construction camp should be established as per the provision of Occupational Safety and Health Administration</p>		
6	Sources of construction materials	Use quarry sites and sources licensed by the Kerala Government	Design Consultant and Contractor	K-Rail
7	Construction Vehicles, Equipment & Machinery	<p>All equipment and machinery used for construction should conform to the relevant Bureau of India Standard (BIS) norms</p> <p>The discharge standards promulgated under the Environment Protection Act, 1986 and Motor Vehicles Act, 1988 should be considered while procuring vehicles</p> <p>The silent/ quiet equipment should be preferred</p>	Design Consultant and Contractor	K-Rail
8	Construction Water	Surface / Ground water for construction requires necessary permissions which should be obtained from the respective State Irrigation Department, KWA and CGWA	Design Consultant and Contractor	K-Rail
9	Quarry Areas	<p>Procurement of construction materials from quarries should be finalized after assessment of the availability of sufficient materials, quality, regulatory and other logistic arrangements</p> <p>Necessary clearances should be obtained for the locations selected from the statutory agencies like the</p>	Design Consultant and Contractor	K-Rail

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
		<p>KSPCB and from the Mining Department</p> <p>Planning of haul roads for accessing quarry areas should be undertaken during this stage</p> <p>The sand should be procured from identified sand mines</p>		
10	Borrow Areas	<p>The earth material is to be borrowed from select borrow areas, until the formal agreement is signed between land owner and the executing agency</p> <p>Planning of haul roads for accessing borrow areas should be undertaken during this stage</p> <p>Locations finalized, and the necessary clearances should be obtained from the statutory agencies like the KSPCB and from the Mining Department</p>	Design Consultant and Contractor	K-Rail
11	Labour Health & Safety	<p>Develop comprehensive site-specific health and safety (H&S) plan.</p> <p>Provisions for health care facilities and Regular health check-up of the deployed workforce should be undertaken</p>	Design Consultant and Contractor	K-Rail
12	Disaster	Adequate cross drainage channels (longitudinal and median drains) should be provided along the route at suitable locations for the smooth passage of the surface run-off to prevent flooding	Design Consultant and Contractor	K-Rail

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
13	Ethnic Community and Indigenous People	The right and interest of the ethnic community and indigenous people should be protected	Design Consultant and Contractor	K-Rail
14	Cultural and Religious site	Pier spacing should be adjusted to avoid the demolition of the religious structures falling within RoW However, if it is unavoidable, every step should be taken to shift these structures at a suitable place in consultation with the local community Effective noise barriers/ screens should be provided close to working heavy equipment	Design Consultant and Contractor	K-Rail
15	Public consultations	Continue information dissemination, consultations, and involvement/ participation of stakeholders during project implementation	Design Consultant and Contractor	K-Rail

Table 8.2 Environmental Management Plan for Construction Phase

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
1	Clearing and uprooting of Vegetation	If required, vegetation should be removed from the construction zone before commencement of construction after obtaining necessary permissions All works should be carried out such that the damage or disruption to flora other than in those areas identified for cutting is kept to a bare minimum	Contractor	Consultant and K-Rail
2	Drinking water availability	Sufficient supply of cold potable water to be provided and maintained	Contractor	Consultant and K-Rail
3	Stockpiling of construction materials	Stockpiling of construction materials does not impact, obstruct the drainage	Contractor	Consultant and K-Rail

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
		Stockpiles should be covered to protect from dust and erosion		
4	Transporting Construction materials and haul road management	<p>Dumpers and trucks carrying the construction material should be spillproof</p> <p>Trucks and dumpers should be properly maintained</p> <p>Water should be sprinkled on the haulage roads</p> <p>Strict speed limits should be followed at the settlement areas and on the haulage roads</p> <p>All the truck and dumper drivers should be properly trained.</p>	Contractor	Consultant and K-Rail
5	Borrow areas and quarry sites	<p>Borrow areas and quarry sites should be away from human settlements</p> <p>The excavation of borrow should be specified as per the guidelines.</p> <p>Access to the quarry operated area and borrow sites should be strictly controlled</p> <p>All workers at the quarry site should be provided with personal protective equipment</p> <p>All the haul roads are watered regularly to reduce dust emissions</p> <p>A vegetative barrier should be created to surround the borrow area</p>	Contractor	Consultant and K-Rail
6	Disposal of debris from dismantling structures	The construction and demolition waste generated should be managed in accordance with the C&D Waste Management Rules, 2016	Contractor	Consultant and K-Rail
7	Traffic diversions and detours	The temporary traffic detours should be kept free of dust by sprinkling water during the day time depending on weather conditions	Contractor	Consultant and K-Rail

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
8	Construction water arrangements	<p>Water required for construction should be drawn from surface waterbodies with prior permission from LSGDs</p> <p>If ground water is drawn then permission from the CGWA or State GWD should be obtained</p>	Contractor	Consultant and K-Rail
9	Waste Management	<p>Avoid uncontrolled solid waste dumping which could be breeding ground for vermin, and as such could pose a vector for disease</p> <p>Segregation of waste depending on the nature of the materials should be carried out</p> <p>Special attention should be given to diverting hazardous materials/ wastes for proper management in accordance with applicable regulatory requirements</p> <p>The prevailing rules and act MSW Act, 2016 should be strictly adhered to</p>	Contractor	Consultant and K-Rail
10	Waste water generation from construction yard and labour camps	The waste water from construction yard and labour camp should be treated (as per applicable discharge standards) before being discharged	Contractor	Consultant and K-Rail
11	Siltation in water bodies	<p>Construct silt fencing at the base of the embankment construction site and around the stockpiles</p> <p>The fencing should be provided prior to commencement of earthwork and continue until the stabilization of the embankment slopes</p> <p>Construction materials containing fine particles should be stored in an enclosure</p> <p>If necessary, siltation pond shall be installed to avoid discharging siltwater from the site</p>	Contractor	Consultant and K-Rail
12	Energy Management	Should use energy efficient lighting, motors and pumps	Contractor	Consultant and K-Rail

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
		<p>Adequate and uniform illumination level at construction sites suitable for the task</p> <p>Proper size and length of cables and wires to match the rating of equipment</p> <p>Camps should be designed for maximum day light and minimum heat gain.</p>		
13	Slope protection and control of soil erosion	Soil erosion and sedimentation should be minimized by constructing breast walls, retaining walls, pilot bioengineering methods, dykes, sedimentation chambers, basins, fibre mats, mulches, grasses, slope, drains and other such devices	Contractor	Consultant and K-Rail
14	Petroleum Oil and Lubricants	<p>POL should be handled with special care with necessary permissions</p> <p>The used oil and lubricants should be sold to authorized parties</p> <p>The storage places for POL should have restricted entry</p> <p>Accidental spillage of oil and lubricant should be immediately cleared</p> <p>The trucks and dumpers will not be washed at the nearby water bodies</p>	Contractor	Consultant and K-Rail
15	Public Health and Safety	<p>The general public/ local residents shall not be allowed in high-risk areas, e.g., excavation sites and areas where heavy equipment is in operation</p> <p>Speed restrictions should be imposed on deployed vehicles & equipment when traversing areas with sensitive receptors.</p> <p>Marshalling attendants should be provided at traffic junctions outside construction yard sites to regulate material / construction vehicles and general vehicular traffic / pedestrians in a safe manner</p>	Contractor	Consultant and K-Rail

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
		Traffic diversion plans should be prepared/ executed and communicated in areas where construction is being carried out on or near existing roads/ highways in consultation with local traffic police		
16	Construction Yards	<p>Site construction yards should minimize adverse impacts by good management practices</p> <p>Implement malaria control, HIV/AIDS education</p> <p>Plan and carry out post construction site clean-up</p>	Contractor	Consultant and K-Rail
17	Air Pollution	<p>Water sprinkling system should be put in place</p> <p>Covering the construction material/ waste during transportation to/ from the construction site should be considered to reduce diffusion of dust</p> <p>Equipment & trucks should be properly maintained at regular intervals</p> <p>No excavation of soil should be carried out without adequate dust mitigation measures in place</p> <p>Grinding and cutting of building materials in open area should be prohibited</p> <p>Motorized vehicles at site should be restricted to a max speed of 20 km/hr</p> <p>Wheel washing facility at exit of construction sites should be provided</p>	Contractor	Consultant and K-Rail
18	Noise Pollution	<p>Construction activities generating high noise levels should be carried out at different time intervals during day time</p> <p>The equipment used should have exhaust mufflers</p>	Contractor	Consultant and K-Rail

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
		<p>All equipment should be properly lubricated.</p> <p>The construction yards located near sensitive receptors should be provided with noise barriers</p> <p>Periodical inspection and effective maintenance of vehicle and equipment</p>		
19	Installation and Operation / Maintenance of Electrical Equipment	<p>All necessary fencing & lights should be provided to protect the public in construction zones</p> <p>All machines to be used in the construction should be kept in good working order, and should be regularly inspected and properly maintained</p>	Contractor	Consultant and K-Rail
20	Establishment and Operation of the Labour Camps	<p>The labour camps should be provided with adequate treatment system and drainage to avoid accumulation of stagnant waste water</p> <p>Toilets/ sanitation facilities with proper flushing provisions in accordance with local regulations to prevent any hazard to public health or contamination of land, surface or groundwater. These facilities should be well maintained to allow effective operation.</p> <p>Fire-extinguishing equipment should be provided at construction camps, asphalt plants, storage areas for combustible materials and other areas where fire hazards are found.</p> <p>All site workers should be provided with personal protective equipment such as safety shoes, helmets, earmuff, nose mask as relevant to the risks that they are exposed to etc.</p>	Contractor	Consultant and K-Rail
21	Clearing of Construction of	On completion of the works, all temporary structures will be cleared away, all rubbish burnt, excreta or other disposal pits or	Contractor	Consultant and K-Rail

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
	Camps and Restoration	trenches filled in and effectively sealed off and the site left clean and tidy		

Table 8.3 Environmental Management Plan for OperationPhase

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
1	Noise	<p>Noise generated from operation of DG set to be optimized and monitored DG sets to generate less than 75 dB(A) Leq at 1-m from the source</p> <p>DG sets are to be provided at basement with acoustic enclosures</p> <p>Periodical inspection and effective maintenance of vehicle and equipment</p> <p>Noise barriers should be erected at appropriate locations such as residential areas and sensitive receptors, which are adjacent to the corridor.</p>	Consultant	K-Rail
2	Vibration	<p>The vibrations can be reduced considerably by ensuring and keeping correct track geometry by advanced measurement. The track structure should be designed to produce low ground-borne vibration</p> <p>Controlling noise and vibrations at the source, e.g. track measures like rail grinding, welding to smooth discontinuity, lubrication, use of soft rail pads and relocation of signals orturnouts</p> <p>The other mitigation measures include wheel lubrication, use of disc brakes, dampening of wheel and use of resilient wheels</p> <p>Avoid vibratory rollers and packers near sensitive areas</p>	Consultant	K-Rail

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
3	Indoor air contamination	Pollutants such as CO, CO ₂ and VOCs to be reduced as per CPCB/ KSPCB guidelines by providing adequate ventilation	Consultant	K-Rail
4	Drinking water availability	Sufficient supply of cold potable water to be provided and maintained at stations & depot areas	Consultant	K-Rail
5	Water Quality and Water Levels	Monitoring groundwater quality and levels should be carried out around station and depot areas	Consultant	K-Rail
6	Waste Management	Avoid uncontrolled solid waste dumping which could be breeding ground for vermin, and assuch could pose a vector for disease Segregation of waste depending on the nature of the materials should be carried out Special attention should be given to diverting hazardous materials/ wastes for proper management in accordance with applicable regulatory requirements The prevailing rules and act MSW Act, 2016 should be strictly adhered to	Consultant	K-Rail
7	Waste water Discharge	No untreated discharge to be made to surface water, ground water or soil. The cleaning water shall be collected in tanks and disposed only after proper treatments as per CPCB guidelines	Consultant	K-Rail
8	Drainage and effluent Management	Ensure drainage system and specific design measures are working effectively. Design to incorporate existing drainage pattern and avoid disturbing the same	Consultant	K-Rail
9	Maintenance Performance	Monitoring of the operational performance of the various mitigation/ enhancement measures should be carried out as a part of the project. The indicators selected for monitoring include the survival rate of trees; utility of	Consultant	K-Rail

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
		enhancement provision for relocated utilities, hand pumps and other relocated structures if any; status of rehabilitation of borrow areas; and noise barriers, which are proposed at different locations.		
10	Borrow area sand quarry sites	Incorporate adequate drainage and fill in borrow pits and quarries Maintain borrow pits and quarries by landscaping them after operation by growing native species The guidelines issued by the State Mines and Geology Department should be followed	Consultant	K-Rail
11	Green belt Development and Management	Maintenance of plantation Local pollutants tolerant species should be selected for plantation	Consultant	K-Rail
12	Training for operational staff	The training should be for all the executives regarding the environment and safety The process should be followed for a minimum period for first six months	Consultant	K-Rail
13	Emergency Preparedness and Response Management	Maintenance of cross drainage channels (longitudinal and median drains) should be carried out. The rolling stock and stations should be provided with the alarm for advance notice of earthquake, cyclone, flood etc. Risk & Disaster Management Plan should be formulated for safe & smooth running of the semi-high-speed train	Consultant	K-Rail
14	Maintenance Depots and Yards	The two major maintenance depots have been proposed The depots shall function in accordance with the provision of the Factory Act, 1948 and State level Factories Rules, as applicable	Consultant	K-Rail

Sl. No.	Parameters/ Components	Mitigation Measures	Responsibility	
			Implementation	Supervision
15	Energy Management	<p>Use of energy efficient lighting, and other products</p> <p>Proper size and length of cables and wires to match the rating of equipment</p> <p>Use of energy efficient air conditioners</p> <p>Stations should be designed for maximum day light and minimum heat gain. The rooms should be well insulated to enhance the efficiency of air conditioners and the use of solar films on windows may be used where feasible</p>	Consultant	K-Rail

8.3 Institutional Framework for Implementation of EMP

In order to effectively implement the EMP, an Institutional arrangement is utmost important. K-Rail headed by the Managing Director is responsible for the overall implementation of the SilverLine Project. Ensuring the better implementation of EMP, K-Rail needs to set up a Social and Environmental Management Unit (SEMU) with sufficient number of experts including an Environmental Expert, an Environmental Engineer and a Social Expert, each with at least Master's degree in relevant subjects and 15 years of experience. SEMU should work with the Project Implementation Unit (PIU). SEMU will be responsible for managing environmental and social matters relating to the project and ensuring compliance with the environmental and social safeguard policies of the Government and lender, and relevant national laws.

The environmental and social experts of the Project Implementation Unit (PIU) will be responsible for preparing the detailed/ up-dated Environmental Management and Monitoring Plan in the early stage of the Consultancy Service based on the EMP in this EIA Report, and carrying out monitoring on Contractor's compliance with the mitigation measures; and provide regular monitoring reports to SEMU in the stage of the construction supervision. The key responsibilities of the Contractor will be based on the EMP and ensure the implementation of the environmental mitigation measures for the construction activities. Site-specific EMP has to be prepared based on the EMP in the EIA Report.

8.4 Grievance Redressal Mechanism and Reporting under EMP

Grievances/ complaints on environmental matters need to be taken up by SEMU set up by K-Rail. Local concerns may mainly arise as a result of inappropriate implementation of the EMP and EMoP, the main aim of which is the reduction of adverse impacts to acceptable levels. These issues should be best addressed through open dialogue and a responsive approach, with acknowledgement of errors where appropriate, followed by rapid remedial action.

The Site Engineer (SE), K-Rail shall report regarding compliance of the EMP and other environment related issues by concerned stakeholders to SEMU in his periodic progress report for review by SEMU during the construction stage. Monthly report of the SE shall indicate clearly regarding the compliance of environmental provisions by Contractor. Contractor's failures to implement the environmental provisions are to be reported to SEMU regularly with request for action.

8.5 Costs for Implementation of EMP

The EMP should be carried out by the Contractor or Consultant appointed by them. The budget provision for implementation of the EMP is detailed in Table 8.4.

Table 8.4 Budgetary Provision for Implementation of the EMP & Environmental Protection Measures

Sl. No.	Item	Unit	Unit Cost (INR)	Quantity	Total Cost (INR in Crore)
1	Compensation for tree cutting	Number	5000	15000	7.5
2	Compensatory Afforestation Programmes & Maintenance	Number	2000	75,000	15
3	Mangrove Cutting	Ha	200000	2 ha	0.04
4	Compensatory Mangrove plantation & Maintenance	Ha	600000	10 ha	0.6
5	Noise & Vibration barrier construction at Identified Sensitive Locations	m ²	30000	50000	150
6	Maintain borrow pit site by landscaping and re-vegetating after operation	Site	500000	10	0.5

Sl. No.	Item	Unit	Unit Cost (INR)	Quantity	Total Cost (INR in Crore)
7	Maintain quarry site by landscaping and re-vegetating after operation	Site	300000	20	0.6
8	Water Sprinkling on the road, especially in/near the settlement areas	Monthly	1200000	60	7.2
9	Solid and Liquid Waste Management	Site	2000000	12	2.4
10	Post construction clean-up to ensure no dangerous debris are left behind the camp	Site	50000	10	0.05
11	Green belt development and Management	Site	500000	20	1
Total					184.89

Chapter 9

ENVIRONMENTAL MONITORING PROGRAMME

9.1 Introduction

An Environmental Monitoring Programme (EMoP) provides the basis for monitoring the status of different components of environment in the construction and operation phases of any development project. The information derived from environmental monitoring activities can be used to mitigate and reduce environmental impacts and enhance project benefits through adaptive management. The implementation of the EMoP is adopted in all project works. An EMoP is important as it provides useful information and helps to:

- Assist in detecting the development of any unexpected environmental or social situation and thus provides opportunities for adopting appropriate control, management or mitigation measures.
- Defines the responsibilities of the project proponents, site engineers, contractors and environmental monitors and provides means of effectively communicating environmental issues among them.
- Defines the monitoring mechanism and identifies monitoring indicators, methods and parameters.
- Provides information, which allows for the evaluation of the performance and effectiveness of mitigation measures proposed in the EMP and enables managers to make improvements in management plan.
- Identifies training requirement at various levels.

This chapter on environmental monitoring describes the processes and activities that need to be undertaken to characterize and monitor the quality of the environment and also to understand whether the quality of environment is getting better or worse due to the various activities of the proposed project.

9.2 Environment Monitoring Programme

An Environmental Monitoring Programme (EMoP) normally involves following two main types of activities, viz., i) **Routine Supervision of the Work**: Observation of the construction/ operation work to ensure mitigation actions will be conducted during routine site inspections. This work will be conducted as general operation working/ maintenance

progress including daily work; ii) **Environmental and Social Impact/ Mitigation Monitoring**: The monitoring to be conducted to determine the actual and social impact. Tables 9.1 & 9.2 shows the EMoP for the construction stage and operation stage.

Table 9.1 Environmental Monitoring Programme for Construction Stage

Sl. No.	Environmental Indicator	Method/ Parameters	Location, Quantity and Frequency	Responsible Agency
1	Air quality monitoring	SO ₂ , NO _x , CO, PM ₁₀ , and PM 2.5	11 Locations at Station area, Twice a week for 24 hours for 1 Month/ year for 5 years	Contractor/ Consultant
2	Surface Water quality monitoring		1 sample of 12 major water bodies, 12 times/year for 5 yrs	Contractor/ Consultant
3	Ground Water quality monitoring		Major habitation areas along alignment (12 locations), 12 times / year for 5 years	Contractor/ Consultant
4	Soil Quality		16 locations (at stations & depots etc.), 4 times/y for 5yrs	Contractor/ Consultant
5	Monitoring of Embankment Drainage		20 critical locations (including stations & depots etc.), 2 times/year for 5 years	Contractor/ Consultant
6	Waste Management		Construction site as required	Contractor/ Consultant
7	Noise Monitoring		22 locations (at stations, depots and other sensitive areas), 4 times/yr for 5 years	Contractor/ Consultant
8	Vibration Monitoring		16 locations (at stations, depots and other sensitive areas), 4 times/yr for 5 years	Contractor/ Consultant
9	Biota and ecosystem	Monitoring whether impacts to ecosystem	Construction site as required	Contractor/ Consultant
10	Land Contamination monitoring	Check the maintenance of construction machine	Construction site as required	Contractor/ Consultant
11	Occupational Health Monitoring	Opinion or complaint of construction worker	Construction site 4 sessions / year for 5 years	Contractor/ Consultant
12	Involuntary resettlement, Poor		Whole through construction stage	Consultant

SI. No.	Environmental Indicator	Method/ Parameters	Location, Quantity and Frequency	Responsible Agency
13	Social Aspects	Opinion or complaint of residents near the construction site	Construction site as required	Contractor/ Consultant
14	Misdistribution of benefits and damages	Opinion or complaint of residents near the construction site	Construction site as required	Contractor/ Consultant
15	Local conflicts of interest	Opinion or complaint of residents	Construction site as required	Contractor/ Consultant

Table 9.2 Environmental Monitoring Programme for Operation Stage

SI. No.	Environmental Indicator	Method/ Parameters	Location, Quantity and Frequency	Responsible Agency
1	Air quality monitoring	SO ₂ , NO _x , CO, PM ₁₀ , and PM 2.5	11 Locations at Station area, Twice a week for 24 hours for 1 Month/ year for 3 years	Contractor/ Consultant
2	Surface Water quality monitoring	pH, SS, Temperature, Oil and Grease, Coliform bacteria	1 sample of 12 major water bodies, 12 times/year for 3 years	Contractor/ Consultant
3	Ground Water quality monitoring	pH, SS, Temperature, Oil and Grease, Coliform bacteria	Major habitation areas along alignment (12 locations), 12 times / year for 3 years	Contractor/ Consultant
4	Soil Quality		16 locations (at stations and depots etc.), 4 times/y for 3yrs	Contractor/ Consultant
5	Monitoring of Embankment Drainage		20 critical locations (including stations and depots etc.), 2 times/year for 3 years	Contractor/ Consultant
6	Waste Management	Inventory record of waste disposal	Every stations and Depot	Contractor/ Consultant
7	Noise Monitoring	Day and Night (L10, L50, L90, LMax, LMin, LeqLDay, LNight)	22 locations (at stations, depots and other sensitive area), 2 times/year for 3 years	Contractor/ Consultant
8	Vibration Monitoring		16 locations (at stations, depots and other sensitive areas), 2 times/y for 3 years	Contractor/ Consultant
9	Biota and ecosystem	Monitoring the impacts to ecosystem & trees planted	Arbitrarily around the planned route & Site of Trees Planted	Contractor/ Consultant

Sl. No.	Environmental Indicator	Method/ Parameters	Location, Quantity and Frequency	Responsible Agency
10	Restoration of Livelihood		1st monitoring: within 6 months after resettlement is completed 2nd monitoring: within 12 months from 1 st monitoring 3rd monitoring: within 24 months from 1 st monitoring	External monitoring Consultant
11	Social Institutions		1st monitoring: within 6 months after resettlement is completed 2nd monitoring: within 12 months from 1 st monitoring 3rd monitoring: within 24 months from 1 st monitoring	External monitoring Consultant
12	Indigenous or ethnic minority	Monitoring by external monitoring agency	1st monitoring: within 6 months after resettlement is completed 2nd monitoring: within 12 months from 1 st monitoring 3rd monitoring: within 24 months from 1 st monitoring	External monitoring Consultant

9.3 Institutional Framework for Implementation of EMoP

In order to effectively implement the EMoP, an Institutional arrangement is utmost important. K-Rail, headed by the Managing Director is responsible for the overall implementation of the SilverLine Project. Ensuring the better implementation of EMoP, K-Rail needs to set up a Social and Environmental Management Unit (SEMU) with sufficient number of experts including an Environmental Expert, an Environmental Engineer and a Social Expert, each with at least Masters degree in relevant subjects and 15 years of experience. SEMU should work with the Project Implementation Unit (PIU).

9.4 Costs for Implementation of EMoP

The EMoP should be carried out by the Contractor or Consultant appointed by them. The budget provision for implementation of the EMoP is detailed in Table 9.3 (Construction Phase), Table 9.4 (Cost of Land and R&R) and Table 9.5 (Operation Phase). While arriving at the cost of implementation of the EMoP, the total construction period has been

considered as 5 years (60 months) and for the operation phase, a period of 3 years has been taken into account.

Table 9.3 Costs for implementation of EMoP for Construction Stage

Sl. No.	Monitoring Item	Unit	Unit Cost (INR)	Quantity	Total Cost (INR in Crore)
1	Air quality monitoring	No. of Sample	7500	330	0.248
2	Surface Water quality monitoring	No. of Sample	5000	720	0.36
3	Ground Water quality monitoring	No. of Sample	5000	720	0.36
4	Soil Quality	No. of Sample	6000	256	0.154
5	Monitoring of Embankment Drainage	Location	15000	200	0.3
6	Waste Management	Lump sum	2400000	1	0.24
7	Noise Monitoring	No. of Sample	5000	440	0.22
8	Vibration Monitoring	No. of Sample	20000	320	0.64
9	Biota and ecosystem	Lump sum	2400000	1	0.24
10	Land Contamination Monitoring	Lump sum	1600000	1	0.16
11	Occupational Health Monitoring	Session	100000	20	0.2
12	Involuntary resettlement, Poor	Lump sum			5.0
13	Social Aspects	Lump sum	1200000	1	0.12
14	Misdistribution of benefits and damages	Lump sum	1200000	1	0.12
15	Local conflicts of interest	Lump sum	1200000	1	0.12
Total					8.482

Table 9.4 Cost of Land and R&R

Sl. No.	Item	Total Cost (INR in Crore)
1	Private land	6100.3
2	Government land	0
3	Railway land 185 Hectares	975
4	Cost for compensation of structure	4460
5	Cost of R&R	1730
Total		13265.3

Table 9.5 Costs for implementation of EMoP for Operation Stage

Sl. No.	Monitoring Item	Unit	Unit Cost (INR)	Quantity	Total Cost (INR in Crore)
1	Air quality monitoring	No. of Sample	7500	240	0.18
2	Surface Water quality monitoring	No. of Sample	5000	432	0.216
3	Ground Water quality monitoring	No. of Sample	5000	432	0.216
4	Soil Quality	No. of Sample	6000	192	0.115
5	Monitoring of Embankment Drainage	Location	15000	120	0.18
6	Waste Management	Lump sum	1800000	1	0.18
7	Noise Monitoring	No. of Sample	5000	132	0.066
8	Vibration Monitoring	No. of Sample	20000	96	0.192
9	Biota and ecosystem	Lump sum	1800000	1	0.18
10	Restoration of Livelihood	Lump sum	1200000	1	0.12
11	Social Institutions	Session	100000	16	0.16
12	Indigenous or ethnic minority	Lump sum	1200000	1	0.12
Total					1.5902

Chapter 10

SUMMARY AND CONCLUSIONS

The present proposal is for the Thiruvananthapuram - Kasaragod Semi High-Speed Rail (SilverLine) Project being executed by Kerala Rail Development Corporation Limited (K-Rail), a joint venture of Government of Kerala and Ministry of Railways. The SilverLine alignment of 529.45 km, begins at Kochuveli (near Thiruvananthapuram Airport) in Thiruvananthapuram District and runs through Kollam, Alappuzha, Kottayam, Ernakulam, Thrissur, Malappuram, Kozhikode and Kannur districts before entering Kasaragod District. The planned route lies between Latitude 8°30'44.88"N-Longitude 76°53'52.43"E and Latitude 12°29'28.37"N-Longitude 74°59'15.57"E. Major project features can be summarized as below

- Facilitating more people to access/ avail high speed services from SilverLine stations
- Transport of vehicles such as trucks, lorries, etc. on RORO facilities
- Last mile connectivity by providing cab feeder services, share auto services, eBus services, bicycle/ bike rental schemes
- Integration with Thiruvananthapuram and Kochi International airports
- Connecting IT corridors – Technopark and Infopark
- 50,000 direct and indirect employment opportunities during construction period
- 10,000 employment opportunities during operation period
- Under passage at every 500m of the corridor
- Provision of service roads along the alignment, boosts the value of land property
- Substantial reduction in road accidents
- Clean mode of transport, Savings in fuel consumption
- Noise mitigation, Reduction in congestion and pollution on the roads
- High Energy Efficiency and Low Emission of Greenhouse Gases
- 100% reliance on renewable energy sources
- Rejuvenation of abandoned paddy fields
- Scientific waste management
- High Capacity and Frequency
- Reduction in Travel Time (Thiruvananthapuram to Kasaragod just 4 hours)
- Strong Infrastructure to counter Natural Disasters

Project Implementation Schedule

Based on the information disclosure of K-Rail, the project is expected to be commissioned over a period of five years from 2020-21 to 2024-25. All the clearances required for the commencement of construction activities shall be secured before commencement of the construction activities.

The Environmental Impact Assessment of the proposed project is carried out by Centre for Environment and Development, Thiruvananthapuram. The assignment is to help the K-Rail in identifying environmental and social impacts; prepare environmental and social management plans to mitigate the identified issues and to ensure that the proposed works are designed and constructed in line with the regulations and stipulations of MoEFCC, CPCB, SPCB, K-Rail and international funding agencies like KfW, ADB, JICA, WB & AIIB. Since the proposed Project is a railway project, Environmental Clearance is not required from MoEFCC, Government of India, but KRDCL in its commitment to safe guard the environment and also to mitigate the social impact due to project is desirous of conducting the EIA. The EIA report will be incorporated in the Detailed Project Report (DPR).

Environment Impact Assessment (EIA)

The present rapid EIA Study was carried out during November 2019 – February 2020. Environmental assessment along the project corridor has been done by collecting information and data through intensive field visits, primary and secondary data collection, taking all ecosystem components and analysing the same.

Objectives of the EIA Study

The overall objective of the present assignment is to carry out a Rapid Environment Impact Assessment (EIA) for the proposed SilverLine Corridor between Thiruvananthapuram to Kasaragod (Total Length of corridor: 529.45 km); to help the K-Rail in identifying environment and social impacts; prepare an Environmental Management Plan to mitigate the identified issues and to ensure that the proposed works are designed and constructed in line with the regulations made by the organizations and funding agencies like MOEF&CC, CPCB, SPCB, K-Rail and KfW/ ADB/ JICA/ WB/ AIIB. The specific objectives are:

1. To analyze the project based on the components and identify activities that can have considerable effect on the local environment - be it positive or negative;
2. To foresee and quantify the magnitude and intensity of the impacts of the various project components on the local environment;
3. To specifically undertake hydrological Environmental Impact Assessment;

4. To carry out an appraisal of the present environmental settings in the area with regard to parameters like air, land, water quality, biodiversity of the region, socio-economic conditions of the people, infrastructure capabilities of the area, etc.
5. To suggest mitigation/ control measures for the major impacts of the SilverLine corridor and also to prepare an Environmental Management Plan for the SilverLine corridor.
6. To prepare a detailed environmental and social baseline situation.
7. To predict and evaluate possible environmental and socio-economic impacts.

Approach and Methodology Adopted for EIA Study

The Government of India guidelines for Rail/ Road/ Highway project; EIA notification 2006 of MoEFCC, and Highway Sector EIA guidance manual 2010 has also been followed in the process of this environmental assessment. The study methodology has been adopted in such a manner to ensure that environmental concerns are given adequate weightage in the selection of alignment and design of proposed SilverLine Project. The study employs an iterative approach in which potential environmental issues have been examined at successive levels in detail and specificity, at each step in the process. The Environmental assessment is based on the information collected from primary as well as secondary sources on various environmental attributes. Based on the analysis of data provided by K-Rail in feasibility report and other inputs for the route and also data collected during field visit and relevant literature review, the initial environmental examination study is made.

Chapter 1 on introduction is to bring out the need for the SilverLine in the state. Need for the environmental study with its objective and scope of work are summarised. Chapter 2 provides salient features of the SilverLine project along with details of route, stations; depot and land requirement for execution of project. The proposed SilverLine is passing through 11 districts from Thiruvananthapuram in the south to Kasaragod in the north. Total land requirement has been estimated including the land required for stations and depot. Train will run at maximum operating speed of 200 kmph and total travel time from Thiruvanthapuram to Kasaragod will be about 4 hours. A total of 1383 ha of land is required for the entire length of SilverLine alignment and its associated facilities including stations (11 nos) and rolling stock depots (2 nos). Out of the total land, 1198 ha. belongs to Private land 185 ha belongs to Railway along the existing Line.

Salient features of Thiruvananthapuram- Kasaragod SilverLine Rail Project is given below.

Sl. No.	Description	Details
1	Route Length	529.45 km
2	Gauge	1435 mm (Standard Gauge)
3	Maximum Operational Speed	200 km/h
4	Stations	Thiruvananthapuram at Kochuveli, Kollam, Chengannur, Kottayam, Ernakulam, Kochi Airport, Thrissur, Tirur, Kozhikode, Kannur and Kasaragod
5	Type of Structures	Tunnel – 11.53 km (2.17%), Bridges – 12.99 km (2.44%) Viaducts – 88.41 km (16.61%), Embankments – 292.73 km (55.00%), Cuttings – 101.74 km (19.12%), Cut & Cover – 24.79 km (4.66%)
6	Track Structure	Mostly Ballasted and ballast-less in viaduct & tunnels
7	Maintenance Depots	Workshop at Kollam and Inspection Depot at Kasaragod
8	Train type	EMU type
9	Car body Width	3400mm (max)
10	Seating	2+2 (Business), 3+2 (Standard)
11	Passenger capacity per Train	675 (9 car set)
12	Traction	2x25kV Auto Transformer Type Feeding System Overhead Contact System – simple catenary type
13	Power Supply	Kerala State Electricity Board supply supplemented by renewable energy supplies
14	Signalling & Train Control System	ETCS level 2 system
15	Communication	LTE with BTN
16	Daily Ridership	79934 in 2025 – 26 (including Airport trips, additional trips due to introduction of city feeder, TOD) increasing to 158946 (including additional trips) in 2052 – 53
17	Train Set	9 cars extendable to 12/15
18	Train operation	37 services in 2025 with peak headway of 20 minutes, increasing to 65 in 2052 with peak headway of 10 minutes
19	Cars requirement	261 in 2025 increasing to 492 in 2052
20	Fare Collection	Automatic Fare collection system with Centralized Computer and other supporting systems
21	Completion time	5 years
22	Capital cost (Rs) (March 2020 price)	49919 Crores
23	Cost with IDC (Rs)	63941 Crores
24	Financing	Debt Rs.33700cr (52.7%), Equity-MoR-Rs.3125cr (4.89%), GoK-Rs.3253cr (5.09%) and other equities-4252cr (6.65%), GoK (land, EIA and R&R)-13362cr (20.90%), Subordinated debt-GoI-Rs.3189cr (4.99%), GoK-Rs.2896cr (4.53%) and balance in IDC-Rs164cr (0.26%)

Since the SilverLine will cover almost the entire state, geological and hydrogeological features of the whole of the state have been presented. Salient features of Kerala with respect to physiography, geology, stratigraphy and lithology, and soil are presented. SilverLine route will be mostly in the coastal region (lowland area <7.5 m above msl) and midland area (between 7.5 to 75 m above msl). Kerala has been endowed with a variety of soils due to the climate, topography and vegetation characteristics. Laterite and loams form the major soil types of Kerala. The other types of soil developed as a result of agro climatic variations include riverine and coastal alluvium. The state is prone to a host of natural hazards such as coastal erosion, floods, drought, lightening, landslides and earthquakes. Almost all districts of Kerala are multi-hazard prone. Since the proposed route goes along the coast for substantial distance coastal hazards such as cyclone, coastal erosion, tsunami and earthquake are discussed in the chapter. Hydrogeological features of the State including status of laterite and alluvium aquifers, springs, groundwater and surface water hydrology are also presented.

Baseline environmental quality status of the Kerala State is presented in chapter 3. Existing status of environmental quality in the region along the proposed route has been assessed through primary data collected for one season during field November 2019 to February 2020 has been utilized. Environmental quality data has been presented for different components of the environment viz. air, surface and ground water, soil, noise, biological (flora and fauna). Ambient air quality data collected in residential, commercial and industrial areas of different districts near the proposed stations reveal that concentration of major air pollutants like PM₁₀, PM_{2.5}, SO₂, NO₂ and CO has been well within the permissible levels. The air quality of the state is fairly good and the SilverLine will not aggravate the situation as road traffic is reduced further. Data on noise levels is also collected through noise measurements from 22 locations. Noise levels at certain locations were high depending upon level of activity taking place and also along the traffic corridor. The SilverLine is not expected to raise the noise further as it is designed to be less noise generating and hence noise will not be an issue. However, proper control/ mitigation measures should be adopted to keep levels within the permissible levels, particularly during construction phase of the project.

Study of water environment encompasses assessment of surface and ground water quality and quantity available in the study area. The surface water quality of various rivers conforms to CPCB classification - Class C (drinking water source after conventional treatment and disinfection) at most of the locations, w.r.t. pH, DO, BOD and Total coliform. The overall groundwater quality in various districts conforms to the permissible limit of drinking water

standards (IS: 10500-2012) at most of the locations. Primary data on the soil quality near the proposed stations and depots were collected. Physical and chemical characteristics of soil have been analysed and also the metallic content in the soil.

Status of flora and fauna in the State as well along the SilverLine route was assessed. Details of different types of forests, forest cover, structure and composition of vegetation, rare and endangered flora are presented. The forests of Kerala are home to some of the endemic and endangered species of India. The recorded forest area in the state is 11,309 km² which is 29.11% of the state's total geographical area. None of the forest area is coming in the proposed route except some patches of mangroves. The floral diversity of Kerala can be categorized into three (i) Wild and Indigenous, (ii) Indigenous and Cultivated, (iii) Exotic, yet cultivated or wild. Most of the area which is under the proposed rail corridor is open scrubland and monoculture of Coconut (*Cocos nucifera*), Areca nut (*Areca catechu*), Anjili (*Artocarpus hirsutus*), Mango (*Mangifera indica*), Teak (*Tectona grandis*), Jackfruit (*Artocarpus heterophyllus*), rubber, and other miscellaneous species while in the remaining area is having agriculture crop fields. The proposed route passes through paddy fields and abandoned paddy fields for a major part. Major area surveyed parallel to the corridor in terms of vegetation is devoted to agricultural practices and plantation of the commercial trees like coconut, areca nut, rubber, mango, jackfruit, tapioca and banana. The forest types are mostly comprising of the tropical forest type while, vegetation is changed near coastal areas. Further, status and details of fauna, faunal diversity, mammals, avifauna, insect diversity, critically endangered animal species and domestic fauna/ livestock are presented.

The transportation projects like the SilverLine project and its associated infrastructure may cause impacts in many ways on the Physical, Biological, Socio-economic and Cultural environment. The ESIA will help to identify those negative impacts that are anticipated in the project under consideration and to suggest the mitigation measures to minimize the negative impacts. Anticipated impacts due to various activities envisaged during construction and operation of the SilverLine project have been assessed and further mitigation measures have been suggested for each of the following environmental components (Chapter 4).

- Land Environment (Impact on land use, soil fertility and agriculture)
- Water Environment ((Impact on ground water quality, surface water quality)
- Air Environment (Impact on Ambient air quality)
- Noise Environment (Impact on Ambient Noise & Vibration)
- Biological Environment (Impact on flora and fauna)

Based on project particulars and the existing environmental conditions, potential impacts are identified that are expected to have adverse impact on the environment due to proposed SilverLine project. The SilverLine alignment is not passing through any notified area such as National Park, Wildlife Sanctuaries, Biosphere Reserves and other Ecological Sensitive areas. However, the alignment is somewhat parallel to one of the Global Biodiversity Hotspots, the Western Ghats and hence impacts relating to biodiversity need to be carefully assessed. A number of households and establishments (shops, schools, temples and mosques, *etc.*) need to be displaced and rehabilitated where the alignment is passing through or over it. The social impacts are also assessed in detail by specific locations and mitigation measures suggested.

In chapter 5, various project alternatives were analyzed to avoid and reduce adverse environmental and social impacts as far as practically possible. The rationales behind preferred choice of taking the Embankment Route Vs the No-SilverLine/ Business as Usual evaluation Vs Express Highway were analysed. On assessment of the advantages and disadvantages of the three alternatives and certain limitation, it is considered that Alternative 1- SilverLine with Embankment, Cuttings & viaducts with minimal cut & cover, Tunnels & Bridges, is the most preferred option.

Impact on hydrology of the project area has been extensively studied and specifically discussed in chapter 6. Results of the study on socio economic environment are also included in this chapter. Results revealed that majority of people have positive attitude towards the SilverLine Project and their expectation are very high as they expect a better living environment with advanced travel facility and employment opportunities by implementing the project in their area. The risks associated with the project's implementation and a description of the specific risk mitigation measures and management approaches were also discussed.

Benefits arising from the implementation of the SilverLine project are discussed in chapter 7. The benefits include high speed connectivity, new technological involvement, ease of travel and freight movement, expansion of urban and industrial areas, employment generation and boost to economy. Green house gas reduction is another aspect of the benefits.

Chapter 8 provides the Environmental Management Plan for the project. The Environmental Management Plan (EMP) addresses the pre-construction, construction, and operation and maintenance phases of each component of the SilverLine project. The EMP identifies the key environmental issues across the project and provides strategies and plans for

managing them effectively. While it was not possible to avoid or reverse all of the adverse impacts of the proposed project, an effort has been made to address some of the significant impacts, by careful consideration and selection of project alternatives. This chapter presents an environmental management and monitoring plan based on the significant environmental impacts and mitigation measures. Further, suitable measures to minimize, control and manage the residual environmental impacts have been identified and described in the EMP in this chapter.

The EMP has been prepared based on a hierarchy of impact avoidance, minimization, mitigation and control of residual impacts, for both, construction and operation phases for all the relevant environmental attributes. It describes administrative aspects of ensuring that mitigatory measures are implemented and their effectiveness is monitored over the life of the project. Mitigation measures have been identified along Institutional arrangements, human resource requirements, their role and responsibilities; budgetary estimates of financial resources required; and performance indicators for tracking mitigation measures for effective implementation of the proposed EMP. Environmental Monitoring Programme (EMoP) for the project is discussed in chapter 9. This includes discussion on Routine Supervision of the Work, observation of the construction/ operation work to ensure mitigation actions to be conducted during routine site inspections. The institutional framework required is also dealt with along with cost for implementation of EMoP.

Analysis of various impacts on the components of the environment reveal that proposed project activity shall have impact on the environment; however, the magnitude of impact is comparatively less. With the implementation of suggested mitigation measures during construction and operational phase of the project, these impacts can be minimized to the acceptable limits/ levels.

Based on the findings of this EIA study and recommendations on mitigation measures and management plan, it is concluded that the SilverLine project is in compliance with JICA E&S guidelines as well as National, State and local environmental regulations. Also, the effective implementation of the proposed mitigation measures, environmental management and monitoring plan are adequate to minimize and control the adverse environmental impacts likely, due to the project. The proposed development of the SilverLine Corridor in Kerala will prove to be a boon for the people and economy of the Kerala State.

Chapter 11

DISCLOSURE OF CONSULTANT ENGAGED IN EIA STUDY

Centre for Environment and Development

The Centre for Environment and Development (CED) is an autonomous research and development, training and consultancy organisation focussing in areas related to Environment and Development and is recognised as a *Scientific and Industrial Research Organisation (SIRO)* by the Department of Scientific and Industrial Research of the Ministry of Science and Technology, Government of India. CED is also the *Centre of Excellence on Solid Waste and Wastewater Management* of Ministry of Housing and Urban Development, Government of India, Empanelled Agency for the *Preparation of City Development Plan (CDP) for the ULBs and also Preparation of DPR for Water Supply, Sanitation and Drainage* and the Training Institute of the MoUD for AMRUT and Smart Cities Mission. It is one of the National Key Resource Centre for Drinking Water and Sanitation of the Ministry of Drinking Water and Sanitation, Government of India and the Regional Resource Agency of Ministry of Environment and Forests and Climate Change, Government of India. *CED* is also an empanelled agency of Indian Council for Forestry Research and Education (ICFRE), Ministry of Environment Forests and Climate Change, Government of India for projects related to Environment Management. CED is also the *Accredited Agency* of Government of Kerala for *Solid Waste Management and Participatory Resource Mapping*.

CED is an ISO 9001 – 2015 Certified Institution. CED has completed nearly 120 projects sponsored by various State, national and International Agencies during the last 27 years. CED has its Head Quarters at Thiruvananthapuram and Eastern Regional Campus at Bhubaneswar, Regional Centre at Hyderabad and projects and programs in Kerala, Odisha, Andhra Pradesh, Telangana, Jharkhand, West Bengal, Gujarat, Maharashtra, Madhya Pradesh, Jammu Kashmir, Uttarakhand, Rajasthan, Himachal Pradesh and Karnataka.

The EIA has been carried out by the experts in the Head office, Thiruvananthapuram. The overall objective of the assignment is to carry out a Rapid Environment Impact Assessment (EIA) for the proposed SilverLine Project in the State of Kerala, running between Thiruvananthapuram to Kasaragod (Total Length of corridor: 529.45 km). The details of Team Leader for the EIA study and other experts involved are as given below:

Team Leader- Dr. Vinod T R, Program Director, CED

Team Composition

Sl. No.	Name of the Professional	Position Assigned
1	Dr. Vinod T R , Program Director, CED	Team Leader ; Forestry & Wildlife Specialist
2	Dr. Radhakrishnan P V , Program Director, CED	Environmental & Legal Expert
3	Dr. T. Sabu , Program Director, CED	Biodiversity and Taxonomy Expert
4	Dr. Thrivikramanji K P , Emeritus Professor, CED	Geologist, GIS and RS Specialist
5	Er. Jayaram B , Former Chief Engineer, Irrigation Department, GoK	Hydrology Specialist
6	Dr. Manilal , Former Chief Scientist, NIIST (CSIR), Gol	Senior Advisor (Environment)
7	Dr. Krishnakumar , Consultant, CED	Social Expert
8	Sri. V T Joseph , Former Asst Development Commissioner, GoK	Social Expert
9	Er. Reghukumar P , Senior Design Engineer, CED	Design Specialist
10	Dr. Chrips N R , Scientist, CED	Botany, GIS and RS Specialist
11	Mr. Baiju P , Program Officer, CED	Social & Logistic Specialist
12	Ms. Jayanthi T A , Scientist, CED	Environment Expert
13	Mr. Arun C Rajan , Research Fellow, CED	Field Biologist
14	Mr. Don Mathew , Research Fellow, CED	Environment Specialist
15	Mr. Jitin J Paul , Research Fellow, CED	Environment Specialist
16	Mr. Prasood S P , Research Fellow, CED	Geology, GIS and RS Specialist

ANNEXURES

Annexure 1

Agencies from where clearances to be obtained before and after the commencement of Project

Sl. No.	Clearances	Acts	Approving Agency	Applicability to the project
	EC is exempted for the project			
	Pre-Construction Stage			
1	Diversion of forest Land for Non-forest use	Forest Conservation Act (1980) Forest Conservation Rules (2003)	MoEFCC	Not Applicable
2	Permission for Mangrove Felling	Forest Conservation Act (1980)		Applicable
3	CRZ Clearance for undertaking construction activities in coastal zone	CRZ Notification 2011	MoEFCC after recommendation from KCZMA	Applicable
	Construction Phase			
4	No Objection Certificate (NOC)	Water (Prevention and Control of Pollution) Act 1974, Air (Prevention and Control of Pollution) Act 1981	Kerala State Pollution Control Board	Applicable
5	NOC for undertaking construction activities within 200 m of the notified heritage site	The Ancient Monuments and Archaeological Sites and Remains Act, 1958	Expert Advisory Committee of ASI	Applicable
6	Permission for Withdrawal of Surface Water from Rivers, Nallah, Water harvesting structure/ Reservoirs/Ponds/ Irrigation canals	Relevant Government orders & circulars	Irrigation Department, GoK	Applicable (If The contractor is extracting Surface water)
7	Permission for withdrawal of ground water and NOC for construction of tube well/bore well	Ground Water Regulation and Control of Development and Management Act, 2005	CGWB	Applicable (if contractor abstract ground water)

Sl. No.	Clearances	Acts	Approving Agency	Applicability to the project
8	Permission for Sand Mining from riverbed	Mines and Minerals (Development and Regulation) Act,1957	Dept. of Mines & Geology, GoK	Applicable
9	Permission for Opening of New Quarry	Mines and Minerals (Development and Regulation) Act,1957	Dept. of Mines & Geology, GoK	Applicable
10	Hotmix plant, Crushers, Cement Batching Plant	Air (Prevention and Control of Pollution) Act.1981	Kerala State Pollution Control Board	Applicable
11	Storage of Hazardous Chemicals	Hazardous and Other Waste (Management and Handling) Rules, 2016	Kerala State Pollution Control Board	Applicable
12	Disposal of Hazardous Waste	Hazardous and Other Waste (Management and Handling) Rules, 2016	Kerala State Pollution Control Board	Applicable
13	Disposal of Wastewater from Labour camps	Water (Prevention and Control of Pollution) Act 1974	Kerala State Pollution Control Board	Applicable
14	Construction Waste	Construction & Demolition Waste Management Rules, 2016	Kerala State Pollution Control Board	Applicable
15	Pollution Under Control Certificate	Central Motor Vehicles Act1988	Kerala Motor Vehicles Department	Applicable
16	Power Supply	Kerala Electricity Regulatory Commission Codes	Kerala State Electricity Board	Applicable
17	Employing Labour		Department of Labour, GoK	Applicable
18	Registration of Workers	Labour Welfare Acts	Department of Labour, GoK	Applicable
19	Approval of Building plan & building permit	KMBR & KPBR	Local Self Governments, Kerala	Applicable
20	Processing of solid waste	SWM Rules, 2016 & PWM Rules, 2016	Kerala State Pollution Control Board & Kerala Suchitwa Mission	Applicable

Annexure 2

FLORA

A. List of Plants identified in the SilverLine Corridor

	Name	Local Name	Family	Habit	IUCN Status
1	<i>Abrus precatorius</i> , L.	Chuvannakunni, Kunni	Fabaceae	Climber-Woody	
2	<i>Abrus pulchellus</i> Wall. ex Thw.	Valiyakattumuthira	Fabaceae	Climber-Woody	
3	<i>Abutilon indicum</i> (L.) Sweet,	Kaluram, Kattooram	Malvaceae	Shrub	
4	<i>Acacia caesia</i> (L.) Willd.	Eenja, Incha	Fabaceae	Climber-Woody	
5	<i>Acacia pennata</i> (L.) Willd.	Karincha	Fabaceae	Climber-Woody	
6	<i>Acacia torta</i> (Roxb.) Craib	Kallinja	Fabaceae	Climber-Woody	
7	<i>Acalypha indica</i> L.	Kuppameni	Euphorbiaceae	Herb-Annual	
8	<i>Acalypha paniculata</i> Miq.	Valiyakuppameni	Euphorbiaceae	Herb-Annual	
9	<i>Acalypha paniculata</i> Miq.	Valiyakuppameni	Euphorbiaceae	Herb-Perennial	
10	<i>Acampe praemorsa</i> (Roxb) Blatt&McCann	Maravazha, Upputhali	Orchidaceae	Herb-Perennial	
11	<i>Acanthospermum hispidum</i> DC.		Asteraceae	Herb-Perennial	
12	<i>Acanthus ilicifolius</i>	Chulli	Acanthaceae	Shrub	
13	<i>Achyranthes aspera</i> L.	Kadaladi	Amaranthaceae	Herb-Annual	
14	<i>Achyranthes bidentata</i> Blume	Cherukadaladi	Amaranthaceae	Herb-Annual	
15	<i>Acmella calva</i> (DC.) R.K. Jansen	Erivalli	Asteraceae	Herb-Annual	
16	<i>Acmella paniculata</i> (Wall. ex DC.) R.K. Jansen		Asteraceae	Herb-Annual	
17	<i>Acmella uliginosa</i> (Sw.) Cass.		Asteraceae	Herb-Annual	
18	<i>Acrostichum aureum</i> L.		Pteridaceae	Herb-Perennial	
19	<i>Adenanthera pavonina</i> L.	Manchadi	Fabaceae	Tree	
20	<i>Adenosma malabaricum</i> Hook.f.		Scrophulariaceae	Herb-Perennial	
21	<i>Aegiceras corniculata</i> (L.) Balco	Pookandal	Myrsinaceae	Shrub	
22	<i>Aegle marmelos</i> (L.) Correa	Koovalam	Rutaceae	Tree	
23	<i>Aerva lanata</i> (L.) Juss. ex Schult.	Cherula, Cherupula	Amaranthaceae	Herb-Annual	
24	<i>Aeschynomene americana</i> L.		Fabaceae	Herb-Perennial	
25	<i>Aeschynomene aspera</i> L.	Neerkadasam Ponguchedi	Fabaceae	Herb-Perennial	
26	<i>Aeschynomene indica</i>	Nellithali	Fabaceae	Herb-Annual	

	Name	Local Name	Family	Habit	IUCN Status
27	<i>Aganosma cymosa</i> (Roxb.) G. Don	Palavarikody	Apocynaceae	Climber-Woody	
28	<i>Ageratum conyzoides</i> (L.) L.	Appa, Kattappa	Asteraceae	Herb-Annual	
29	<i>Ageratum conyzoides</i> , L	Neelappa	Asteraceae	Herb-Annual	
30	<i>Aglaia elaeagnoidea</i> (A. Juss.) Benth.	Punyava	Meliaceae	Tree	
31	<i>Ailanthus excelsa</i> Roxb.	Mattipongalyam, Peemaram, Pongalyam,	Simaroubaceae	Tree	
32	<i>Alangium salviifolium</i> (L. f.) Wang	Ankolam	Alanginaceae	Tree	
33	<i>Albizia chinensis</i> (Osbeck) Merr.	Mottavaka, Pottavak	Fabaceae	Tree	
34	<i>Albizia lebeck</i> (L.) Benth.	Nenmenivaka Kattuvaka	Fabaceae	Tree	
35	<i>Albizia odoratissima</i> (L. f.) Benth.	Karivaka, Kunnivaka	Fabaceae	Tree	
36	<i>Albizia saman</i> (Jacq.) F.Muell	Mazhamaram, Urakkamthoongimaram	Fabaceae	Tree	
37	<i>Allamanda cathartica</i> L.	Kolampi poo	Apocynaceae	Climber	
38	<i>Allmania nodiflora</i> (L.) R. Br. ex Wight	Vellakkakeera	Amaranthaceae	Herb-Annual	
39	<i>Allophylus cobbe</i> (L.) Raeusch.	Mukkannanpezhu	Sapindaceae	Shrub	
40	<i>Alloteropsis cimicina</i> (L.) Stapf		Poaceae	Herb-Annual	
41	<i>Alocasia macrorrhiza</i> (L.) G. Don	Maranchemp	Araceae	Herb-Perennial	
42	<i>Alseodaphne semecarpifolia</i> Nees	Mulakunari	Lauraceae	Tree	
43	<i>Alstonia scholaris</i> (L.) R. Br.	Ezhilampala, Yakshipala	Apocynaceae	Tree	
44	<i>Alternanthera bettzickiana</i> (Regel) Voss		Amaranthaceae	Herb-Perennial	
45	<i>Alternanthera brasiliana</i> (L.) Kuntze	Joy weed	Amaranthaceae	Herb-Annual	
46	<i>Alternanthera philoxeroides</i> (Mart.) Grisb.		Amaranthaceae	Herb-Perennial	
47	<i>Alternanthera sessilis</i> (L.) R. Br. ex. DC.	Kozhuppa, Ponnamkannikkera	Amaranthaceae	Herb-Perennial	
48	<i>Alysicarpus bupleurifolius</i> (L.) DC.		Fabaceae	Herb-Perennial	
49	<i>Alysicarpus glumaceus</i> (Vahl) DC.	Oosapayar	Fabaceae	Herb-Perennial	
50	<i>Alysicarpus vaginalis</i> (L.) DC.	Nila-orila	Fabaceae	Herb-Perennial	
51	<i>Amaranthus spinosus</i> L.	Mullanchera	Amaranthaceae	Herb-Annual	
52	<i>Amaranthus spinosus</i> L.	Mullencheera	Amaranthaceae	Herb-Perennial	
53	<i>Amaranthus viridis</i> L.	Kuppacheera	Amaranthaceae	Herb-Annual	
54	<i>Ammannia baccifera</i> L.	Kalluruvi	Lythraceae	Herb-Annual	
55	<i>Ammannia multiflora</i> Roxb.		Lythraceae	Herb-Annual	
56	<i>Amorphophallus commutatus</i> (Schott) Engl.	Kattuchena	Araceae	Herb-Perennial	
57	<i>Amorphophallus paeoniifolius</i> (Dennst.) Nicolson	Chena	Araceae	Herb-Perennial	

	Name	Local Name	Family	Habit	IUCN Status
58	<i>Ampelocissus indica</i> (L.) Planch.	Chemparavalli	Vitaceae	Climber	
59	<i>Ampelocissus latifolia</i> (Roxb.) Planch.	Karantavalli	Vitaceae	Climber	
60	<i>Anacardium occidentale</i> L.	Kashumaavu	Anacardiaceae	Tree	
61	<i>Anamirta cocculus</i> (L.) Wight & Arn.	Pollakai, Nanchuvalli	Menispermaceae	Climber-Woody	
62	<i>Ananas comosus</i> (L.) Merr.	Kaithachakka, Puruthi	Bromeliaceae	Herb-Perennial	
63	<i>Ancistrocladus heyneanus</i> Wall. ex Graham		Ancistrocladaceae	Climber-Woody	
64	<i>Andrographis paniculata</i> (Burm.f.) Nees	Kiriyathu, Nilavepu	Acanthaceae	Herb-Annual	
65	<i>Aniseia martinicensis</i> (Jacq.) Choisy	Kulayadambu, Venthiruthali	Convolvulaceae	Herb-Perennial	
66	<i>Anisochilus carnosus</i> (L.f.) Wall. ex Benth.	Kaattukoorkka, Chomara, Karpooravalli	Lamiaceae	Herb-Annual	
67	<i>Anisomeles indica</i> (L.) Kuntze	Chedayan, Karinthumba	Lamiaceae	Herb-Annual	
68	<i>Annona glabra</i> L.	Kattathi	Annonaceae	Tree	
69	<i>Annona muricata</i> L.	Mullaatha	Annonaceae	Tree	
70	<i>Annona reticulata</i> L.	Atha, Seethappazham	Annonaceae	Tree	
71	<i>Annona squamosa</i> L.	Atha	Annonaceae	Tree	
72	<i>Anodendron paniculatum</i> (Roxb.) A. DC.	Kakkakodi	Apocynaceae	Climber-Woody	
73	<i>Antidesma acidum</i> Retz.	Ariyaporiyan	Euphorbiaceae	Shrub	
74	<i>Antidesma bunius</i> (L.) Spreng.	Cherutali, Mayilkombi	Euphorbiaceae	Tree	
75	<i>Antidesma montanum</i> Blume	Thathalamaram	Euphorbiaceae	Tree	
76	<i>Antigonon leptopus</i> Hook. & Arn.	Thenpoovali	Polygonaceae	Climber	
77	<i>Apluda mutica</i> L.		Poaceae	Herb-Annual	
78	<i>Apocopis mangalorensis</i> (Hochst.) Henrard		Poaceae	Herb-Annual	
79	<i>Aponogeton appendiculatus</i> van Bruggen		Aponogetonaceae	Herb-Perennial	Endemic
80	<i>Aponogeton natans</i> (L.) Engl. & Krause	Paruakizhangu	Aponogetonaceae	Herb-Perennial	
81	<i>Aporosa cardiosperma</i> (Gaertn.) Merr.	Ponvetti, Vetti	Euphorbiaceae	Tree	
82	<i>Ardisia littoralis</i> Andr.		Myrsinaceae	Shrub	
83	<i>Areca catechu</i> L.	Kamuk	Arecaceae	Tree	
84	<i>Argyrea nervosa</i> (Burm.f.) Bojer	Samudrappacha	Convolvulaceae	Climber	
85	<i>Ariopsis peltata</i> Nimmo		Araceae	Herb-Annual	
86	<i>Aristolochia acuminata</i> Lam.	Garudakodi, Eswaramulla	Aristolochiaceae	Climber	
87	<i>Aristolochia indica</i> L.	Garudakodi, Eswaramulla	Aristolochiaceae	Climber	
88	<i>Artocarpus heterophyllus</i> Lam.	Plavu	Moraceae	Tree	

	Name	Local Name	Family	Habit	IUCN Status
89	<i>Artocarpus hirsutus</i> Lam.	Anjili, Ayani	Moraceae	Tree	
90	<i>Artocarpus incisus</i> (Thunb.) L.f.	Kadaplavu	Moraceae	Tree	
91	<i>Arundinella cannanorica</i> V.J. Nair		Poaceae	Herb-Annual	
92	<i>Arundinella metzii</i> Hochst. ex Miq.		Poaceae	Herb-Annual	
93	<i>Arundinella pumila</i> (Hochst.ex A.Rich)Steud.		Poaceae	Herb-Annual	
94	<i>Arundo donax</i> L.	Oodappullu	Poaceae	Herb-Annual	
95	<i>Asclepias curassavica</i> L.	Kammalchedi	Asclepiadaceae	Shrub	
96	<i>Asparagus racemosus</i> Willd.	Sathavari	Asparagaceae	Climber	
97	<i>Asystasia dalzelliana</i> Sant.		Acanthaceae	Herb-Annual	
98	<i>Asystasia gangetica</i> (L.) Anders.	Upputhali	Acanthaceae	Herb-Annual	
99	<i>Atalantia wightii</i> Tanaka	Kattuelumachan	Rutaceae	Shrub	
100	<i>Averrhoa bilimbi</i> L.	Irumpanpuli	Oxalidaceae	Tree	
101	<i>Averrhoa carambola</i> L.	Chathurapuli	Oxalidaceae	Tree	
102	<i>Avicennia marina</i> (Forssk.) Vierh.	Cheru uppatti	Avicenniaceae	Tree	
103	<i>Avicennia officinalis</i> L.	Uppatti	Avicenniaceae	Tree	
104	<i>Axonopus compressus</i> (Sw.) P. Beauv.	Kaalapullu	Poaceae	Herb-Annual	
105	<i>Azadirachta indica</i> A.Juss.	Aaryaveppu,	Meliaceae	Tree	
106	<i>Azolla pinnata</i> R. Brown		Salviniaceae	Herb-Annual	
107	<i>Bacopa floribunda</i> (R. Br.) Wettst.		Scrophulariaceae	Herb-Annual	
108	<i>Bacopa hamiltoniana</i> (Benth.) Wettst.		Scrophulariaceae	Herb-Annual	
109	<i>Bacopa monnieri</i> (L.) Pennell	Bhrahmi	Scrophulariaceae	Herb-Annual	
110	<i>Bambusa balcooa</i> Roxb.		Poaceae	Shrub	
111	<i>Bambusa bambos</i> (L.) Voss	Ili, Kaniyaram, Mula	Poaceae	Shrub	
112	<i>Bambusa striata</i> Lodd. ex Lindl.	Manja mula	Poaceae	Shrub	
113	<i>Barleria cristata</i> L.	Kankambaram	Acanthaceae	Shrub	
114	<i>Barleria prionitis</i> Linn.	Manjakanakambaram	Acanthaceae	Herb-Perennial	
115	<i>Barringtonia acutangula</i> (L.) Gaertn.	Aattupezhu, Neerpezhu	Lecythidaceae	Tree	
116	<i>Barringtonia racemosa</i> (L.) Spreng.	Samudrachampa Samudrakai	Lecythidaceae	Tree	
117	<i>Basilicum polystachyon</i> (L.) Moench		Lamiaceae	Herb-Perennial	
118	<i>Bauhinia malabarica</i> Roxb.	Vellamandaram	Fabaceae	Tree	
119	<i>Bauhinia racemosa</i> Lam.	Malamandaram	Fabaceae	Tree	
120	<i>Bauhinia variegata</i> L.	Chuvanna mandaram	Fabaceae	Tree	

	Name	Local Name	Family	Habit	IUCN Status
121	<i>Begonia malabarica</i> Lam.,	Muthalminuki	Begoniaceae	Herb-Annual	
122	<i>Benkara malabarica</i> (Lam.) Tirveng.	Cholakara	Rubiaceae	Tree	
123	<i>Bergia capensis</i> L.		Elatinaceae	Herb-Annual	
124	<i>Bhidea fischeri</i> Sreek. & B.V. Shetty		Poaceae	Herb-Annual	
125	<i>Bidens biternata</i> (Lour.) Merr. & Sheriff	Kandavarekootti	Asteraceae	Herb-Annual	
126	<i>Bidens pilosa</i> L.		Asteraceae	Herb-Annual	
127	<i>Biophytum intermedium</i> Wight		Oxalidaceae	Herb-Annual	
128	<i>Biophytum reinwardtii</i> (Zucc.) Klotzsch.	Mukkutti	Oxalidaceae	Herb-Annual	
129	<i>Biophytum sensitivum</i> (L.) DC.	Mukkutti	Oxalidaceae	Herb-Perennial	
130	<i>Blumea axillaris</i> (Lam.) DC.		Asteraceae	Shrub	
131	<i>Blumea belangeriana</i> DC.	Venappacha	Asteraceae	Herb-Annual	
132	<i>Blumea membranacea</i> Wall. ex DC.	Bhoothamkolli	Asteraceae	Herb-Annual	
133	<i>Blumea oxyodonta</i> DC.		Asteraceae	Herb-Annual	
134	<i>Blyxa aubertii</i> L.C. Rich.		Hydrocharitaceae	Herb-Perennial	
135	<i>Blyxa aubertii</i> L.C. Rich. var. <i>echinosperma</i> (Clarke) Cook & Lound,		Hydrocharitaceae	Herb-Annual	
136	<i>Blyxa octandra</i> (Roxb.) Planch. ex Thw.		Hydrocharitaceae	Herb-Annual	
137	<i>Boerhavia diffusa</i> L.	Thazhuthaama	Nyctaginaceae	Herb-Annual	
138	<i>Bombax ceiba</i> L.	Elavu, Mulliavu,	Bombacaceae	Tree	
139	<i>Bonamia semidigyna</i> (Roxb.) Hall.f.		Convolvulaceae	Climber	
140	<i>Bougainvillea glabra</i> Choisy		Nyctaginaceae	Shrub	
141	<i>Brachiaria mutica</i> (Forssk.) Stapf		Poaceae	Herb-Annual	
142	<i>Brachiaria mutica</i> (Forssk.) Stapf		Poaceae	Herb-Perennial	
143	<i>Brachiaria reptans</i> (L.) Gard. & C.E.Hubb.		Poaceae	Herb-Perennial	
144	<i>Breynia retusa</i> (Dennst.) Alston	Ekdania, Mulluvenga	Euphorbiaceae	Shrub	
145	<i>Breynia vitis-idaea</i> (Burm. f.) C.E.C. Fisch.	Chuvannaniruri	Euphorbiaceae	Shrub	
146	<i>Bridelia retusa</i> (L.) A.Juss.	Mulluvenga	Euphorbiaceae	Tree	
147	<i>Briedelia stipularis</i> (L.) Blume	Cherupanachi	Euphorbiaceae	Climber-Woody	
148	<i>Bruguiera cylindrica</i> (L.) Blume	Kuttikandal	Rhizophoraceae	Tree	
149	<i>Bruguiera gymnorrhiza</i> (L.) Savi.	Karakandal	Rhizophoraceae	Tree	
150	<i>Bryophyllum pinnatum</i> (Lam.) Kurz	Ilamulachi	Crassulaceae	Herb-Perennial	
151	<i>Buchanania lanzan</i> Spreng.	Padacheru	Anacardiaceae	Tree	
152	<i>Bulbophyllum sterile</i> (Lam.) Suresh	Mookittakaya	Orchidaceae	Herb-Epiphyte	

	Name	Local Name	Family	Habit	IUCN Status
153	<i>Bulbostylis barbata</i> (Rottb.)Kunth ex Clarke		Cyperaceae	Herb-Annual	
154	<i>Bulbostylis puberula</i> (Poir.) Clarke		Cyperaceae	Herb-Annual	
155	<i>Burmannia coelestis</i> D. Don		Burmanniaceae	Herb-Annual	
156	<i>Butea monosperma</i> (Lam.) Taub.	Chamatha, Plasu	Fabaceae	Tree	
157	<i>Cabomba caroliniana</i> A.Gray		Cabombaceae	Herb-Perennial	
158	<i>Caesalpinia coriaria</i> (Jacq.) Willd.	Dividivi	Fabaceae	Tree	
159	<i>Caesalpinia crista</i> L.	Aattuparanda	Fabaceae	Climber	
160	<i>Caesalpinia mimosoides</i> Lam.	Theemullu, Kalthottavadi	Fabaceae	Climber-Woody	
161	<i>Cajanus scarabaeoides</i> (L.) Thouars	Kattumuthira	Fabaceae	Shrub	
162	<i>Caladium bicolor</i> (Ait. ex Dryand.) Vent.	Varnachembu	Araceae	Herb-Perennial	
163	<i>Calamus travancoricus</i> Bedd. ex Becc.	Arichooral, Vallichooral	Arecaceae	Climber-Woody	
164	<i>Callicarpa tomentosa</i> (L.) L. in Murr.	Cheruthekku, Naikumbil	Verbenaceae	Shrub	
165	<i>Calophyllum calaba</i> L.	Aattupunna,	Clusiaceae	Tree	
166	<i>Calophyllum inophyllum</i> L.	Kattupunna, Punna	Clusiaceae	Tree	
167	<i>Calopogonium mucunoides</i> Desv.		Fabaceae	Climber	
168	<i>Calotropis gigantea</i> (L.) W.T.Aiton	Erikku, Vella-erikku	Asclepiadaceae	Shrub	
169	<i>Calycopteris floribunda</i> Lam.	Pullanni, Pullanji,	Combretaceae	Climber-Woody	
170	<i>Cananga odorata</i> (Lam.) Hook.f.& Thoms.		Annonaceae	Tree	
171	<i>Canavalia gladiata</i> (Jacq.) DC.	Vettukatthipayar	Fabaceae	Climber	
172	<i>Canscora diffusa</i> (Vahl) R. Br. ex Roem.	Jeerakapullu	Gentianaceae	Herb-Annual	
173	<i>Canscora pauciflora</i> Dalz.	Kanchankora	Gentianaceae	Herb-Annual	
174	<i>Cansjera rheedei</i> Gmel.	Cherukanhiravalli	Opiliaceae	Climber	
175	<i>Canthium angustifolium</i> Roxb.	Kattarumullu	Rubiaceae	Shrub	
176	<i>Canthium coromandelicum</i> (Burm.f.) Alston	Kandakara	Rubiaceae	Shrub	
177	<i>Capparis floribunda</i> Wight		Capparaceae	climber	
178	<i>Capparis rheedei</i> DC.	Kannakkarremaram	Capparaceae	Shrub	
179	<i>Capparis sepiaria</i> L.	Kakkathondi	Capparaceae	Shrub	
180	<i>Capsicum annuum</i> L.	Chuvannamulaku, Kappalmulaku, Mulaku	Solanaceae	Herb-Perennial	
181	<i>Capsicum frutescens</i> L.	Kanharimulak	Solanaceae	Herb-Perennial	
182	<i>Carallia brachiata</i> (Lour.) Merr.	Vallabham, Varungu, Vankana	Rhizophoraceae	Tree	
183	<i>Cardiospermum halicacabum</i> L.	Paluruvam, Uzhinja, Karuthakunni	Sapindaceae	Climber	

	Name	Local Name	Family	Habit	IUCN Status
184	<i>Careya arborea</i> Roxb	Pezhu	Lecythidaceae	Tree	
185	<i>Carica papaya</i> L.	Karmmus, Papaya	Caricaceae	Tree	
186	<i>Caryota urens</i> L.	Choondappana	Arecaceae	Tree	
187	<i>Cassia fistula</i> L.	Kanikonna, Konna	Fabaceae	Tree	
188	<i>Cassia toral</i> .		Fabaceae	Shrub	
189	<i>Catharanthus pusillus</i> (Murr.) G. Don	Kapavila	Apocynaceae	Herb-Perennial	
190	<i>Catunaregam spinosa</i> (Thunb.) Tirveng.	Kattakkara	Fabaceae	Shrub	
191	<i>Cayratia trifolia</i> (L.) Domin	Vathakkodi	Vitaceae	Climber	
192	<i>Ceiba pentandra</i> (L.) Gaertn.	Panjimaram, Poola	Bombacaceae	Tree	
193	<i>Celosia argentea</i> L. var. <i>cristata</i> (L) Kuntze	Kozhivalan	Amaranthaceae	Herb-Annual	
194	<i>Centella asiatica</i> (L.) Urban	Kodangal, Kudakan	Apiaceae	Herb-Perennial	
195	<i>Centranthera indica</i> (L.) Gamble		Scrophulariaceae	Herb-Annual	
196	<i>Centratherum intermedium</i> Less.		Asteraceae	Herb-Annual	
197	<i>Centrosema molle</i> Benth.	Kattupayar	Fabaceae	Climber	
198	<i>Ceratophyllum demersum</i> L.	Kaimbayal	Ceratophyllaceae	Herb-Perennial	
199	<i>Ceratopteris thalictroides</i>		Parkeriaceae	Herb-Perennial	
200	<i>Cerbera odollam</i> Gaertn.	Othallam	Apocynaceae	Tree	
201	<i>Cereus pterogonus</i> Lam.	Kalli	Cactaceae	Shrub	
202	<i>Ceropegia candelabrum</i> L.	Kammanamkizhangu	Asclepiadaceae	Climber	
203	<i>Chamaecrista mimosoides</i> (L.) Greene	Cheruthakara	Fabaceae	Herb-Perennial	
204	<i>Chassalia curviflora</i> (Wall. ex Kurz) Thw. var. <i>ophioxylodes</i> (Wall.) Deb & B.Krishna	Karutha-amalppori Yamari	Rubiaceae	Shrub	
205	<i>Chionanthus mala-elengi</i> (Dennst.) P.S.Green	Mala-elengi, Perumbal	Oleaceae	Tree	
206	<i>Chloris barbata</i> Sw.	Mayilpullu, Kodapullu	Poaceae	Herb-Annual	
207	<i>Chromolaena odorata</i> (L) R.M.King & H.Rob.	Communistpacha	Asteraceae	Shrub	
208	<i>Chrysophyllum cainito</i> L.		Sapotaceae	Tree	
209	<i>Chrysopogon aciculatus</i> (Retz.) Trin.	Snehapullu, Asthrapullu	Poaceae	Herb-Annual	
210	<i>Cinnamomum malabattrum</i> (Burm.f.) J.Presl	Ilavangam, Vayana, Idana	Lauraceae	Tree	
211	<i>Cipadessa baccifera</i> (Roth) Miq.	Kaipanarangi, Potti	Meliaceae	Tree	
212	<i>Cissampelos pareira</i> L.	Karanakody	Menispermaceae	Climber-Woody	
213	<i>Cissus latifolia</i> Lam.	Chunnambuvalli	Vitaceae	Climber	
214	<i>Cissus trilobata</i> Lam.	Neelachunnambuvalli	Vitaceae	Climber	

	Name	Local Name	Family	Habit	IUCN Status
215	<i>Citharexylum spinosum</i> L.	Parijatham	Verbenaceae	Tree	
216	<i>Citrus maxima</i> (Burm.f.) Merr.	Babloos Kambilinaranga	Rutaceae	Tree	
217	<i>Cleome burmannii</i> Wight & Arn.	Kattukadugu	Capparaceae	Herb-Annual	
218	<i>Cleome rutidosperma</i> DC.	Neelavela	Capparaceae	Herb-Annual	
219	<i>Cleome viscosa</i> L.	Naikadugu, Ariyavela	Capparaceae	Herb-Annual	
220	<i>Clerodendrum indicum</i> (L.) Kuntze		Verbenaceae	Shrub	
221	<i>Clerodendrum inerme</i> (L.) Gaertn.	Vishamulla	Verbinaceae	Shrub	
222	<i>Clerodendrum infortunatum</i> L.	Perivelam, Peruku,	Verbinaceae	Shrub	
223	<i>Clerodendrum paniculatum</i> L.	Krishnakiredam,	Verbinaceae	Shrub	
224	<i>Clidemia hirta</i> (L.) D. Don		Melastomataceae	Shrub	
225	<i>Clitoria tematea</i> L.	Sankupushpam, Aaral	Fabaceae	Climber	
226	<i>Coccinia grandis</i> (L.) Voigt	Koval	Cucurbitaceae	Climber	
227	<i>Cocos nucifera</i> L.	Thengu	Arecaceae	Tree	
228	<i>Coffea arabica</i> L.	Kappi	Rubiaceae	Tree	
229	<i>Coix lacryma-jobi</i> L.	Kakkappallunku	Poaceae	Herb-Perennial	
230	<i>Coldenia procumbens</i> L.	Nilamparanda	Boraginaceae	Herb-Annual	
231	<i>Colocasia esculenta</i> (L.) Schott	Chembu	Araceae	Herb-Perennial	
232	<i>Combretum latifolium</i> Blume	Manjavalli	Combretaceae	Climber	
233	<i>Commelina attenuata</i> Koenig ex Vahl		Commelinaceae	Herb-Annual	
234	<i>Commelina benghalensis</i> L.	Kanavazhai	Commelinaceae	Herb-Annual	
235	<i>Commelina diffusa</i> Burm.f.		Commelinaceae	Herb-Annual	
236	<i>Corchorus aestuans</i> L.		Tiliaceae	Herb-Perennial	
237	<i>Cordia obliqua</i> Willd.	Pasakamaram	Boraginaceae	Tree	
238	<i>Corypha umbraculifera</i> L.	Kodappana, Thalippana	Arecaceae	Tree	
239	<i>Cosmostigma racemosum</i> (Roxb.) Wight	Vattuvalli	Asclepiadaceae	Climber	
240	<i>Costus speciosus</i> (Koenig) J.E. Smith	Channakoova	Costaceae	Herb-Perennial	
241	<i>Courtoisina cyperoides</i> (Roxb.) Soják		Cyperaceae	Herb-Annual	
242	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore		Asteraceae	Herb-Annual	
243	<i>Crataeva magna</i> (Lour.) DC.	Neermathalam	Capparaceae	Tree	
244	<i>Crinum viviparum</i> (Lam.) R. Ansari & V.J. Nair		Amaryllidaceae	Herb-Annual	

	Name	Local Name	Family	Habit	IUCN Status
245	<i>Crinum viviparum</i> (Lam.) R.Ansari & V.J.Nair	Veluthapolathali	Amaryllidaceae	Herb-Perennial	
246	<i>Crotalaria evolvuloides</i> Wight ex Wight & Arn.	Kilukkichedi	Fabaceae	Herb-Perennial	
247	<i>Crotalaria laburnifolia</i> L.	Kilukilikki	Fabaceae	Shrub	
248	<i>Crotalaria nana</i> Burm.f.		Fabaceae	Herb-Perennial	
249	<i>Crotalaria pallida</i> Aiton	Kilukkichedi	Fabaceae	Shrub	
250	<i>Crotalaria quinquefolia</i> L.		Fabaceae	Herb-Perennial	
251	<i>Crotalaria retusa</i> L.	Kilukilikki	Fabaceae	Herb-Perennial	
252	<i>Croton bonplandianus</i> Baill.		Euphorbiaceae	Herb-Perennial	
253	<i>Croton caudatus</i> Geiseler		Euphorbiaceae	Tree	
254	<i>Croton hirtus</i> L'Herit.		Euphorbiaceae	Herb-Perennial	
255	<i>Cryptocoryne retrospiralis</i> (Roxb.) Kunth		Araceae	Herb-Perennial	
256	<i>Cryptocoryne sivadasanii</i> Bogner		Araceae	Herb-Annual	
257	<i>Cryptocoryne spiralis</i> (Retz.) Fisch. ex Wydler		Araceae	Herb-Annual	
258	<i>Cryptocoryne spiralis</i> (Retz.) Fisch. ex Wydler		Araceae	Herb-Perennial	
259	<i>Cryptolepis buchananii</i> Roem. & Schult.	Kattupaluvalli	Periplocaceae	Climber	
260	<i>Cucurbita pepo</i> L.	Mathanga	Cucurbitaceae	Climber	
261	<i>Curculigo orchioides</i> Gaertn.	Nilappana	Hypoxidaceae	Herb-Perennial	
262	<i>Curcuma aurantiaca</i> Zipp	Manjal	Zingiberaceae	Herb-Perennial	
263	<i>Curcuma longa</i> L.	Manjal	Zingiberaceae	Herb-Perennial	
264	<i>Cuscuta reflexa</i> Roxb.	Akashagarudakodi	Convolvulaceae	Climber	
265	<i>Cyanotis axillaris</i> (L.) D.Don ex Sweet		Commelinaceae	Herb-Annual	
266	<i>Cyanotis cristata</i> (L.) D.Don		Commelinaceae	Herb-Annual	
267	<i>Cyanotis papilionacea</i> (Burm. f.) Schult. f.		Commelinaceae	Herb-Annual	
268	<i>Cyanthillium cinereum</i> (L.) H.Rob.	Poovamkurunthal	Asteraceae	Herb-Annual	
269	<i>Cyathula prostrata</i> (L.) Blume	Cherukadaladi	Amaranthaceae	Herb-Annual	
270	<i>Cycas circinalis</i> L.	Eenth	Cycadaceae	Tree	
271	<i>Cyclea peltata</i> (Lam.) Hook. f. & Thoms.	Padakizhangu Padathali	Menispermaceae	Climber-Woody	
272	<i>Cymbopogon flexuosus</i> (Nees ex Steud.) W.Watson	Inchi pullu, Chukkunari pullu	Poaceae	Herb-Perennial	
273	<i>Cymbopogon travancorensis</i> Bor.	Kattuvovvapullu	Poaceae	Herb-Perennial	
274	<i>Cynodon dactylon</i> (L.) Pers.	Karuka, Karukapullu	Poaceae	Herb-Perennial	

	Name	Local Name	Family	Habit	IUCN Status
275	<i>Cyperus alopecuroides</i> Rottb.		Cyperaceae	Herb-Annual	
276	<i>Cyperus amabilis</i> Vahl		Cyperaceae	Herb-Annual	
277	<i>Cyperus bulbosus</i> Vahl		Cyperaceae	Herb-Annual	
278	<i>Cyperus cephalotes</i> Vahl		Cyperaceae	Herb-Annual	
279	<i>Cyperus compressus</i> L.,		Cyperaceae	Herb-Annual	
280	<i>Cyperus cyperinus</i> (Retz.) Sur.		Cyperaceae	Herb-Annual	
281	<i>Cyperus difformis</i> L.		Cyperaceae	Herb-Annual	
282	<i>Cyperus diffusus</i> Vahl		Cyperaceae	Herb-Annual	
283	<i>Cyperus digitatus</i> Roxb.		Cyperaceae	Herb-Annual	
284	<i>Cyperus distans</i> L.f.		Cyperaceae	Herb-Perennial	
285	<i>Cyperus haspan</i> L.		Cyperaceae	Herb-Perennial	
286	<i>Cyperus javanicus</i> Houtt.		Cyperaceae	Herb-Annual	
287	<i>Cyperus pilosus</i> Vahl		Cyperaceae	Herb-Annual	
288	<i>Cyperus platystylis</i> R. Br.		Cyperaceae	Herb-Annual	
289	<i>Cyperus procerus</i> Rottb.		Cyperaceae	Herb-Annual	
290	<i>Cyperus rotundus</i> L.	Karimuttan, Muthanga	Cyperaceae	Herb-Annual	
291	<i>Cyperus tenuispica</i> Steud		Cyperaceae	Herb-Annual	
292	<i>Dactyloctenium aegyptium</i> (L.) Willd.	Kavarapullu	Poaceae	Herb-Perennial	
293	<i>Dalbergia candenatensis</i> (Dennst.) Prain		Fabaceae	Climber	
294	<i>Dalbergia horrida</i> (Dennst.) Mabb.var. horrida; Ansari	Jadavalli	Fabaceae	Climber-Woody	
295	<i>Dalbergia latifolia</i> Roxb.	Kariveetti	Fabaceae	Tree	VU
296	<i>Dalbergia sissooides</i> Graham ex Wight & Arn	Eetti	Fabaceae	Tree	
297	<i>Datura stramonium</i> L.	Ummam	Solanaceae	Shrub	
298	<i>Delonix regia</i> (Boj. ex Hook.) Rafin.	Gulmohar	Fabaceae	Tree	
299	<i>Dendrocalamus strictus</i> (Roxb.) Nees	Illii, Mula	Poaceae	Tree	
300	<i>Dendrophthoe falcata</i> (L.f.) Ettingsh	Ithilkanni, Ithil	Loranthaceae	Herb-Perennial	
301	<i>Dentella repens</i> (L.) J. R. & G. Forst.	Cherumaneli	Rubiaceae	Herb-Annual	
302	<i>Derris scandens</i> (Roxb.) Benth.	Ponnamvalli	Fabaceae	Climber-Woody	
303	<i>Derris trifoliata</i> Lour.	Poonjali	Fabaceae	Climber-Woody	
304	<i>Desmodium gangeticum</i> (L.) DC.	Orila	Fabaceae	Herb-Perennial	
305	<i>Desmodium triflorum</i> (L.) DC.	Cherupulladi	Fabaceae	Herb-Perennial	
306	<i>Desmodium triquetrum</i> (L.) DC.		Fabaceae	Herb-Perennial	

	Name	Local Name	Family	Habit	IUCN Status
307	<i>Digitaria radicata</i> (Pers.) Miq.		Poaceae	Herb-Annual	
308	<i>Dillenia pentagyna</i> Roxb.	Malampunna	Dilliniaceae	Tree	
309	<i>Dimeria hohenackeri</i> Hochst. ex Miq.		Poaceae	Herb-Perennial	
310	<i>Dioscorea alata</i> L.	Kachil	Dioscoreaceae	Climber	
311	<i>Dioscorea bulbifera</i> L.	Kattukachil	Dioscoreaceae	Climber	
312	<i>Dioscorea pentaphylla</i> L.	Noorakkizhangu	Dioscoreaceae	Climber	
313	<i>Diplacrum caricinum</i> R. Br.		Cyperaceae	Herb-Annual	
314	<i>Diplocyclos palmatus</i> (L.) Jeffrey	Neyyunnikka	Cucurbitaceae	Climber	
315	<i>Dipteracanthus prostratus</i> (Poir.) Nees	Velipadakkam, Thuppalampotti	Acanthaceae	Herb-Perennial	
316	<i>Dolichandrone spathacea</i> (L.f.) K.Schum.		Bignoniaceae	Tree	
317	<i>Dopatrium junceum</i> (Roxb.) Buch.-Ham. ex Benth.		Scrophulariaceae	Herb-Annual	
318	<i>Drosera burmannii</i> Vahl		Droseraceae	Herb-Annual	
319	<i>Drosera indica</i> L.	Theppullu	Droseraceae	Herb-Annual	
320	<i>Drosera peltata</i> Smith	Azhukanni	Droseraceae	Herb-Annual	
321	<i>Echinochloa colona</i> (L.) Link,	Kavada	Poaceae	Herb-Perennial	
322	<i>Echinochloa crus-galli</i> (L.) P.Beauv.	Oothupullu, Kavadpullu	Poaceae	Herb-Perennial	
323	<i>Echinochloa stagnina</i> (Retz.) P.Beauv.		Poaceae	Herb-Perennial	
324	<i>Eclipta prostrata</i> (L.)	Kaithonni, Kanjunni	Asteraceae	Herb-Annual	
325	<i>Ehretia canarensis</i> (Clarke) Gamble	Chavandi	Boraginaceae	Tree	
326	<i>Eichhornia crassipes</i> (Mart.) Solms	Kulavazha	Pontederiaceae	Herb-Perennial	
327	<i>Elaeocarpus serratus</i> L.	Bhadraksham, Kara	Elaeocarpaceae	Tree	
328	<i>Elatostema acuminatum</i> (Poir.) Brongn.		Urticaceae	Herb-Perennial	
329	<i>Eleocharis acutangula</i> (Roxb.) Schult.		Cyperaceae	Herb-Perennial	
330	<i>Eleocharis dulcis</i> (Burm. f.) Trimen ex Hensch.	Neerchelli	Cyperaceae	Herb-Perennial	
331	<i>Eleocharis retroflexa</i> (Poir.) Urban ssp. chaetaria (Roem. & Schult.) Koyama.	Neerchelli	Cyperaceae	Herb-Perennial	
332	<i>Elephantopus scaber</i> L.	Anachuvadi	Asteraceae	Herb-Annual	
333	<i>Eleusine coracana</i> (L.) Gaertn.	Kora, Panjapullu	Poaceae	Herb-Perennial	
334	<i>Eleusine indica</i> (L.) Gaertn.		Poaceae	Herb-Annual	
335	<i>Emilia sonchifolia</i> (L.) DC.	Muyalchevian	Asteraceae	Herb-Annual	
336	<i>Eragrostis gangetica</i> (Roxb.) Steud.		Poaceae	Herb-Annual	
337	<i>Eragrostis japonica</i> (Thunb.) Trin.		Poaceae	Herb-Perennial	

	Name	Local Name	Family	Habit	IUCN Status
338	<i>Eragrostis nutans</i> (Retz.) Nees ex Steud.		Poaceae	Herb-Annual	
339	<i>Eragrostis pilosa</i> (L.) P. Beauv.		Poaceae	Herb-Annual	
340	<i>Eragrostis riparia</i> (Willd.) Nees		Poaceae	Herb-Annual	
341	<i>Eragrostis subsecunda</i> (Lam.) Four.		Poaceae	Herb-Annual	
342	<i>Eragrostis tenella</i> (L.) P. Beauv. ex Roem. & Schult. var. <i>tenella</i> ; Manilal & Sivar.		Poaceae	Herb-Annual	
343	<i>Eragrostis unioides</i> (Retz.) Nees ex Steud.	Karayampullu	Poaceae	Herb-Annual	
344	<i>Eranthemum capense</i> L.		Acanthaceae	Herb-Perennial	
345	<i>Eriocaulon cinereum</i> R.Br.,		Eriocaulaceae	Herb-Annual	
346	<i>Eriocaulon conicum</i> (Fyson) C.E.C. Fisch		Eriocaulaceae	Herb-Annual	
347	<i>Eriocaulon cuspidatum</i> Dalz.		Eriocaulaceae	Herb-Annual	
348	<i>Eriocaulon eurypleplon</i> Koernicke		Eriocaulaceae	Herb-Annual	
349	<i>Eriocaulon heterolepis</i> Steud.		Eriocaulaceae	Herb-Annual	
350	<i>Eriocaulon lanceolatum</i> Miq. ex Koernicke		Eriocaulaceae	Herb-Annual	
351	<i>Eriocaulon madayiparense</i>		Eriocaulaceae	Herb-Annual	
352	<i>Eriocaulon quinquangulare</i> L.		Eriocaulaceae	Herb-Annual	
353	<i>Eriocaulon setaceum</i> L.		Eriocaulaceae	Herb-Annual	
354	<i>Eriocaulon sexangulare</i> L.,		Eriocaulaceae	Herb-Annual	
355	<i>Eriocaulon sivarajanii</i> R. Ansari & N.P. Balakr.		Eriocaulaceae	Herb-Annual	
356	<i>Eriocaulon truncatum</i> Bunch.		Eriocaulaceae	Herb-Perennial	
357	<i>Eriocaulon xeranthemum</i> Mart.		Eriocaulaceae	Herb-Perennial	
358	<i>Eriochloa procera</i> (Retz.) C. E. Hubb.		Poaceae	Herb-Annual	
359	<i>Erycibe paniculata</i> Roxb.	Erumathali	Convolvulaceae	Climber	
360	<i>Erythrina fusca</i> Lour.		Fabaceae	Tree	
361	<i>Erythrina variegata</i> L.	Kalyana, Mulmurikku	Fabaceae	Tree	
362	<i>Euphorbia deccanensis</i> V.S.Raju		Euphorbiaceae	Herb-Perennial	
363	<i>Euphorbia heterophylla</i> L.		Euphorbiaceae	Herb-Annual	
364	<i>Euphorbia hirta</i> L.	Kuzhinagapala	Euphorbiaceae	Herb-Annual	
365	<i>Euphorbia indica</i> Lam		Euphorbiaceae	Herb-Perennial	
366	<i>Euphorbia pulcherrima</i> Willd. ex Klotzsch.	Christmas flower	Euphorbiaceae	Shrub	
367	<i>Euphorbia thymifolia</i> L.	Chitrapala, Nilampala	Euphorbiaceae	Herb-Annual	
368	<i>Evolvulus alsinoides</i> , var. <i>alsinoides</i> ; Hook. f.	Krishnakranti	Convolvulaceae	Herb-Perennial	

	Name	Local Name	Family	Habit	IUCN Status
369	<i>Evolvulus nummularius</i> (L.) L.	Vellakranthi	Convolvulaceae	Herb-Perennial	
370	<i>Excoecaria agallocha</i> L.	Kannampotti	Euphorbiaceae	Tree	
371	<i>Ficus arnottiana</i> (Miq.) Miq.	Kallal, Kallarayal	Moraceae	Tree	
372	<i>Ficus auriculata</i> Lour.	Atthi	Moraceae	Tree	
373	<i>Ficus benghalensis</i> L.	Peral, Vadavriksham	Moraceae	Tree	
374	<i>Ficus exasperata</i> Vahl	Therakam	Moraceae	Tree	
375	<i>Ficus heterophylla</i> L.f.	Vallitherakam	Moraceae	Shrub	
376	<i>Ficus hispida</i> L.f.	Erumanakku, Kattathi,	Moraceae	Tree	
377	<i>Ficus religiosa</i> L.	Arayal	Moraceae	Tree	
378	<i>Ficus tsjahela</i> Burm.f.	Chela, Kara	Moraceae	Tree	
379	<i>Fimbristylis acuminata</i> Vahl		Cyperaceae	Herb-Annual	
380	<i>Fimbristylis aestivalis</i> Vahl		Cyperaceae	Herb-Annual	
381	<i>Fimbristylis albovidis</i> Clarke		Cyperaceae	Herb-Annual	
382	<i>Fimbristylis argentea</i> (Rottb.) Vahl		Cyperaceae	Herb-Annual	
383	<i>Fimbristylis cinnamometorum</i> (Vahl) Kunth,		Cyperaceae	Herb-Annual	
384	<i>Fimbristylis cymosa</i> R.Br.		Cyperaceae	Herb-Annual	
385	<i>Fimbristylis dichotoma</i> (L.) Vahl		Cyperaceae	Herb-Annual	
386	<i>Fimbristylis dipsacea</i> (Rottb.) Clarke		Cyperaceae	Herb-Annual	
387	<i>Fimbristylis eragrostis</i> (Nees & Meyen) Hance		Cyperaceae	Herb-Annual	
388	<i>Fimbristylis ferruginea</i> (L.) Vahl		Cyperaceae	Herb-Annual	
389	<i>Fimbristylis ovata</i> (Burn. f.) Kern		Cyperaceae	Herb-Annual	
390	<i>Fimbristylis polytrichoides</i> (Retz.) R.Br.		Cyperaceae	Herb-Annual	
391	<i>Fimbristylis pubisquama</i> Kern		Cyperaceae	Herb-Annual	
392	<i>Fimbristylis quinquangularis</i> (Vahl) Kunth		Cyperaceae	Herb-Annual	
393	<i>Fimbristylis schoenoides</i> (Retz.) Vahl		Cyperaceae	Herb-Annual	
394	<i>Fimbristylis tetragona</i> R. Br.		Cyperaceae	Herb-Annual	
395	<i>Fioria vitifolia</i> (L.) Mattei	Kattuvelluram	Malvaceae	Shrub	
396	<i>Flacourtia indica</i> (Burm. f.) Merr.	Oushadakkara	Flacourtiaceae	Tree	
397	<i>Flemingia strobilifera</i> (L.) R. Br. ex Ait.f	Kumalu	Fabaceae	Shrub	
398	<i>Floscopa scandens</i> Lour.		Commelinaceae	Herb-Perennial	
399	<i>Flueggea virosa</i> (Roxb. ex Willd.) Voigt	Perimklavu, Vellapoolam	Euphorbiaceae	Shrub	
400	<i>Fuirena ciliaris</i> (L.) Roxb.		Cyperaceae	Herb-Perennial	

	Name	Local Name	Family	Habit	IUCN Status
401	<i>Fuirena umbellata</i> Rottb.		Cyperaceae	Herb-Annual	
402	<i>Fuirena uncinata</i> (Willd.) Kunth		Cyperaceae	Herb-Annual	
403	<i>Garcinia gummi-gutta</i> (L.) Roxb.	Kudampuli, Perumpuli	Clusiaceae	Tree	
404	<i>Geissaspis cristata</i> Wight & Arn.,		Fabaceae	Herb-Annual	
405	<i>Geissaspis tenella</i> Benth., var. <i>tenella</i> Hook. f.,		Fabaceae	Herb-Annual	
406	<i>Geophila repens</i> (L.) I.M.Johnst.	Karimuthil	Rubiaceae	Herb-Annual	
407	<i>Glinus oppositifolius</i> (L.) A. DC.	Kaippujeerakam	Molluginaceae	Herb-Annual	
408	<i>Gliricidia sepium</i> (Jacq.) Kunth ex Walp.		Fabaceae	Shrub	
409	<i>Gliricidia sepium</i> (Jacq.) Walp.	Seema-konna	Fabaceae	Tree	
410	<i>Globba sessiliflora</i> Sims	Kolachanna	Zingiberaceae	Herb-Perennial	
411	<i>Gloriosa superba</i> L.	Menthonni	Liliaceae	Climber	
412	<i>Glycosmis pentaphylla</i> (Retz.) DC.	Panal, Kurumpanal,	Rutaceae	Shrub	
413	<i>Gomphrena celosioides</i> Mart.	Neervadamalli	Amaranthaceae	Herb-Perennial	
414	<i>Grangea maderaspatana</i> (L.) Poir.	Nelampala	Asteraceae	Herb-Perennial	
415	<i>Grewia nervosa</i> (Lour.) Panigrahi	Cherikkotta	Tiliaceae	Shrub	
416	<i>Hedyotis cyanantha</i> Kurz, J.		Rubiaceae	Herb-Perennial	
417	<i>Helicteres isora</i> L.	Edampiri-valampiri	Sterculiaceae	Shrub	
418	<i>Heliotropium indicum</i> L.	Thelkkada, Napacha	Boraginaceae	Herb-Perennial	
419	<i>Heliotropium keralense</i> Sivar. & Manilal,	Thelkkada	Boraginaceae	Herb-Perennial	
420	<i>Heliotropium marifolium</i> Retz.,		Boraginaceae	Herb-Perennial	
421	<i>Hemidesmus indicus</i> (L.) R.Br. ex Schult.	Nannari, Naruneendi	Asclepiadaceae	climber	
422	<i>Hevea brasiliensis</i> (Willd. ex A.Juss.) Müll.Arg.	Rubber	Euphorbiaceae	Tree	
423	<i>Hewittia malabarica</i> (L.) Suresh	Ohanamvalli	Convolvulaceae	Climber	
424	<i>Hibiscus hispidissimus</i> Griff.	Mattipuli, Uppanacham	Malvaceae	Shrub	
425	<i>Hibiscus surattensis</i> L.	Pulichai, Panchakam	Malvaceae	Herb-Perennial	
426	<i>Hiptage benghalensis</i> (L.) Kurz	Njarambodal	Malpighiaceae	Climber-Woody	
427	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall. ex G. Don	Kudakapala	Apocynaceae	Tree	
428	<i>Holigarna amottiana</i> Hook.f.	Cheru	Anacardiaceae	Tree	
429	<i>Holoptelea integrifolia</i> (Roxb.) Planch.	Aaval	Ulmaceae	Tree	
430	<i>Hopea parviflora</i> Bedd.	Irupakam	Dipterocarpaceae	Tree	
431	<i>Hopea ponga</i> (Dennst.) Mabb.	Kambakam, Naikambakam	Dipterocarpaceae	Tree	EN

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432	<i>Hoppea fastigiata</i> (Griseb.) Clarke		Gentianaceae	Herb-Perennial	
433	<i>Hugonia mystax</i> L.	Modirakkanni	Linaceae	Climber	
434	<i>Hybanthus enneaspermus</i> (L.) F.v. Muell.	Orithalthamara	Violaceae	Herb-Annual	
435	<i>Hydnocarpus pentandrus</i> (Buch.-Ham.) Oken	Marotti	Flacourtiaceae	Tree	VU
436	<i>Hydrilla verticillata</i> (L.f.) Royle		Hydrocharitaceae	Herb-Perennial	
437	<i>Hydrocera triflora</i> (L.) Wight & Arn.		Balsaminaceae	Herb-Annual	
438	<i>Hydrocotyle javanica</i> Thunb.,	Vella-vaite	Apiaceae	Herb-Annual	
439	<i>Hydrolea zeylanica</i> (L.) Vahl	Velloi	Hydrophyllaceae	Herb-Perennial	
440	<i>Hydrophylax maritima</i> L.f.		Rubiaceae	Herb-Annual	
441	<i>Hygrophila ringens</i> (L.) Steud.		Acanthaceae	Herb-Perennial	
442	<i>Hygrophila schulli</i> (Buch.-Ham.) M. R. & S. M. Almeida	Neermulli, Vayalchulli	Acanthaceae	Herb-Perennial	
443	<i>Hygrophila triflora</i> (Roxb.) Fosb. & Sacht		Acanthaceae	Herb-Annual	
444	<i>Hygroryza aristata</i> (Retz.) Nees ex Wight & Arn.	Varinellu	Poaceae	Herb-Annual	
445	<i>Hyptis suaveolens</i> (L.) Poit.			Shrub	
446	<i>Ichnocarpus frutescens</i> (L.) R. Br.	Palvalli	Apocynaceae	Climber	
447	<i>Impatiens balsamina</i> L.	Kashithumpa	Balsaminaceae	Herb-Perennial	
448	<i>Imperata cylindrica</i> (L.) Raeusch.	Vidulam , Darbha	Poaceae	Herb-Annual	
449	<i>Indigofera tinctoria</i> L.	Neelayamari	Fabaceae	Herb-Perennial	
450	<i>Indigofera trifoliata</i> L.		Fabaceae	Herb-Perennial	
451	<i>Ipomoea alba</i> L.	Chandrakanthi	Convolvulaceae	Climber	
452	<i>Ipomoea aquatica</i> Forssk.	Kozhuppa	Convolvulaceae	Herb-Perennial	
453	<i>Ipomoea cairica</i> (L.) Sweet	Railway creeper	Convolvulaceae	Climber-Woody	
454	<i>Ipomoea campanulata</i> L.		Convolvulaceae	Climber	
455	<i>Ipomoea carnea</i> Jack. ssp. fistulosa	Neyveli katta	Convolvulaceae	Shrub	
456	<i>Ipomoea hederifolia</i> L.	Theeporimulla	Convolvulaceae	Climber	
457	<i>Ipomoea mauritiana</i> Jacq.	Palmuthakk	Convolvulaceae	Climber	
458	<i>Ipomoea nil</i> (L.) Roth	Thaliyari	Convolvulaceae	Climber	
459	<i>Ipomoea pes-caprae</i> (L.) R.Br.	Adambuvalli	Convolvulaceae	Climber	
460	<i>Ipomoea pes-tigridis</i> L.	Pulichuvadi	Convolvulaceae	Climber	
461	<i>Isachne miliacea</i> Roth.		Poaceae	Herb-Perennial	
462	<i>Ischaemum barbatum</i> Retz.		Poaceae	Herb-Annual	
463	<i>Ischaemum hirtum</i> Hack.		Poaceae	Herb-Annual	

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464	<i>Ischaemum indicum</i> (Houtt.) Merr.	Chenkodipullu	Poaceae	Herb-Perennial	
465	<i>Ischaemum mangaluricum</i> (Hack.) Stapf ex C.E.C. Fisch.		Poaceae	Herb-Annual	
466	<i>Ischaemum molle</i> Hook.f.		Poaceae	Herb-Annual	
467	<i>Ischaemum muticum</i> L.		Poaceae	Herb-Annual	
468	<i>Ischaemum rugosum</i> Salisb.		Poaceae	Herb-Annual	
469	<i>Ischaemum timorense</i> Kunth		Poaceae	Herb-Perennial	
470	<i>Ixora brachiata</i> Roxb.	Marachethi	Rubiaceae	Shrub	
471	<i>Ixora coccinea</i> L.	Chethi	Rubiaceae	Shrub	
472	<i>Jasminum angustifolium</i> (L.) Willd.	Kattumulla	Oleaceae	Climber-Woody	
473	<i>Jasminum azoricum</i> Burm. f.	Kattumulla	Oleaceae	Climber-Woody	
474	<i>Jasminum multiflorum</i> (Burm.f.) Andrews	Kashurimulla, Kudamulla	Oleaceae	Climber-Woody	
475	<i>Jatropha curcas</i> L.	Kadalavanakku, Kammatti, Nanchupathal	Euphorbiaceae	Shrub	
476	<i>Jatropha gossypifolia</i> L.	Chuvannakadalavanakku	Euphorbiaceae	Shrub	
477	<i>Justicia adhatoda</i> L.	Adalotakam	Acanthaceae	Shrub	
478	<i>Justicia diffusa</i> Willd. var. <i>diffusa</i> ; Hook. f.	Cherupulladi	Acanthaceae	Herb-Annual	
479	<i>Justicia ekakusuma</i> Pradeep & Sivar.		Acanthaceae	Herb-Annual	
480	<i>Justicia gendarussa</i> Burm. f.	Vishamooli	Acanthaceae	Shrub	
481	<i>Kammetia caryophyllata</i> (Roxb.) Nicolson & Suresh	Narumarathivu	Apocynaceae	Climber	
482	<i>Kandelia candel</i> (L.) Druce	Cherukandal	Rhizophoraceae	Shrub	
483	<i>Kingiodendron pinnatum</i> (Roxb. ex DC.) Harms	Kulavu, Churali	FABACEAE	Tree	EN
484	<i>Kyllinga brevifolia</i> Rottb.		Cyperaceae	Herb-Annual	
485	<i>Kyllinga bulbosa</i> P. Beauv.	Korapullu	Cyperaceae	Herb-Annual	
486	<i>Lagenandra meeboldii</i> (Engl.) C.E.C.Fisch.		Araceae	Herb-Perennial	
487	<i>Lagenandra toxicaria</i> Dalzell	Andavazha, Neerkizhangu	Araceae	Herb-Perennial	
488	<i>Lagerstroemia speciosa</i> (L.) Pers.	Manimaruthu, Poomaruthu	Lythraceae	Tree	
489	<i>Lannea coromandelica</i> (Houtt.) Merr	Uthi, Kalayam, Karasu, Karayam, Odiamaram	Anacardiaceae	Tree	
490	<i>Lantana camara</i> L.	Aripoochedi, Edamakki, Poochedi, Konda	Verbenaceae	Shrub	
491	<i>Laportea interrupta</i> (L.) Chew	Kodithuva	Urticaceae	Herb-Perennial	
492	<i>Lawsonia inermis</i> L.	Mylandhi	Lythraceae	Shrub	

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493	<i>Leea indica</i> (Burm.f.) Merr.	Choriantthali, Njallu	Vitaceae	Shrub	
494	<i>Lemna perpusilla</i> Torrey	Payal	Lemnaceae	Herb-Perennial	
495	<i>Lepidagathis keralensis</i> Madhu. & Singh	Paramullu	Acanthaceae	Herb-Perennial	
496	<i>Leucas aspera</i> (Willd.) Link	Thumpa	Lamiaceae	Herb-Annual	
497	<i>Leucas biflora</i> (Vahl) R. Br.		Lamiaceae	Herb-Annual	
498	<i>Limnocharis flava</i> (L.) Buch.	Nagapola	Alismataceae	Herb-Perennial	
499	<i>Limnophila aquatica</i> (Roxb.) Alston		Scrophulariaceae	Herb-Perennial	
500	<i>Limnophila aromatica</i> (Lam.) Merr.	Manganari	Scrophulariaceae	Herb-Perennial	
501	<i>Limnophila heterophylla</i> (Roxb.) Benth.	Manganari	Scrophulariaceae	Herb-Annual	
502	<i>Limnophila indica</i> (L.) Druce	Manganari	Scrophulariaceae	Herb-Perennial	
503	<i>Limnophila repens</i> (Benth.) Benth.	Manganari	Scrophulariaceae	Herb-Perennial	
504	<i>Limnophylla chinensis</i>	Manganari	Scrophulariaceae	Herb-Annual	
505	<i>Limnophyton obtusifolium</i> (L.) Miq.	culi-tamara	Alismataceae	Herb-Annual	
506	<i>Limnopoa meeboldii</i> (C.E.C. Fisch.) C.E.Hubb.		Poaceae	Herb-Annual	EN
507	<i>Lindernia anagallis</i> (Burm. f.) Pennell		Scrophulariaceae	Herb-Perennial	
508	<i>Lindernia angustifolia</i>		Scrophulariaceae	Herb-Annual	
509	<i>Lindernia antipoda</i> (L.) Alston		Scrophulariaceae	Herb-Perennial	
510	<i>Lindernia caespitosa</i> (Blume) Panigrahi		Scrophulariaceae	Herb-Perennial	
511	<i>Lindernia ciliata</i> (Colsm.) Pennell		Scrophulariaceae	Herb-Perennial	
512	<i>Lindernia crustacea</i> (L.) F.v. Muell.		Scrophulariaceae	Herb-Annual	
513	<i>Lindernia estaminodosa</i> (Blatt. & Hallb.) Mukerjee,		Scrophulariaceae	Herb-Annual	
514	<i>Lindernia hyssopioides</i> (L.) Haines		Scrophulariaceae	Herb-Perennial	
515	<i>Lindernia manilaliana</i> Sivar.		Scrophulariaceae	Herb-Annual	
516	<i>Lindernia oppositifolia</i> (Retz.) Mukerjee		Scrophulariaceae	Herb-Perennial	
517	<i>Lindernia parviflora</i> (Roxb.) Haines		Scrophulariaceae	Herb-Perennial	
518	<i>Lindernia rotundifolia</i> (L.) Mukerjee		Scrophulariaceae	Herb-Perennial	
519	<i>Lindernia tenuifolia</i> (Colsm.) Alston		Scrophulariaceae	Herb-Perennial	
520	<i>Lindernia viscosa</i> (Hornem.) Merr.		Scrophulariaceae	Herb-Annual	
521	<i>Lipocarpa gracilis</i> (Rich. ex Pers.) Nees		Cyperaceae	Herb-Perennial	
522	<i>Lipocarpa squarrosa</i> (L.) Goetgh.		Cyperaceae	Herb-Annual	
523	<i>Lobelia alsinoides</i> Lam.	Kakkapoo	Lobeliaceae	Herb-Perennial	
524	<i>Lobelia heyneana</i> Schult.		Lobeliaceae	Herb-Perennial	

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525	<i>Ludwigia adscendens</i> (L.) H. Hara		Onagraceae	Herb-Perennial	
526	<i>Ludwigia hyssopifolia</i> (G. Don) Exell	Neerkarayambu	Onagraceae	Herb-Perennial	
527	<i>Ludwigia octovalvis</i> (Jacq.) Raven ssp. sessiliflora (Michx.) Raven	Kattukarayambu	Onagraceae	Herb-Annual	
528	<i>Ludwigia perennis</i> L.	Neerkarayambu	Onagraceae	Herb-Perennial	
529	<i>Ludwigia peruviana</i> (L.) H. Hara		Onagraceae	Herb-Perennial	
530	<i>Ludwigia prostrata</i> Roxb.		Onagraceae	Herb-Perennial	
531	<i>Luffa acutangula</i> (L.) Roxb.	Peechanga	Cucurbitaceae	Climber	
532	<i>Luffa cylindrica</i> (L.) Roem.	Kattupeecheil	Cucurbitaceae	Climber	
533	<i>Lumnitzera racemosa</i> Willd.	Kadakandal	Combretaceae	Shrub	
534	<i>Lygodium Flexuosum</i> (L.) Sw.		Lygodiaceae	Climber	
535	<i>Macaranga peltata</i> (Roxb.) Müll.Arg.	Vatta, Thodukanni	Euphorbiaceae	Tree	
536	<i>Macrosolen parasiticus</i> (L.) Danser	Chempoo	Loranthaceae	shrub-	
537	<i>Mallotus atrovirens</i> Muell.-Arg.		Euphorbiaceae	Tree	VU
538	<i>Mallotus philippensis</i> (Lam.) Müll.Arg.	Chenkolli, Kurangumanjal,	Euphorbiaceae	Tree	
539	<i>Mallotus tetracoccus</i> (Roxb.) Kurz	Adukanni, Porivatta	Euphorbiaceae	Tree	
540	<i>Mangifera indica</i> L.	Mavu	Anacardiaceae	Tree	
541	<i>Manihot esculenta</i> Crantz	Maracheeni, Kappa	Euphorbiaceae	Shrub	
542	<i>Marsilea minuta</i>		Marsileaceae	Herb-Annual	
543	<i>Martynia annua</i> L.	<i>Kakka-chundu</i>	Pedaliaceae	Herb-Perennial	
544	<i>Mecardonia procumbens</i> (Mill.) Small		Scrophulariaceae	Herb-Perennial	
545	<i>Melastoma malabathricum</i> L.	Athirani, Kadali, Kalampotta, Thodukkara	Melastomataceae	Shrub	
546	<i>Melicope lunu-ankenda</i> (Gaertn.) Hartley	Kanala	Rutaceae	Tree	
547	<i>Melochia corchorifolia</i> L.	Cheruvuoram	Sterculiaceae	Herb-Annual	
548	<i>Memecylon randerianum</i> SM & MR Almeida	Kashavu	Melastomataceae	Shrub	
549	<i>Memecylon umbellatum</i> Burm.f.	Anakombi, Kasavu	Melastomataceae	Shrub	
550	<i>Merremia umbellata</i> (L.) Hall.	Koaravally	Convolvulaceae	Climber	
551	<i>Merremia vitifolia</i> (Burm.f.) Hallier f.	Manja-kolambi	Convolvulaceae	Climber	
552	<i>Microcarpaea minima</i> (Koenig ex Retz.) Merr.		Scrophulariaceae	Herb-Annual	
553	<i>Micrococca mercurialis</i> (L.) Benth.	Kunukku-thooki	Euphorbiaceae	Herb-Perennial	
554	<i>Microstachys chamaelea</i> (L.) Muell.-Arg.	Kodiyavannakku	Euphorbiaceae	Herb-Perennial	

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555	<i>Mikania micrantha</i> Kunth	Vayara	Asteraceae	climber	
556	<i>Milium tomentosum</i> (Roxb.) Finet & Gagnep.	Kaithamavu Thavidi	Annonaceae	Tree	
557	<i>Millingtonia hortensis</i> L.f., Suppl.	Akasaveppu	Bignoniaceae	Tree	
558	<i>Mimosa diplotricha</i> C.Wright ex Sauvalle	Anathottavadi	Fabaceae	Climber	
559	<i>Mimosa pudica</i> L.	Thottavadi	Fabaceae	Herb-Perennial	
560	<i>Mimusops elengi</i> L.	Elanji	Sapotaceae	Tree	
561	<i>Mitracarpus hirtus</i> (L.) DC.	Thaval	Rubiaceae	Herb-Perennial	
562	<i>Mollugo pentaphylla</i> L.	Parpadakapullu	Molluginaceae	Herb-Perennial	
563	<i>Mollugo stricta</i> L.		Molluginaceae	Herb-Annual	
564	<i>Momordica charantia</i> L.	Paval, Pavaykka	Cucurbitaceae	Climber	
565	<i>Momordica dioica</i> Roxb. ex Willd	Kattupaval	Cucurbitaceae	Climber	
566	<i>Monochoria vaginalis</i> (Burm. f.) Presl.	Kakkapola	Pontederiaceae	Herb-Perennial	
567	<i>Morinda citrifolia</i> L.	Cherumanjanathi	Rubiaceae	Tree	
568	<i>Mucuna pruriens</i> (L.) DC.	Naikuranam	Fabaceae	Climber	
569	<i>Mukia maderaspatana</i> (L.) M.Roem.	Mukkapeeram	Cucurbitaceae	Climber	
570	<i>Muntingia calabura</i> L.	Panchaarappazham	Elaeocarpaceae	Tree	
571	<i>Murdannia dimorpha</i> (Dalz.) Brueck.		Commelinaceae	Herb-Annual	
572	<i>Murdannia pauciflora</i> (Wight) Brueck.		Commelinaceae	Herb-Annual	
573	<i>Murdannia vaginata</i> (L.) Brueck.		Commelinaceae	Herb-Annual	
574	<i>Musa paradisiaca</i> L.		Musaceae	Herb-Perennial	
575	<i>Mussaenda frondosa</i> L.	Parathole, Vellila	Rubiaceae	Shrub	
576	<i>Myristica fragrans</i> Houtt.	Jaathi	Myristicaceae	Tree	
577	<i>Myxopyrum smilacifolium</i> (Wall.) Blume	Chathuramulla	Oleaceae	Climber-Woody	
578	<i>Najas graminea</i> Del		Najadaceae	Herb-Perennial	
579	<i>Naravelia zeylanica</i> (L.) DC.	Vathamkodi	Ranunculaceae	Climber	
580	<i>Naregamia alata</i> Wight & Arn.	Nilanaragam	Meliaceae	Herb-Annual	
581	<i>Neanotis rheedei</i> (Wall. ex Wight & Arn.) Lewis,		Rubiaceae	Herb-Annual	
582	<i>Nelumbo nucifera</i> Gaertn.	Thamara	Nelumbonaceae	Herb-Perennial	
583	<i>Neolamarckia cadamba</i> (Roxb.) Bosser	Aattuthekku, Kadambu	Rubiaceae	Tree	
584	<i>Nerium oleander</i> L.	Arali	Apocynaceae	Shrub	
585	<i>Nymphaea caerulea</i> Savi	Neela-ambel	Nymphaeaceae	Herb-Perennial	
586	<i>Nymphaea malabarica</i> Poir	Sitambel	Nymphaeaceae	Herb-Perennial	
587	<i>Nymphaea nouchali</i> Burm.f	Poothali, Vellambal	Nymphaeaceae	Herb-Perennial	

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588	<i>Nymphaea pubescens</i> Willd.	Neerambal, Periambal	Nymphaeaceae	Herb-Perennial	
589	<i>Nymphaea rubra</i> Roxb. ex Salisb.	Chuvanna ambal	Nymphaeaceae	Herb-Perennial	
590	<i>Nymphoides hydrophylla</i> (Lour.) O. Ktze.	Neythelambal	Menyanthaceae	Herb-Perennial	
591	<i>Nymphoides indica</i> (L.) Kuntze	Chinnambal, Panchi	Menyanthaceae	Herb-Perennial	
592	<i>Nymphoides krishnakesara</i> Joseph & Sivar.		Menyanthaceae	Herb-Annual	
593	<i>Ochlandra travancorica</i> (Bedd.) Gamble	Eetta, Karetta, Oda	Poaceae	Shrub	
594	<i>Ocimum americanum</i> L.	Kattuthulasi	Lamiaceae	Herb-Perennial	
595	<i>Ocimum tenuiflorum</i> L.	Thulasi	Lamiaceae	Herb-Perennial	
596	<i>Oldenlandia auricularia</i> (L.) K. Schum.	Erachiketti	Rubiaceae	Herb-Annual	
597	<i>Oldenlandia corymbosa</i> L.	Parpadakapullu,	Rubiaceae	Herb-Annual	
598	<i>Oldenlandia diffusa</i> (Willd.) Roxb.	Parpadakapullu	Rubiaceae	Herb-Annual	
599	<i>Oldenlandia trinervia</i> Retz.		Rubiaceae	Herb-Annual	
600	<i>Olea dioica</i> Roxb.	Edala, Vayila	Oleaceae	Tree	
601	<i>Oryza rufipogon</i> Griff.		Poaceae	Herb-Perennial	
602	<i>Oryza sativa</i> L.	Nellu	Poaceae	Herb-Annual	
603	<i>Osbeckia muralis</i> Naud.		Melastomataceae	Herb-Perennial	
604	<i>Ottelia alismoides</i> (L.) Pers.		Hydrocharitaceae	Herb-Perennial	
605	<i>Ottochloa nodosa</i> (Kunth) Dandy		Poaceae	Herb-Perennial	
606	<i>Oxalis corniculata</i> L.	Puliyarila	Oxalidaceae	Herb-Annual	
607	<i>Pajanelia longifolia</i> (Willd.) K. Schum.	Payyazhantha	Bignoniaceae	Tree	
608	<i>Pandanus kaida</i> Kurz	Kaitha	Pandanaceae	Shrub	
609	<i>Pandanus odorifer</i> (Forssk.) Kuntze	Pookaitha, Thazhampoo	Pandanaceae	Shrub	
610	<i>Panicum paludosum</i> Roxb.		Poaceae	Herb-Perennial	
611	<i>Panicum repens</i> L.		Poaceae	Herb-Perennial	
612	<i>Parsonia inodora</i> (Lour.) M. R. & S. M. Almeida,	Peenarivalli	Apocyanaceae	Climber	
613	<i>Parthenium hysterophorus</i> L.	Congresspacha	Asteraceae	Herb-Perennial	
614	<i>Paspalidium flavidum</i> (Retz.) A. Camus	Varakapullu	Poaceae	Herb-Perennial	
615	<i>Paspalum conjugatum</i> P.J.Bergius		Poaceae	Herb-Perennial	
616	<i>Paspalum distichum</i> L.		Poaceae	Herb-Perennial	
617	<i>Paspalum scrobiculatum</i> L.	Varagu Kattarakku	Poaceae	Herb-Perennial	
618	<i>Passiflora edulis</i> Sims	Passion fruit	Passifloraceae	Climber-Woody	
619	<i>Passiflora foetida</i> L.	Chadayan, Poodapazham	Passifloraceae	Climber	

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620	<i>Pedaliium murex</i> L.	Kattunjerinjil	Pedaliaceae	Herb-Perennial	
621	<i>Peltophorum pterocarpum</i> (DC.) Backer ex Heyne	Charakonna	Fabaceae	Tree	
622	<i>Pennisetum purpureum</i> Schum.	Elephant grass	Poaceae	Herb-Perennial	
623	<i>Pentanema indicum</i> (L.) Ling	Kammalchedi	Asteraceae	Herb-Annual	
624	<i>Peperomia pellucida</i> (L.) Kunth	Mashipacha	Piperaceae	Herb-Annual	
625	<i>Perotis indica</i> (L.) O. Ktze.		Poaceae	Herb-Annual	
626	<i>Persicaria barbata</i> (L.) H.Hara	Veluthamuthalamookku	Polygonaceae	Herb-Perennial	
627	<i>Persicaria chinensis</i> (L.) H. Gross	Thiruthanni	Polygonaceae	Herb-Perennial	
628	<i>Persicaria glabra</i> (Willd.) M.Gómez	Kozhivalan	Polygonaceae	Herb-Perennial	
629	<i>Persicaria hydropiper</i> (L.) Spach.		Polygonaceae	Herb-Perennial	
630	<i>Phragmites karka</i> (Retz.) Trin. ex Steud.	Vezhamkole Chora pullu	Poaceae	Herb-Perennial	
631	<i>Phyla nodiflora</i> (L.) Greene	Neerthipali	Verbenaceae	Herb-Annual	
632	<i>Phyllanthus amarus</i> Schumach. & Thonn.	Keezharnelli	Euphorbiaceae	Herb-Annual	
633	<i>Phyllanthus emblica</i> L.	Nelli	Euphorbiaceae	Tree	
634	<i>Phyllanthus reticulatus</i> Poir.		Euphorbiaceae	shrub	
635	<i>Phyllanthus urinaria</i> L.	Chuvannakeezharnelli	Euphorbiaceae	Herb-Annual	
636	<i>Physalis angulata</i> L.	Njottanjodian	Solanaceae	Herb-Perennial	
637	<i>Pilea microphylla</i> (L.) Liebm.	Rockweed	Urticaceae	Herb-Annual	
638	<i>Piper longum</i> L.	Thippali	Piperaceae	Climber	
639	<i>Piper nigrum</i> L.	Kurumulak	Piperaceae	Climber	
640	<i>Pistia stratiotes</i> L.	Akasathamara	Araceae	Herb-Perennial	
641	<i>Plumeria alba</i> L.	Seemayalari	Apocynaceae	Tree	
642	<i>Pogostemon deccanensis</i> (Panigrahi) Press		Lamiaceae	Herb-Perennial	
643	<i>Pogostemon paniculatus</i> (Willd.) Benth.		Lamiaceae	Herb-Perennial	
644	<i>Polyalthia longifolia</i> (Sonner.) Thw.	Aranamaram	Annonaceae	Tree	
645	<i>Polycarpaea corymbosa</i> (L.) Lam.	Achaaramkolli	Caryophyllaceae	Herb-Annual	
646	<i>Polycarpon prostratum</i> (Forssk.) Asch. & Schweinf.		Caryophyllaceae	Herb-Annual	
647	<i>Pongamia pinnata</i> (L.) Pierre	Pungu, Ungu	Fabaceae	Tree	
648	<i>Pothos scandens</i> L.		Araceae	Climber	
649	<i>Pouzolzia zeylanica</i> (L.) Bennett	Kallurukki	Urticaceae	Herb-Annual	
650	<i>Premna serratifolia</i> L.	Munja	Verbenaceae	Shrub	
651	<i>Psidium guajava</i> L.	Pera	Myrtaceae	Tree	

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652	<i>Pteridium aquilinum</i> (L.) Kuhn	Thavi	Dennstaedtiaceae	Herb-Perennial	
653	<i>Pterocarpus marsupium</i> Roxb.	Venga	Fabaceae	Tree	
654	<i>Pueraria phaseoloids</i> (Roxb.) Benth.	Thotta-payar	Fabaceae	Climber	
655	<i>Pycreus flavescens</i> (L.) Rchb.f.		Cyperaceae	Herb-Annual	
656	<i>Pycreus flavidus</i> (Retz.) Koyama		Cyperaceae	Herb-Annual	
657	<i>Pycreus macrostachyos</i> (Lam.) Raynal		Cyperaceae	Herb-Annual	
658	<i>Pycreus malabaricus</i> Clarke,		Cyperaceae	Herb-Annual	
659	<i>Pycreus polystachyos</i> (Rottb.) P. Beauv.		Cyperaceae	Herb-Annual	
660	<i>Pycreus polystachyos</i> (Rottb.) P. Beauv. var. <i>polystachyos</i> Hook. f.		Cyperaceae	Herb-Annual	
661	<i>Pycreus pumilus</i> (L.) Nees		Cyperaceae	Herb-Annual	
662	<i>Pycreus puncticulatus</i> (Vahl) Nees		Cyperaceae	Herb-Annual	
663	<i>Pycreus sanguinolentus</i> (Vahl) Nees ex Clarke		Cyperaceae	Herb-Annual	
664	<i>Pycreus stramineus</i> Clarke		Cyperaceae	Herb-Annual	
665	<i>Quassia indica</i> (Gaertn.) Nooteb.	Karinjotta	Simaroubaceae	Tree	
666	<i>Quisqualis indica</i> L.	Kulamarijni	Combretaceae	Climber-Woody	
667	<i>Racosperma auriculiforme</i> (Benth.) Pedley	Akasia	Fabaceae	Tree	
668	<i>Racosperma mangium</i> (Willd.) Pedley	Manchiam	Fabaceae	Tree	
669	<i>Rauvolfia serpentina</i> (L.) Benth. ex Kurz	Sarpagandhi	Apocynaceae	Herb-Perennial	
670	<i>Rauvolfia tetraphylla</i> L.	Pampukolli	Apocynaceae	Shrub	
671	<i>Remirea maritima</i> Aubl.		Cyperaceae	Herb-Annual	
672	<i>Rhamphicarpa longiflora</i> (Arn.) Benth.	Aarumanippoovu	Scrophulariaceae	Herb-Annual	
673	<i>Rhinacanthus nasutus</i> (L.) Kurz	Puzhukkolli	Acanthaceae	Herb-Perennial	
674	<i>Rhizophora apiculata</i> Blume	Kaya-kandel	Rhizophoraceae	Tree	
675	<i>Rhizophora mucronata</i> Poir.	Panachikandal	Rhizophoraceae	Shrub	
676	<i>Rhynchospora corymbosa</i> (L.) Brit.		Cyperaceae	Herb-Annual	
677	<i>Ricinus communis</i> L.	Aavanakku, Erandam	Euphorbiaceae	Shrub	
678	<i>Rivina humilis</i> L.	Rakthanelli	Phytolacaceae	Herb-Perennial	
679	<i>Rorippa indica</i> (L.) Hiern	Kattukaduk	Brassicaceae	Herb-Annual	
680	<i>Rotala densiflora</i> (Roth ex Roem. & Schult.) Koehne		Lythraceae	Herb-Annual	
681	<i>Rotala indica</i> (Willd.) Koehne		Lythraceae	Herb-Perennial	
682	<i>Rotala macrandra</i> Koehne		Lythraceae	Herb-Perennial	

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683	<i>Rotala malabarica</i> Pradeep		Lythraceae	Herb-Annual	
684	<i>Rotala malampuzhensis</i> R.V. Nair ex Cook		Lythraceae	Herb-Annual	
685	<i>Rotala rosea</i> (Poir.) Cook		Lythraceae	Herb-Annual	
686	<i>Rotala rotundifolia</i> (Buch.-Ham. ex Roxb.) Koehne		Lythraceae	Herb-Annual	
687	<i>Rothea serrata</i> (L.) Steane & Mabb.	Cheruthekku	Verbenaceae	shrub	
688	<i>Ruellia tuberosa</i> L.		Acanthaceae	Herb-Perennial	
689	<i>Rungia pectinata</i> (L.) Nees		Acanthaceae	Herb-Annual	
690	<i>Rungia repens</i> (L.) Nees		Acanthaceae	Herb-Annual	
691	<i>Saccharum arundinaceum</i> Retz.	Naimana	Poaceae	Herb-Perennial	
692	<i>Saccharum spontaneum</i> L.	Njangana, Chottapullu,	Poaceae	Herb-Perennial	
693	<i>Sacciolepis indica</i> (L.) Chase	Bocha-pul	Poaceae	Herb-Perennial	
694	<i>Sacciolepis interrupta</i> (Willd.) Stapf		Poaceae	Herb-Perennial	
695	<i>Sagittaria guayanensis</i> HBK ssp. lappula (D. Don) Bogin		Alismataceae	Herb-Annual	
696	<i>Sagittaria trifolia</i> L.		Alismataceae	Herb-Annual	
697	<i>Salacia fruticosa</i> Heyne ex Lawson	Ponkarandi	Hippocrateaceae	climber	
698	<i>Salvinia molesta</i> D.S.Mitch.		Salviniaceae	Herb-Annual	
699	<i>Santalum album</i> L.	Chandanam	Santalaceae	Tree	
700	<i>Sauropus quadrangularis</i> (Willd.) Muell.	Aruni, Punarmuringa	Euphorbiaceae	Shrub	
701	<i>Scaevola sericea</i> G. Forst. ex Vahl,	Badraksham	Goodeniaceae	Shrub	
702	<i>Schleichera oleosa</i> (Lour.) Merr.	Dhoothalam, Poovanam	Sapindaceae	Tree	
703	<i>Schoenoplectiella juncooides</i> (Roxb.) Lye	Mattipullu	Cyperaceae	Herb-Perennial	
704	<i>Schoenoplectiella lateriflora</i> (Gmel.) Lye		Cyperaceae	Herb-Annual	
705	<i>Schoenoplectus litoralis</i> (Schrad.) Palla ssp. <i>thermalis</i> (Trab.) S.S.Hooper		Cyperaceae	Herb-Annual	
706	<i>Scleria levis</i> Retz.		Cyperaceae	Herb-Annual	
707	<i>Scleria lithosperma</i> (L.) Sw.	Nakkupullu	Cyperaceae	Herb-Perennial	
708	<i>Scleria sumatrensis</i> Retz.		Cyperaceae	Herb-Annual	
709	<i>Scoparia dulcis</i> L.	Kallurukki	Scrophulariaceae	Herb-Perennial	
710	<i>Senna alata</i> (L.) Roxb.	Puzhukkadikonna	Fabaceae	Shrub	
711	<i>Senna occidentalis</i> (L.) Link	Ponnariveeram	Fabaceae	Shrub	
712	<i>Senna tora</i> (L.) Roxb.	Ponthakara	Fabaceae	Herb-Perennial	
713	<i>Sesamum orientale</i> L.	Ellu Kattellu	Pedaliaceae	Herb-Annual	

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714	<i>Sesbania bispinosa</i> (Jacq.) W.Wight	Kilannu, Kitamu	Fabaceae	Herb-Perennial	
715	<i>Sesuvium portulacastrum</i> (L.) L.		Aizoaceae	Herb-Annual	
716	<i>Sida cordata</i> (Burm. f.) Borss.	Vallikurunthotti	Malvaceae	Herb-Perennial	
717	<i>Sida cordifolia</i> L.	Anakurunthotti	Malvaceae	Herb-Perennial	
718	<i>Sida rhombifolia</i> L.	Kurunthotti	Malvaceae	Herb-Perennial	
719	<i>Smilax zeylanica</i> L.	Kareelanchi, Valiyakanni	Smilacaceae	Climber-Woody	
720	<i>Smithia sensitiva</i> Ait.		Fabaceae	Herb-Annual	
721	<i>Solanum torvum</i> Sw.	Anachunda, Parachunda	Solanaceae	Shrub	
722	<i>Solena amplexicaulis</i> (Lam.) Gandhi	Kakkarikka	Cucurbitaceae	Climber	
723	<i>Sonneratia alba</i> J. E. Smith	Nakshathrakandel	Sonneratiaceae	Tree	
724	<i>Sonneratia caseolaris</i> (L.) Engl.	Chakkarakandal	Sonneratiaceae	Tree	
725	<i>Spermacoce articularis</i> L.f.	Tharthaval, Nathachuri	Rubiaceae	Herb-Annual	
726	<i>Spermacoce latifolia</i> Aubl	Vellatharavu	Rubiaceae	Herb-Perennial	
727	<i>Sphaeranthus africanus</i> L.	Velutha-adykkamaniyan	Asteraceae	Herb-Perennial	
728	<i>Sphaeranthus indicus</i> L.	Adakkyamaniyan	Asteraceae	Herb-Perennial	
729	<i>Sphagneticola trilobata</i> (L.) Pruski	Singapore daisy	Asteraceae	Herb-Perennial	
730	<i>Sphenoclea zeylanica</i> Gaertn.		Campanulaceae	Herb-Perennial	
731	<i>Spilanthes ciliata</i> Kunth	Palluedhanachedi	Asteraceae	Herb-Annual	
732	<i>Spilanthes radicans</i> Jacq.	Venapacha	Asteraceae	Herb-Annual	
733	<i>Spirodela polyrhiza</i> (L.) Schleid.		Lemnaceae	Herb-Annual	
734	<i>Sporobolus indicus</i> (L.) R. Br. var. <i>fertilis</i> (Steud.) Jovet & Guedes		Poaceae	Herb-Annual	
735	<i>Stachytarpheta jamaicensis</i> (L.) Vahl	Seemakongini	Verbenaceae	Shrub	
736	<i>Stemodia verticillata</i> (Mill.) Sprague		Scrophulariaceae	Herb-Annual	
737	<i>Sterculia foetida</i> L.	Peenari	Sterculiaceae	Tree	
738	<i>Sterculia guttata</i> Roxb. ex DC.	Aanathondimaram	Sterculiaceae	Tree	
739	<i>Streblus asper</i> Lour.	Dindumaram	Moraceae	Tree	
740	<i>Striga asiatica</i> (L.) O. Ktze.	Kalupullappan	Scrophulariaceae	Herb-Annual	
741	<i>Strychnos nux-vomica</i> L.	Kanjiram	Loganiaceae	Tree	
742	<i>Swietenia mahagoni</i> (L.) Jacq.	Mahagani	Meliaceae	Tree	
743	<i>Synedrella nodiflora</i> (L.) Gaertn.	Mudianpacha	Asteraceae	Herb-Annual	
744	<i>Syzygium cumini</i> (L.) Skeels var. <i>cumini</i> ; Manilal & Sivar.	Njaval	Myrtaceae	Tree	
745	<i>Tabernaemontana alternifolia</i> L.	Kundalapala,	Apocynaceae	Tree	

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746	<i>Tabernaemontana divaricata</i> (L.) R.Br.	Nandiyar-vattom	Apocynaceae	Shrub	
747	<i>Talipariti tiliaceum</i> (L.) Fryxell	Aattuparuthi	Malvaceae	Shrub	
748	<i>Tamarindus indica</i> L.	Kolpuli, Valampuli,	Fabaceae	Tree	
749	<i>Tecoma stans</i> (L.) HBK	Manja arali	Bignoniaceae	Shrub	
750	<i>Tectona grandis</i> L.	Thekku	Verbenaceae	Tree	
751	<i>Tephrosia purpurea</i> (L.) Pers.	Kodikozhingil	Fabaceae	Shrub	
752	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Thanni	Combretaceae	Tree	
753	<i>Terminalia catappa</i> L.	Kadappa	Combretaceae	Tree	
754	<i>Terminalia paniculata</i> Roth	Maruthu	Combretaceae	Tree	
755	<i>Theobroma cacao</i> L.	Kokko	Sterculiaceae	Tree	
756	<i>Thespesia populnea</i> (L.) Sol. ex Corrêa	Cheelanthi, Poovarasu	Malvaceae	Tree	
757	<i>Thevetia peruviana</i> (Pers.) Merr.	Manjaarali	Apocynaceae	Shrub	
758	<i>Thunbergia erecta</i> (Benth.) Anders.	Blue Bell	Acanthaceae	Shrub	
759	<i>Tiliacora acuminata</i> Miers	Vallikanjiram	Menispermaceae	Climber	
760	<i>Tinospora cordifolia</i> (Willd.) Miers	Amruthu, Chittamruthu	Menispermaceae	Climber-Woody	
761	<i>Torenia bicolor</i> Dalz.	Kakkapoovu	Scrophulariaceae	Herb-Annual	
762	<i>Tragia involucrata</i> L.	Choriyanam, Kodithoova	Euphorbiaceae	Herb-Perennial	
763	<i>Trapa natans</i> L.	Karimbolam	Trapaceae	Herb-Perennial	
764	<i>Trema orientalis</i> (L.) Blume	Aamathali, Ampotti, Ami	Ulmaceae	Tree	
765	<i>Trewia nudiflora</i> L.	Ammanaka, Naikumbil	Euphorbiaceae	Tree	
766	<i>Trianthemum portulacastrum</i> L.	Pasalikeera	Molluginaceae	Herb-Annual	
767	<i>Trichosanthes anguina</i> L.	Padavala	Cucurbitaceae	Climber	
768	<i>Trichosanthes nervifolia</i> L.	Kattupadavalam	Cucurbitaceae	Climber	
769	<i>Tridax procumbens</i> L.	Kumminipacha	Asteraceae	Herb-Annual	
770	<i>Triumfetta rhomboidea</i> Jacq.	Urpam	Tiliaceae	Shrub	
771	<i>Turnera subulata</i> Smith	Chiravathali	Turneraceae	Herb-Perennial	
772	<i>Tylophora tetrapetala</i> (Dennst.) Suresh	Parparam	Asclepidaceae	Climber	
773	<i>Typha angustifolia</i> L.	Aattudharbapullu	Typhaceae	Herb-Perennial	
774	<i>Typhonium flagelliforme</i> (Lodd.) Blume	Kakkapalung	Araceae	Herb-Annual	
775	<i>Urena lobata</i> L.	Oorpam, Uthiram, Uram	Malvaceae	Shrub	
776	<i>Utricularia aurea</i> Lour.		Lentibulariaceae	Herb-Perennial	
777	<i>Utricularia bifida</i> L.		Lentibulariaceae	Herb-Annual	
778	<i>Utricularia caerulea</i> L.		Lentibulariaceae	Herb-Perennial	

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779	<i>Utricularia ceciliae</i> Taylor	Krishnapoo	Lentibulariaceae	Herb-Perennial	
780	<i>Utricularia exoleta</i> R. Br.		Lentibulariaceae	Herb-Annual	
781	<i>Utricularia graminifolia</i> Vahl	Kakkapoovu	Lentibulariaceae	Herb-Annual	
782	<i>Utricularia minutissima</i> Vahl		Lentibulariaceae	Herb-Annual	
783	<i>Utricularia reticulata</i> Smith	Krishnapoovu	Lentibulariaceae	Herb-Annual	
784	<i>Utricularia striatula</i> Smith		Lentibulariaceae	Herb-Annual	
785	<i>Utricularia uliginosa</i> Vahl		Lentibulariaceae	Herb-Annual	
786	<i>Uvaria narum</i> (Dunal) Wall. ex Hook.f. & Thoms.	Narumpanal	Annonaceae	Climber-Woody	
787	<i>Vallisneria natans</i> (Lour.) Hara		Hydrocharitaceae	Herb-Annual	
788	<i>Vateria indica</i> L.	Payin, Painimaram	Dipterocarpaceae	Tree	CR
789	<i>Vernonia cinerea</i> (L.) Less.	Poovamkurunthala	Asteraceae	Herb-Annual	
790	<i>Vernonia divergens</i> (Roxb.) Edgew.		Asteraceae	Shrub	
791	<i>Vigna adenantha</i> (Meyer) Marechal	Kattupayar	Fabaceae	Climber	
792	<i>Vigna trilobata</i> (L.) Verdc.	Cheruidukol	Fabaceae	Climber	
793	<i>Vitex altissima</i> L.f.	Mayila, Mayilellu	Verbenaceae	Tree	
794	<i>Vitex negundo</i> L.	Nochi, Karinochi	Verbenaceae	Tree	
795	<i>Waltheria indica</i> L.		Sterculiaceae	Herb-Perennial	
796	<i>Wattakaka volubilis</i> (L. f.) Stapf	Vattakakkakkoti	Asclepiadaceae	Climber	
797	<i>Wrightia tinctoria</i> (Roxb.) R. Br.	Danthapala	Apocynaceae	Tree	
798	<i>Xenostegia tridentata</i> (L.) Austin & Staples ssp. <i>hastata</i> (Desr.) Panigrahi&Murti	Cheruvayera	Convolvulaceae	Herb-Perennial	
799	<i>Xylia xylocarpa</i> (Roxb.) Taub.	Irul	Fabaceae	Tree	
800	<i>Xyris indica</i> L.		Xyridaceae	Herb-Annual	
801	<i>Xyris pauciflora</i> Willd.		Xyridaceae	Herb-Annual	
802	<i>Zingiber officinale</i> Rosc.	Inchi	Zingiberaceae	Herb-Perennial	
803	<i>Zingiber zerumbet</i> (L.) Roscoe ex Sm.	Kaattinchi, Kattukolinchi	Zingiberaceae	Herb-Perennial	
804	<i>Ziziphus oenopolia</i> (L.) Mill.	Cheriyalantha, Thodali	Rhamnaceae	Shrub	
805	<i>Zornia gibbosa</i> Span	Kozhuppa	Fabaceae	Herb-Annual	
806	<i>Zoysia matrella</i> (L.) Merr.		Poaceae	Herb-Annual	

B. A Detailed Checklist of Major Cultivated Crops, Kerala

	Common Name	Malayalam Name	Botanical Name	Family
Cereals				
1.	Chama (little millet)	Chama	<i>Panicum sumatrense</i>	Poaceae
2.	Kodo millet	Varagu	<i>Paspalum scrobiculatum</i>	Poaceae
3.	Maize	Cholam	<i>Zea mays</i>	Poaceae
4.	Rice	Nellu	<i>Oryza sativa</i>	Poaceae
5.	Ragi (Finger millet)	Koovaraku	<i>Eleusine coracana</i>	Poaceae
Pulses				
6.	Black gram	Uzhunnu	<i>Vigna mungo</i>	Fabaceae
7.	Cowpea	Perumpayar	<i>Vigna unguiculata</i>	Fabaceae
8.	Green gram	Cherupayar	<i>Vigna radiata</i>	Fabaceae
9.	Horse gram	Muthira	<i>Macrotyloma uniflorum</i>	Fabaceae
10.	Red gram	Thuvarappayar	<i>Cajanus cajan</i>	Fabaceae
Tubers				
11.	Colocasia	Chembu	<i>Colocasia esculenta</i>	Araceae
12.	Elephant foot Yam	Chena	<i>Amorphophallus paeoniifolius</i>	Araceae
13.	Potato	Urulakizhangu	<i>Solanum tuberosum</i>	Solanaceae
14.	Radish	Mullangi	<i>Raphanus sativus</i>	Brassicaceae
15.	Sweet potato	Cheenikizhangu	<i>Ipomoea batatas</i>	Convolvulaceae
16.	Turnip	Seemamullangi	<i>Brassica rapa</i>	Brassicaceae
17.	Tapioca	Maracheeni	<i>Manihot esculenta</i>	Euphorbiaceae
18.	Greater Yam	Kachil	<i>Dioscorea alata</i>	Dioscoreaceae.
Vegetable				
19.	Brinjal	Vazhuthana	<i>Solanum melongena</i>	Solanaceae
20.	Tomato	Thakkali	<i>Lycopersicon esculentum</i>	Solanaceae
21.	Chilli	Mulaku	<i>Capsicum annuum</i>	Solanaceae
22.	Amaranthus	Cheera	<i>Amaranthus spp,</i>	Amaranthaceae
23.	Okra	Venda	<i>Abelmoschus esculentus</i>	Malvaceae
24.	Bitter gourd	Paval	<i>Momordica charantia</i>	Cucurbitaceae
25.	Bottle gourd	Churakka	<i>Lagenaria siceraria</i>	Cucurbitaceae
26.	Snake gourd	Padavalam	<i>Trichosanthes anguina</i>	Cucurbitaceae
27.	Ridge gourd	Peechanga	<i>Luffa acutangula</i>	Cucurbitaceae
28.	Ash gourd	Kumbalam	<i>Benincasa hispida</i>	Cucurbitaceae
29.	Little gourd	Koval	<i>Coccinia grandis</i>	Cucurbitaceae
30.	Sword bean	Valaringa	<i>Canavalia gladiata</i>	Fabaceae
31.	French bean	Beans	<i>Phaseolus vulgaris</i>	Fabaceae
32.	Beet root	Beet root	<i>Beta vulgaris</i>	Chenopodiaceae

	Common Name	Malayalam Name	Botanical Name	Family
33.	Cabbage	Muttakose	<i>Brassica oleracea var. capitata</i>	Brassicaceae
34.	Carrot	Carrot	<i>Daucus carota</i>	Apiaceae
35.	Cauliflower	Cauliflower	<i>Brassica oleracea var. botrytis</i>	Brassicaceae
36.	Indian bean	Amara	<i>Lablab purpureus</i>	Fabaceae
37.	Drumstick	Muringa	<i>Moringa oleifera</i>	Moringaceae
38.	Musk melon	Thaikumbalam	<i>Cucumis melo</i>	Cucurbitaceae
39.	Onion	Ulli	<i>Allium cepa</i>	Liliaceae
40.	Pumpkin	Mathan	<i>Cucurbita moschata</i>	Cucurbitaceae
41.	Red pumpkin	Vellarimathan	<i>Cucurbita maxima</i>	Cucurbitaceae
Fruits				
42.	Banana	Vazha	<i>Musa spp.</i>	Musaceae
43.	Bread fruit	Seemachakka	<i>Artocarpus altilis</i>	Moraceae
44.	Bullock's heart	Malamunthiri	<i>Annona reticulata</i>	Annonaceae
45.	Cashew	Kasuvandi	<i>Anacardium occidentale</i>	Anacardiaceae
46.	Sweet-sop	Seethapazham	<i>Annona squamosa</i>	Annonaceae
47.	Grapes	Munthiringa	<i>Vitis vinifera</i>	Vitaceae
48.	Guava	Perakka	<i>Psidium guajava</i>	Myrtaceae
49.	Jack	Chakka	<i>Artocarpus heterophyllus</i>	Moraceae
50.	Jujube	Elantha	<i>Zizyphus jujuba</i>	Rhamnaceae
51.	Lemon	Naranga	<i>Citrus limon</i>	Rutaceae
52.	Lime	Cherunaranga	<i>Citrus aurantifolia</i>	Rutaceae
53.	Mango	Manga	<i>Mangifera indica</i>	Anacardiaceae
54.	Mangosteen	Mangosteen	<i>Garcinia mangostana</i>	Clusiaceae
55.	Papaya	Pappakka	<i>Carica papaya</i>	Caricaceae
56.	Pineapple	Kaithachakka	<i>Ananas comosus</i>	Bromeliaceae
57.	Pomegranate	Mathalanaranga	<i>Punica granatum</i>	Punicaceae
58.	Sapota	Sapota	<i>Achras sapota</i>	Sapotaceae
59.	Orange	Mandarin	<i>Citrus reticulata</i>	Rutaceae
60.	Pomelo	Bamplimas	<i>Citrus decumana</i>	Rutaceae
Condiments & Spices				
61.	Chilli	Mulaku	<i>Capsicum annuum</i>	Solanaceae
62.	Turmeric	Manjal	<i>Curcuma domestica</i>	Zingiberaceae
63.	Coriander	Kothamalli	<i>Coriandrum sativum</i>	Apiaceae
64.	Indian mustard	Kaduku	<i>Brassica juncea</i>	Brassicaceae
65.	Cumin	Jeerakam	<i>Cuminum cyminum</i>	Apiaceae
66.	Pepper	Kurumulaku	<i>Piper nigrum</i>	Piperaceae
67.	Garlic	Veluthulli	<i>Allium sativum</i>	Liliaceae

	Common Name	Malayalam Name	Botanical Name	Family
68.	Ginger	Inchi	<i>Zingiber officinale</i>	Zingiberaceae
69.	Cardamom	Etam	<i>Elettaria cardamomum</i>	Zingiberaceae
70.	Long Pepper	Thippali	<i>Piper longum</i>	Piperaceae
71.	Nutmeg	Jathika	<i>Myristica fragrans</i>	Myristicaceae
72.	Cinnamon	Karuvapatta	<i>Cinnamomum zeylanicum</i>	Lauraceae
73.	Clove	Grambu	<i>Syzygium aromaticum</i>	Myrtaceae
74.	Cinchona	Cinchona	<i>Cinchona officinalis</i>	Rubiaceae
75.	Fennel	Perumjeerakam	<i>Foeniculum vulgare</i>	Apiaceae
Oil Seeds				
76.	Coconut	Thengu	<i>Cocos nucifera</i>	Arecaceae
77.	Sesamum	Ellu	<i>Sesamum indicum</i>	Pedaliaceae
78.	Groundnut	Nilakkadala	<i>Arachis hypogaea</i>	Fabaceae
79.	Indian Mustard	Kaduku	<i>Brassica juncea</i>	Brassicaceae
80.	Castor	Avanakku	<i>Ricinus communis</i>	Euphorbiaceae
81.	Oil Palm	Ennappana	<i>Elaeis guineensis</i>	Arecaceae
Beverages				
82.	Glyricidia	Seemakonna	<i>Gliricidia maculata</i>	Fabaceae
83.	Crotalaria(Striped)	Kilukki	<i>Crotalaria mucronata</i>	Fabaceae
84.	Sunnhemp	Kattuchanambu	<i>Crotalaria juncea</i>	Fabaceae
85.	Calapagonium	Calapagonium	<i>Calapagonium mucunoides</i>	Fabaceae
86.	Kudzuvine	Kudzu payar	<i>Pueraria javanica</i>	Fabaceae
87.	Wild indigo	Kozhinji	<i>Tephrosia purpurea</i>	Fabaceae
Fodder Crops				
88.	Bermuda	Karuka	<i>Cynodon dactylon</i>	Poaceae
89.	Napier	Napier	<i>Pennisetum purpureu</i>	Poaceae
90.	Guinea	Kuthirappullu	<i>Panicum maximum</i>	Poaceae
91.	Para	Parapullu	<i>Brachiaria mutica</i>	Poaceae
92.	Tropical kudzu	Kudzu	<i>Pueraria phaseoloides</i>	Fabaceae
Other Crops				
93.	Tobacco	Pukayila	<i>Nicotiana tabacum</i>	Solanaceae
94.	Betel vine	Vettila	<i>Piper betle</i>	Piperaceae
95.	Arecanut	Kamuku	<i>Areca catechu</i>	Arecaceae
96.	Para rubber	Rubber	<i>Hevea brasiliensis</i>	Euphorbiaceae
97.	Sugarcane	Karimbu	<i>Saccharum officinarum</i>	Poaceae

Source: Department of Agriculture Development and Farmer Welfare

<http://www.keralaagriculture.gov.in/html/crops/cropsfs.htm>

Annexure 3

FAUNA

A. List of Birds reported in Kerala

Sl.No.	English name	Species name	Authority	IUCN	END
I. ORDER ANSERIFORMES					
1. Family Anatidae (ducks, geese, swans)					
1	Lesser Whistling Duck	<i>Dendrocygna javanica</i>	Horsfield, 1821	LC	
2	Bar-headed Goose	<i>Anser indicus</i>	Latham, 1790	LC	
3	Ruddy Shelduck	<i>Tadorna ferruginea</i>	Pallas, 1764	LC	
4	Ferruginous Duck	<i>Aythya nyroca</i>	Güldenstädt, 1770	NT	
5	Tufted Duck	<i>Aythya fuligula</i>	Linnaeus, 1758	LC	
6	Garganey	<i>Spatula querquedula</i>	Linnaeus, 1758	LC	
7	Northern Shoveler	<i>Spatula clypeata</i>	Linnaeus, 1758	LC	
8	Gadwall	<i>Mareca strepera</i>	Linnaeus, 1758	LC	
9	Eurasian Wigeon	<i>Mareca penelope</i>	Linnaeus, 1758	LC	
10	Indian Spot-billed Duck	<i>Anas poecilorhyncha</i>	Forster, JR, 1781	LC	
11	Northern Pintail	<i>Anas acuta</i>	Linnaeus, 1758	LC	
12	Common Teal	<i>Anas crecca</i>	Linnaeus, 1758	LC	
13	Comb Duck	<i>Sarkidiornis melanotos</i>	Pennant, 1769	LC	
14	Cotton Teal	<i>Nettapus coromandelianus</i>	Gmelin, JF, 1789	LC	
II. ORDER GALLIFORMES					
2. Family Phasianidae (partridges, pheasants, grouse)					
15	Indian Peafowl	<i>Pavo cristatus</i>	Linnaeus, 1758	LC	
16	Rain Quail	<i>Coturnix coromandelica</i>	Gmelin, JF, 1789	LC	
17	Jungle Bush Quail	<i>Perdica asiatica</i>	Latham, 1790	LC	
18	Painted Bush Quail ¹	<i>Perdica erythrorhyncha</i>	Sykes, 1832	LC	
19	Grey Francolin	<i>Francolinus pondicerianus</i>	Gmelin, JF, 1789	LC	
20	Grey Junglefowl	<i>Gallus sonneratii</i>	Temminck, 1813	LC	
21	Red Spurfowl	<i>Galloperdix spadicea</i>	Gmelin, JF, 1789	LC	
22	Painted Spurfowl	<i>Galloperdix lunulata</i>	Valenciennes, 1825	LC	
III. ORDER PHOENICOPTERI- FORMES					
3. Family Phoenicopteridae (flamingos)					
23	Greater Flamingo	<i>Phoenicopus roseus</i>	Pallas, 1811	LC	
4. Family Podicipedidae (grebes)					
24	Little Grebe	<i>Tachybaptus ruficollis</i>	Pallas, 1764	LC	
IV. ORDER COLUMBIFORMES					
5. Family Columbidae (pigeons)					

Sl.No.	English name	Species name	Authority	IUCN	END
25	Rock Pigeon	<i>Columba livia</i>	Gmelin, JF, 1789	LC	
26	Nilgiri Wood Pigeon	<i>Columba elphinstonii</i>	Sykes, 1832	VU	WG
27	Oriental Turtle Dove	<i>Streptopelia orientalis</i>	Latham, 1790	LC	
28	Eurasian Collared Dove	<i>Streptopelia decaocto</i>	Frivaldszky, 1838	LC	
29	Red Collared Dove	<i>Streptopelia tranquebarica</i>	Hermann, 1804	LC	
30	Spotted Dove	<i>Streptopelia chinensis</i>	Scopoli, 1786	LC	
31	Laughing Dove	<i>Streptopelia senegalensis</i>	Linnaeus, 1766	LC	
32	Orange-breasted Green Pigeon	<i>Treron bicinctus</i>	Jerdon, 1840	LC	
33	Pompadour Green Pigeon	<i>Treron pompadora</i>	Gmelin, 1789	LC	
34	Yellow-footed Green Pigeon	<i>Treron phoenicopterus</i>	Latham, 1790	LC	
35	Emerald Dove	<i>Chalcophaps indica</i>	Linnaeus, 1758	LC	
36	Green Imperial Pigeon	<i>Ducula aenea</i>	Linnaeus, 1766	LC	
37	Mountain Imperial Pigeon	<i>Ducula badia</i>	Raffles, 1822	LC	
V. ORDER PTEROCLIFORMES					
6. Family Pteroclididae (sandgrouse)					
38	Chestnut-bellied Sandgrouse	<i>Pterocles exustus</i>	Temminck, 1825	LC	
VI. ORDER PHAETHONTIFORMES					
7. Family Phaethontidae (tropicbirds)					
39	Red-billed Tropicbird	<i>Phaethon aethereus</i>	Linnaeus, 1758	LC	
40	White-tailed Tropicbird	<i>Phaethon lepturus</i>	Daudin, 1802	LC	
VII. ORDER CAPRIMULGIFORMES					
8. Family Podargidae (frogmouths)					
41	Sri Lanka Frogmouth	<i>Batrachostomus moniliger</i>	Blyth, 1849	LC	
9. Family Caprimulgidae (nightjars)					
42	Great Eared Nightjar	<i>Lyncornis macrotis</i>	Vigors, 1831	LC	
43	Grey Nightjar	<i>Caprimulgus indicus</i>	Latham, 1790	LC	
44	Jerdon's Nightjar	<i>Caprimulgus atripennis</i>	Jerdon, 1845	LC	
45	Indian Nightjar	<i>Caprimulgus asiaticus</i>	Latham, 1790	LC	
46	Savanna Nightjar	<i>Caprimulgus affinis</i>	Horsfield, 1821	LC	
10. Family Apodidae (swifts)					
47	Crested Treeswift	<i>Hemiprocne coronata</i>	Tickell, 1833	LC	
48	White-rumped Spinetail	<i>Zoonavena sylvatica</i>	Tickell, 1846	LC	
49	Brown-backed Needletail	<i>Hirundapus giganteus</i>	Temminck, 1825	LC	
50	Indian Swiftlet	<i>Aerodramus unicolor</i>	Jerdon, 1840	LC	
51	Asian Palm Swift	<i>Cypsiurus balasiensis</i>	Gray, JE, 1829	LC	

Sl.No.	English name	Species name	Authority	IUCN	END
52	Alpine Swift	<i>Tachymarptis melba</i>	Linnaeus, 1758	LC	
53	Pacific Swift	<i>Apus pacificus</i>	Blyth, 1845	LC	
54	Indian House Swift	<i>Apus affinis</i>	Gray, JE, 1830	LC	
55	Common Swift	<i>Apus apus</i>	Linnaeus, 1758	LC	
VIII. ORDER CUCULIFORMES					
11. Family Cuculidae (cuckoos)					
56	Greater Coucal	<i>Centropus sinensis</i>	Stephens, 1815	LC	
57	Lesser Coucal	<i>Centropus bengalensis</i>	Gmelin, JF, 1788	LC	
58	Sirkeer Malkoha	<i>Taccocua leschenaultii</i>	Lesson, 1830	LC	
59	Blue-faced Malkoha	<i>Phaenicophaeus viridirostris</i>	Jerdon, 1840	LC	
60	Pied Cuckoo	<i>Clamator jacobinus</i>	Boddaert, 1783	LC	
61	Chestnut-winged Cuckoo	<i>Clamator coromandus</i>	Linnaeus, 1766	LC	
62	Asian Koel	<i>Eudynamys scolopaceus</i>	Linnaeus, 1758	LC	
63	Banded Bay Cuckoo	<i>Cacomantis sonneratii</i>	Latham, 1790)	LC	
64	Grey-bellied Cuckoo	<i>Cacomantis passerinus</i>	(Vahl, 1797	LC	
65	Drongo Cuckoo	<i>Surniculus lugubris</i>	Horsfield, 1821	LC	
66	Large Hawk Cuckoo	<i>Hierococcyx sparveroides</i>	Vigors, 1832	LC	
67	Common Hawk Cuckoo	<i>Hierococcyx varius</i>	Vahl, 1797	LC	
68	Indian Cuckoo	<i>Cuculus micropterus</i>	Gould, 1838	LC	
69	Common Cuckoo	<i>Cuculus canorus</i>	Linnaeus, 1758	LC	
70	Lesser Cuckoo	<i>Cuculus poliocephalus</i>	Latham, 1790	LC	
IX. ORDER GRUIFORMES					
12. Family Rallidae (rails and coots)					
71	Slaty-legged Crake	<i>Rallina eurizonoides</i>	Lafresnaye, 1845	LC	
72	Slaty-breasted Rail	<i>Lewinia striata</i>	Linnaeus, 1766	LC	
73	Ruddy-breasted Crake	<i>Zapornia fusca</i>	Linnaeus, 1766	LC	
74	Baillon's Crake	<i>Zapornia pusilla</i>	Pallas, 1776	LC	
75	White-breasted Waterhen	<i>Amauornis phoenicurus</i>	Pennant, 1769	LC	
76	Watercock	<i>Gallicrex cinerea</i>	Gmelin, JF, 1789	LC	
77	Purple Swampphen	<i>Porphyrio porphyrio</i>	Linnaeus, 1758	LC	
78	Common Moorhen	<i>Gallinula chloropus</i>	Linnaeus, 1758	LC	
79	Common Coot	<i>Fulica atra</i>	Linnaeus, 1758	LC	
X. ORDER OTIDIFORMES					
13. Family Otidae (bustards)					
80	Lesser Florican	<i>Sypheotides indicus</i>	Miller, JF, 1782	EN	
81	Macqueen's Bustard	<i>Chlamydotis macqueenii</i>	Gray, JE, 1832	VU	
XI. ORDER PROCELLARIIFORMES					

Sl.No.	English name	Species name	Authority	IUCN	END
14. Family Oceanitidae (austral storm-petrels)					
82	Wilson's Storm-petrel	<i>Oceanites oceanicus</i>	Kuhl, 1820	LC	
83	White-faced Storm-petrel	<i>Pelagodroma marina</i>	(Latham, 1790)	LC	
15. Family Hydrobatidae (northern storm-petrels)					
84	Swinhoe's Storm-petrel	<i>Hydrobates monorhis</i>	Swinhoe, 1867	NT	
16. Family Procellariidae (petrels & shearwaters)					
85	Wedge-tailed Shearwater	<i>Ardenna pacifica</i>	Gmelin, JF, 1789	LC	
86	Short-tailed Shearwater	<i>Ardenna tenuirostris</i>	Temminck, 1835	LC	
87	Flesh-footed Shearwater	<i>Ardenna carneipes</i>	Gould, 1844	LC	
88	Streaked Shearwater	<i>Calonectris leucomelas</i>	Temminck, 1836	NT	
89	Cory's Shearwater	<i>Calonectris borealis</i>	Cory, 1881	LC	
90	Tropical Shearwater	<i>Puffinus bailloni</i>	Bonaparte, 1857	LC	
91	Jouanin's Petrel	<i>Bulweria fallax</i>	Jouanin, 1955	NT	
XII. ORDER PELECANIFORMES					
17. Family Ciconiidae (storks)					
92	Lesser Adjutant	<i>Leptoptilos javanicus</i>	Horsfield, 1821	VU	
93	Painted Stork	<i>Mycteria leucocephala</i>	Pennant, 1769	NT	
94	Asian Openbill	<i>Anastomus oscitans</i>	Boddaert, 1783	LC	
95	Black Stork	<i>Ciconia nigra</i>	Linnaeus, 1758	LC	
96	Woolly-necked Stork	<i>Ciconia episcopus</i>	Boddaert, 1783	VU	
97	European White Stork	<i>Ciconia ciconia</i>	Linnaeus, 1758	LC	
18. Family Pelecanidae (pelicans)					
98	Great White Pelican	<i>Pelecanus onocrotalus</i>	Linnaeus, 1758	LC	
99	Spot-billed Pelican	<i>Pelecanus philippensis</i>	Gmelin, JF, 1789	NT	
19. Family Ardeidae (herons)					
100	Eurasian Bittern	<i>Botaurus stellaris</i>	Linnaeus, 1758	LC	
101	Little Bittern	<i>Ixobrychus minutus</i>	Linnaeus, 1766	LC	
102	Yellow Bittern	<i>Ixobrychus sinensis</i>	Gmelin, JF, 1789	LC	
103	Cinnamon Bittern	<i>Ixobrychus cinnamomeus</i>	Gmelin, JF, 1789	LC	
104	Black Bittern	<i>Ixobrychus flavicollis</i>	Latham, 1790	LC	
105	Malayan Night Heron	<i>Gorsachius melanolophus</i>	Raffles, 1822	LC	
106	Black-crowned Night Heron	<i>Nycticorax nycticorax</i>	Linnaeus, 1758	LC	
107	Little Heron	<i>Butorides striata</i>	Linnaeus, 1758	LC	
108	Indian Pond Heron	<i>Ardeola grayii</i>	Sykes, 1832	LC	
109	Cattle Egret	<i>Bubulcus ibis</i>	Boddaert, 1783	LC	
110	Grey Heron	<i>Ardea cinerea</i>	Linnaeus, 1758	LC	
111	Purple Heron	<i>Ardea purpurea</i>	Linnaeus, 1766	LC	

SI.No.	English name	Species name	Authority	IUCN	END
112	Great Egret	<i>Ardea alba</i>	Linnaeus, 1758	LC	
113	Intermediate Egret	<i>Ardea intermedia</i>	Wagler, 1829	LC	
114	Little Egret	<i>Egretta garzetta</i>	Linnaeus, 1766	LC	
115	Western Reef Egret	<i>Egretta gularis</i>	Bosc, 1792	LC	
20. Family Threskiornithidae (ibises)					
116	Black-headed Ibis	<i>Threskiornis melanocephalus</i>	Latham, 1790	NT	
117	Eurasian Spoonbill	<i>Platalea leucorodia</i>	Linnaeus, 1758	LC	
118	Indian Black Ibis	<i>Pseudibis papillosa</i>	Temminck, 1824	LC	
119	Glossy Ibis	<i>Plegadis falcinellus</i>	Linnaeus, 1766	LC	
21. Family Fregatidae (frigatebirds)					
120	Lesser Frigatebird	<i>Fregata ariel</i>	Gray, GR, 1845	LC	
121	Great Frigatebird	<i>Fregata minor</i>	Gmelin, JF, 1789	LC	
122	Christmas Island Frigatebird	<i>Fregata andrewsi</i>	Mathews, 1914	CR	
22. Family Sulidae (gannets and boobies)					
123	Red-footed Booby	<i>Sula sula</i>	Linnaeus, 1766	LC	
124	Masked Booby	<i>Sula dactylatra</i>	Lesson, 1831	LC	
23. Family Phalacrocoracidae (cormorants)					
125	Little Cormorant	<i>Microcarbo niger</i>	Vieillot, 1817	LC	
126	Great Cormorant	<i>Phalacrocorax carbo</i>	Linnaeus, 1758	LC	
127	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	Stephens, 1826	LC	
24. Family Anhingidae (darters)					
128	Oriental Darter	<i>Anhinga melanogaster</i>	Pennant, 1769	NT	
XIII. ORDER CHARADRIIFORMES					
25. Family Burhinidae (thick-knees)					
129	Indian Thick-knee	<i>Burhinus oedicnemus</i>	Salvadori, 1865	LC	
130	Great Thick-knee	<i>Esacus recurvirostris</i>	Cuvier, 1829	NT	
26. Family Haematopodidae (oystercatchers & ibisbill)					
131	Eurasian Oystercatcher	<i>Haematopus ostralegus</i>	Linnaeus, 1758	NT	
27. Family Recurvirostridae (stilts and avocets)					
132	Pied Avocet	<i>Recurvirostra avosetta</i>	Linnaeus, 1758	LC	
133	Black-winged Stilt	<i>Himantopus himantopus</i>	Linnaeus, 1758	LC	
28. Family Charadriidae (plovers & lapwings)					
134	Grey Plover	<i>Pluvialis squatarola</i>	Linnaeus, 1758	LC	
135	Pacific Golden Plover	<i>Pluvialis fulva</i>	Gmelin, JF, 1789	LC	
136	Common Ringed Plover	<i>Charadrius hiaticula</i>	Linnaeus, 1758	LC	
137	Little Ringed Plover	<i>Charadrius dubius</i>	Scopoli, 1786	LC	

SI.No.	English name	Species name	Authority	IUCN	END
138	Kentish Plover	<i>Charadrius alexandrinus</i>	Linnaeus, 1758	LC	
139	Lesser Sand Plover	<i>Charadrius mongolus</i>	Pallas, 1776	LC	
140	Greater Sand Plover	<i>Charadrius leschenaultii</i>	Lesson, 1826	LC	
141	Caspian Plover	<i>Charadrius asiaticus</i>	Pallas, 1773	LC	
142	Yellow-wattled Lapwing	<i>Vanellus malarbaricus</i>	Boddaert, 1783	LC	
143	Grey-headed Lapwing	<i>Vanellus cinereus</i>	Blyth, 1842	LC	
144	Red-wattled Lapwing	<i>Vanellus indicus</i>	Boddaert, 1783	LC	
145	Sociable Lapwing	<i>Vanellus gregarius</i>	Pallas, 1771	CR	
146	White-tailed Lapwing	<i>Vanellus leucurus</i>	Lichtenstein, MHK, 1823	LC	
29. Family Rostratulidae (painted- snipe)					
147	Greater Painted-snipe	<i>Rostratula benghalensis</i>	Linnaeus, 1758	LC	
30. Family Jacanidae (jacanas)					
148	Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>	Scopoli, 1786	LC	
149	Bronze-winged Jacana	<i>Metopidius indicus</i>	Latham, 1790	LC	
31. Family Scolopacidae (sandpipers)					
150	Whimbrel	<i>Numenius phaeopus</i>	Linnaeus, 1758	LC	
151	Eurasian Curlew	<i>Numenius arquata</i>	Linnaeus, 1758	NT	
152	Bar-tailed Godwit	<i>Limosa lapponica</i>	Linnaeus, 1758	NT	
153	Black-tailed Godwit	<i>Limosa limosa</i>	Linnaeus, 1758	NT	
154	Ruddy Turnstone	<i>Arenaria interpres</i>	Linnaeus, 1758	LC	
155	Great Knot	<i>Calidris tenuirostris</i>	Horsfield, 1821	EN	
156	Red Knot	<i>Calidris canutus</i>	Linnaeus, 1758	NT	
157	Ruff	<i>Calidris pugnax</i>	Linnaeus, 1758	LC	
158	Broad-billed Sandpiper	<i>Calidris falcinellus</i>	Pontoppidan, 1763	LC	
159	Curlew Sandpiper	<i>Calidris ferruginea</i>	Pontoppidan, 1763	NT	
160	Temminck's Stint	<i>Calidris temminckii</i>	Leisler, 1812	LC	
161	Long-toed Stint	<i>Calidris subminuta</i>	Middendorff, 1853	LC	
162	Sanderling	<i>Calidris alba</i>	Pallas, 1764	LC	
163	Dunlin	<i>Calidris alpina</i>	Linnaeus, 1758	LC	
164	Little Stint	<i>Calidris minuta</i>	Leisler, 1812	LC	
165	Buff-breasted Sandpiper	<i>Calidris subruficollis</i>	Vieillot, 1819	NT	
166	Pectoral Sandpiper	<i>Calidris melanotos</i>	Vieillot, 1819	LC	
167	Eurasian Woodcock	<i>Scolopax rusticola</i>	Linnaeus, 1758	LC	
168	Wood Snipe	<i>Gallinago nemoricola</i>	Hodgson, 1836	VU	
169	Pintail Snipe	<i>Gallinago stenura</i>	Bonaparte, 1831	LC	
170	Swinhoe's Snipe	<i>Gallinago megala</i>	Swinhoe, 1861	LC	
171	Common Snipe	<i>Gallinago gallinago</i>	Linnaeus, 1758	LC	

Sl.No.	English name	Species name	Authority	IUCN	END
172	Jack Snipe	<i>Lymnocyptes minimus</i>	Brünnich, 1764	LC	
173	Terek Sandpiper	<i>Xenus cinereus</i>	Güldenstädt, 1775	LC	
174	Common Sandpiper	<i>Actitis hypoleucos</i>	Linnaeus, 1758	LC	
175	Green Sandpiper	<i>Tringa ochropus</i>	Linnaeus, 1758	LC	
176	Spotted Redshank	<i>Tringa erythropus</i>	Pallas, 1764	LC	
177	Common Greenshank	<i>Tringa nebularia</i>	Gunnerus, 1767	LC	
178	Common Redshank	<i>Tringa totanus</i>	Linnaeus, 1758	LC	
179	Wood Sandpiper	<i>Tringa glareola</i>	Linnaeus, 1758	LC	
180	Marsh Sandpiper	<i>Tringa stagnatilis</i>	Bechstein, 1803	LC	
181	Red-necked Phalarope	<i>Phalaropus lobatus</i>	Linnaeus, 1758	LC	
32. Family Turnicidae (buttonquails)					
182	Yellow-legged Buttonquail	<i>Turnix tanki</i>	Blyth, 1843	LC	
183	Barred Buttonquail	<i>Turnix suscitator</i>	Gmelin, JF, 1789	LC	
33. Family Dromadidae (crab- plover)					
184	Crab-plover	<i>Dromas ardeola</i>	Paykull, 1805	LC	
34. Family Glareolidae (coursers and pratincoles)					
185	Indian Courser	<i>Cursorius coromandelicus</i>	Gmelin, JF, 1789	LC	
186	Collared Pratincole	<i>Glareola pratincola</i>	Linnaeus, 1766	LC	
187	Oriental Pratincole	<i>Glareola maldivarum</i>	Forster, JR, 1795	LC	
188	Little Pratincole	<i>Glareola lactea</i>	Temminck, 1820	LC	
35. Family Stercorariidae (skuas or jaegers)					
189	Long-tailed Skua	<i>Stercorarius longicaudus</i>	Vieillot, 1819	LC	
190	Arctic Skua	<i>Stercorarius parasiticus</i>	Linnaeus, 1758	LC	
191	Pomarine Skua	<i>Stercorarius pomarinus</i>	Temminck, 1815	LC	
192	South Polar Skua	<i>Stercorarius maccormicki</i>	Saunders, H, 1893	LC	
193	Brown Skua	<i>Stercorarius antarcticus</i>	Lesson, 1831	LC	
36. Family Laridae (gulls and terns)					
194	Brown Noddy	<i>Anous stolidus</i>	Linnaeus, 1758	LC	
195	Lesser Noddy	<i>Anous tenuirostris</i>	Temminck, 1823	LC	
196	White Tern	<i>Gygis alba</i>	Sparrman, 1786	LC	
197	Black-legged Kittiwake	<i>Rissa tridactyla</i>	Linnaeus, 1758	LC	
198	Sabine's Gull	<i>Xema sabini</i>	Sabine, 1819	LC	
199	Slender-billed Gull	<i>Chroicocephalus genei</i>	Brème, 1839	LC	
200	Brown-headed Gull	<i>Chroicocephalus brunnicephalus</i>	Jerdon, 1840	LC	
201	Black-headed Gull	<i>Chroicocephalus ridibundus</i>	Linnaeus, 1766	LC	

Sl.No.	English name	Species name	Authority	IUCN	END
202	Pallas's Gull	<i>Ichthyaetus ichthyaetus</i>	Pallas, 1773	LC	
203	Lesser Black-backed Gull	<i>Larus fuscus</i>	Linnaeus, 1758	LC	
204	Sooty Tern	<i>Onychoprion fuscatus</i>	Linnaeus, 1766	LC	
205	Bridled Tern	<i>Onychoprion anaethetus</i>	Scopoli, 1786	LC	
206	Little Tern	<i>Sternula albifrons</i>	Pallas, 1764	LC	
207	Gull-billed Tern	<i>Gelochelidon nilotica</i>	Gmelin, JF, 1789	LC	
208	Caspian Tern	<i>Hydroprogne caspia</i>	Pallas, 1770	LC	
209	Whiskered Tern	<i>Chlidonias hybrida</i>	Pallas, 1811	LC	
210	White-winged Tern	<i>Chlidonias leucopterus</i>	Temminck, 1815	LC	
211	River Tern	<i>Sterna aurantia</i>	Gray, JE, 1831	NT	
212	Roseate Tern	<i>Sterna dougallii</i>	Montagu, 1813	LC	
213	Common Tern	<i>Sterna hirundo</i>	Linnaeus, 1758	LC	
214	White-cheeked Tern	<i>Sterna repressa</i>	Hartert, 1916	LC	
215	Black-bellied Tern	<i>Sterna acuticauda</i>	Gray, JE, 1831	EN	
216	Lesser Crested Tern	<i>Thalasseus bengalensis</i>	Lesson, 1831	LC	
217	Sandwich Tern	<i>Thalasseus sandvicensis</i>	Latham, 1787	LC	
218	Greater Crested Tern	<i>Thalasseus bergii</i>	Lichtenstein, MHK, 1823	LC	
XIV. ORDER ACCIPITRIFORMES					
37. Family Pandionidae (osprey)					
219	Osprey	<i>Pandion haliaetus</i>	Linnaeus, 1758	LC	
38. Family Accipitridae (kites, hawks and eagles)					
220	Black-winged Kite	<i>Elanus caeruleus</i>	Desfontaines, 1789	LC	
221	Oriental Honey Buzzard	<i>Pernis ptilorhynchus</i>	Temminck, 1821	LC	
222	Jerdon's Baza	<i>Aviceda jerdoni</i>	Blyth, 1842	LC	
223	Black Baza	<i>Aviceda leuphotes</i>	Dumont, 1820	LC	
224	Egyptian Vulture	<i>Neophron percnopterus</i>	Linnaeus, 1758	EN	
225	Crested Serpent Eagle	<i>Spilornis cheela</i>	Latham, 1790	LC	
226	Short-toed Snake Eagle	<i>Circaetus gallicus</i>	Gmelin, JF, 1788	LC	
227	Red-headed Vulture	<i>Sarcogyps calvus</i>	Scopoli, 1786	EN	
228	Himalayan Vulture	<i>Gyps himalayensis</i>	Hume, 1869	NT	
229	White-rumped Vulture	<i>Gyps bengalensis</i>	Gmelin, JF, 1788	CR	
230	Indian Vulture	<i>Gyps indicus</i>	Scopoli, 1786	CR	
231	Cinereous Vulture	<i>Aegypius monachus</i>	Linnaeus, 1766	NT	
232	Mountain Hawk Eagle	<i>Nisaetus nipalensis</i>	Hodgson, 1836	LC	
233	Crested Hawk Eagle	<i>Nisaetus cirrhatus</i>	Gmelin, JF, 1788	LC	
234	Rufous-bellied Eagle	<i>Lophotriorchis kienerii</i>	de Sparre, 1835	LC	
235	Black Eagle	<i>Ictinaetus malaiensis</i>	Temminck, 1822	LC	

Sl.No.	English name	Species name	Authority	IUCN	END
236	Indian Spotted Eagle	<i>Clanga hastata</i>	Lesson, 1831	VU	
237	Greater Spotted Eagle	<i>Clanga clanga</i>	Pallas, 1811	VU	
238	Steppe Eagle	<i>Aquila nipalensis</i>	Hodgson, 1833	EN	
239	Eastern Imperial Eagle	<i>Aquila heliaca</i>	Savigny, 1809	VU	
240	Bonelli's Eagle	<i>Aquila fasciata</i>	Vieillot, 1822	LC	
241	Booted Eagle	<i>Hieraaetus pennatus</i>	Gmelin, JF, 1788	LC	
242	Western Marsh Harrier	<i>Circus aeruginosus</i>	Linnaeus, 1758	LC	
243	Hen Harrier	<i>Circus cyaneus</i>	Linnaeus, 1766	LC	
244	Pallid Harrier	<i>Circus macrourus</i>	Gmelin, SG, 1770	NT	
245	Pied Harrier	<i>Circus melanoleucos</i>	Pennant, 1769	LC	
246	Montagu's Harrier	<i>Circus pygargus</i>	Linnaeus, 1758	LC	
247	Crested Goshawk	<i>Accipiter trivirgatus</i>	Temminck, 1824	LC	
248	Shikra	<i>Accipiter badius</i>	Gmelin, JF, 1788	LC	
249	Besra	<i>Accipiter virgatus</i>	Temminck, 1822	LC	
250	Eurasian Sparrowhawk	<i>Accipiter nisus</i>	Linnaeus, 1758	LC	
251	White-bellied Sea Eagle	<i>Haliaeetus leucogaster</i>	Gmelin, JF, 1788	LC	
252	White-tailed Eagle	<i>Haliaeetus albicilla</i>	Linnaeus, 1758	LC	
253	Lesser Fish Eagle	<i>Ichthyophaga humilis</i>	Müller S & Schlegel, 1841	NT	
254	Grey-headed Fish Eagle	<i>Ichthyophaga ichthyaetus</i>	Horsfield, 1821	NT	
255	Brahminy Kite	<i>Haliastur indus</i>	Boddaert, 1783	LC	
256	Black Kite	<i>Milvus migrans</i>	Boddaert, 1783	LC	
257	White-eyed Buzzard	<i>Butastur teesa</i>	Franklin, 1831	LC	
258	Common Buzzard	<i>Buteo buteo</i>	Linnaeus, 1758	LC	
XV. ORDER STRIGIFORMES					
39. Family Tytonidae (barn owls)					
259	Bay Owl	<i>Phodilus badius</i>	Horsfield, 1821	LC	
260	Eastern Grass Owl	<i>Tyto longimembris</i>	Jerdon, 1839	LC	
261	Common Barn Owl	<i>Tyto alba</i>	Scopoli, 1769	LC	
40. Family Strigidae (owls)					
262	Brown Hawk Owl	<i>Ninox scutulata</i>	Raffles, 1822	LC	
263	Jungle Owlet	<i>Glaucidium radiatum</i>	Tickell, 1833	LC	
264	Spotted Owlet	<i>Athene brama</i>	Temminck, 1821	LC	
265	Pallid Scops Owl	<i>Otus brucei</i>	Hume, 1873	LC	
266	Oriental Scops Owl	<i>Otus sunia</i>	Hodgson, 1836	LC	
267	Indian Scops Owl	<i>Otus bakkamoena</i>	Pennant, 1769	LC	
268	Short-eared Owl	<i>Asio flammeus</i>	Pontoppidan, 1763	LC	
269	Mottled Wood Owl	<i>Strix ocellata</i>	Lesson, 1839	LC	

SI.No.	English name	Species name	Authority	IUCN	END
270	Brown Wood Owl	<i>Strix leptogrammica</i>	Temminck, 1832	LC	
271	Indian Eagle Owl	<i>Bubo bengalensis</i>	Franklin, 1831	LC	
272	Spot-bellied Eagle Owl	<i>Bubo nipalensis</i>	Hodgson, 1836	LC	
273	Brown Fish Owl	<i>Ketupa zeylonensis</i>	Gmelin, JF, 1788	LC	
XVI. ORDER TROGONIFORMES					
41. Family Trogonidae (trogons)					
274	Malabar Trogon	<i>Harpactes fasciatus</i>	Pennant, 1769	LC	
XVII. ORDER BUCEROTIFORMES					
42. Family Bucerotidae (hornbills)					
275	Great Hornbill	<i>Buceros bicornis</i>	Linnaeus, 1758	NT	
276	Malabar Pied Hornbill	<i>Anthracoceros coronatus</i>	Boddaert, 1783	NT	
277	Malabar Grey Hornbill	<i>Ocyrceros griseus</i>	Latham, 1790	LC	WG
278	Indian Grey Hornbill	<i>Ocyrceros birostris</i>	Scopoli, 1786	LC	
43. Family Upupidae (hoopoes)					
279	Common Hoopoe (Eurasian Hoopoe)	<i>Upupa epops</i>	Linnaeus, 1758	LC	
XVIII. ORDER PICIFORMES					
44. Family Picidae (woodpeckers)					
280	Northern Wryneck	<i>Jynx torquilla</i>	Linnaeus, 1758	LC	
281	Speckled Piculet	<i>Picumnus innominatus</i>	Burton, 1836	LC	
282	Heart-spotted Woodpecker	<i>Hemicircus canente</i>	Lesson, 1832	LC	
283	Common Golden- backed Woodpecker	<i>Dinopium javanense</i>	Ljungh, 1797	LC	
284	Lesser Golden-backed Woodpecker	<i>Dinopium benghalense</i>	Linnaeus, 1758	LC	
285	Rufous Woodpecker	<i>Micropternus brachyurus</i>	Vieillot, 1818	LC	
286	Lesser Yellow-naped Woodpecker	<i>Picus chlorolophus</i>	Vieillot, 1818	LC	
287	Streak-throated Woodpecker	<i>Picus xanthopygaeus</i>	Gray,JE & Gray, GR, 1847	LC	
288	White-bellied Woodpecker	<i>Dryocopus javensis</i>	Horsfield, 1821	LC	
289	Greater Golden-backed Woodpecker	<i>Chrysocolaptes lucidus</i>	Tickell, 1833	LC	
290	White-naped Woodpecker	<i>Chrysocolaptes festivus</i>	Boddaert, 1783	LC	
291	Brown-capped Pygmy Woodpecker	<i>Dendrocopos moluccensis</i>	Vigors, 1832	LC	
292	Yellow-crowned Woodpecker	<i>Dendrocopos mahrattensis</i>	Latham, 1801	LC	
45. Family Ramphastidae (toucans and barbets)					

Sl.No.	English name	Species name	Authority	IUCN	END
293	Brown-headed Barbet	<i>Psilopogon zeylanicus</i>	Gmelin, JF, 1788	LC	
294	White-cheeked Barbet	<i>Psilopogon viridis</i>	Boddaert, 1783	LC	
295	Malabar Barbet	<i>Psilopogon malabaricus</i>	Blyth, 1847	LC	WG
296	Coppersmith Barbet	<i>Psilopogon haemacephalus</i>	Statius Müller, 1776	LC	
XIX. ORDER CORACIIFORMES					
46. Family Meropidae (bee-eaters)					
297	Blue-bearded Bee-eater	<i>Nyctornis athertoni</i>	Jardine & Selby, 1828	LC	
298	Green Bee-eater	<i>Merops orientalis</i>	Latham, 1801	LC	
299	Chestnut-headed Bee-eater	<i>Merops leschenaulti</i>	Vieillot, 1817	LC	
300	Blue-tailed Bee-eater	<i>Merops philippinus</i>	Linnaeus, 1767	LC	
301	Blue-cheeked Bee-eater	<i>Merops persicus</i>	Pallas, 1773	LC	
47. Family Coraciidae (rollers)					
302	Indian Roller	<i>Coracias benghalensis</i>	Linnaeus, 1758	LC	
303	European Roller	<i>Coracias garrulus</i>	Linnaeus, 1758	LC	
304	Oriental Dollarbird	<i>Eurystomus orientalis</i>	Linnaeus, 1766	LC	
48. Family Alcedinidae (kingfishers)					
305	Oriental Dwarf Kingfisher	<i>Ceyx erithaca</i>	Linnaeus, 1758	LC	
306	Blue-eared Kingfisher	<i>Alcedo meninting</i>	Horsfield, 1821	LC	
307	Common Kingfisher	<i>Alcedo atthis</i>	Linnaeus, 1758	LC	
308	Pied Kingfisher	<i>Ceryle rudis</i>	Linnaeus, 1758	LC	
309	Stork-billed Kingfisher	<i>Pelargopsis capensis</i>	Linnaeus, 1766	LC	
310	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	Linnaeus, 1758	LC	
311	Black-capped Kingfisher	<i>Halcyon pileata</i>	Boddaert, 1783	LC	
XX. ORDER FALCONIFORMES					
49. Family Falconidae (falcons and caracaras)					
312	Lesser Kestrel	<i>Falco naumanni</i>	Fleischer, JG, 1818	LC	
313	Common Kestrel	<i>Falco tinnunculus</i>	Linnaeus, 1758	LC	
314	Red-necked Falcon	<i>Falco chicquera</i>	Daudin, 1800	NT	
315	Amur Falcon	<i>Falco amurensis</i>	Radde, 1863	LC	
316	Oriental Hobby	<i>Falco severus</i>	Horsfield, 1821	LC	
317	Peregrine Falcon	<i>Falco peregrinus</i>	Tunstall, 1771	LC	
XXI. ORDER PSITTACIFORMES					
50. Family Psittaculidae (old world parrots)					
318	Plum-headed Parakeet	<i>Psittacula cyanocephala</i>	Linnaeus, 1766	LC	
319	Malabar Parakeet	<i>Psittacula columboides</i>	Vigors, 1830	LC	WG
320	Alexandrine Parakeet	<i>Psittacula eupatria</i>	Linnaeus, 1766	NT	

Sl.No.	English name	Species name	Authority	IUCN	END
321	Rose-ringed Parakeet	<i>Psittacula krameri</i>	Scopoli, 1769	LC	
322	Vernal Hanging Parrot	<i>Loriculus vernalis</i>	Sparrman, 1787	LC	
XXII. ORDER PASSERIFORMES					
51. Family Pittidae (pittas)					
323	Indian Pitta	<i>Pitta brachyura</i>	Linnaeus, 1766	LC	
52. Family Campephagidae (minivets and cuckooshrikes)					
324	Small Minivet	<i>Pericrocotus cinnamomeus</i>	Linnaeus, 1766	LC	
325	Scarlet Minivet	<i>Pericrocotus flammeus</i>	Forster, JR, 1781	LC	
326	Ashy Minivet	<i>Pericrocotus divaricatus</i>	Raffles, 1822	LC	
327	Large Cuckooshrike	<i>Coracina javensis</i>	Lesson, 1831	LC	
328	Black-headed Cuckooshrike	<i>Lalage melanoptera</i>	Rüppell, 1839	LC	
53. Family Oriolidae (orioles, figbirds and allies)					
329	Black-hooded Oriole	<i>Oriolus xanthornus</i>	Linnaeus, 1758	LC	
330	Indian Golden Oriole	<i>Oriolus kundoo</i>	Sykes, 1832	LC	
331	Black-naped Oriole	<i>Oriolus chinensis</i>	Linnaeus, 1766	LC	
54. Family Artamidae (woodswallows, australian magpies and allies)					
332	Ashy Woodswallow	<i>Artamus fuscus</i>	Vieillot, 1817	LC	
55. Family Vangidae (vangas and helmet-shrikes)					
333	Bar-winged Flycatcher-shrike	<i>Hemipus picatus</i>	Sykes, 1832	LC	
334	Malabar Woodshrike	<i>Tephrodornis virgatus</i>	Raffles, 1822	LC	
335	Common Woodshrike	<i>Tephrodornis pondicerianus</i>	Gmelin, JF, 1789	LC	
56. Family Aegithinidae (ioras)					
336	Common Iora	<i>Aegithina tiphia</i>	Linnaeus, 1758	LC	
57. Family Dicruridae (drongos)					
337	Black Drongo	<i>Dicrurus macrocercus</i>	Vieillot, 1817	LC	
338	Ashy Drongo	<i>Dicrurus leucophaeus</i>	Vieillot, 1817	LC	
339	White-bellied Drongo	<i>Dicrurus caerulescens</i>	Linnaeus, 1758	LC	
340	Bronzed Drongo	<i>Dicrurus aeneus</i>	Vieillot, 1817	LC	
341	Hair-crested Drongo	<i>Dicrurus hottentottus</i>	Linnaeus, 1766	LC	
342	Greater Racket-tailed Drongo	<i>Dicrurus paradiseus</i>	Linnaeus, 1766	LC	
58. Family Rhipiduridae (fantails)					
343	White-browed Fantail	<i>Rhipidura aureola</i>	Lesson, 1831	LC	
59. Family Laniidae (shrikes)					
344	Brown Shrike	<i>Lanius cristatus</i>	Linnaeus, 1758	LC	
345	Bay-backed Shrike	<i>Lanius vittatus</i>	Valenciennes, 1826	LC	

Sl.No.	English name	Species name	Authority	IUCN	END
346	Long-tailed Shrike	<i>Lanius schach</i>	Linnaeus, 1758	LC	
60. Family Corvidae (crows and jays)					
347	Rufous Treepie	<i>Dendrocitta vagabunda</i>	Latham, 1790	LC	
348	White-bellied Treepie	<i>Dendrocitta leucogastra</i>	Gould, 1833	LC	WG
349	House Crow	<i>Corvus splendens</i>	Vieillot, 1817	LC	
350	Indian Jungle Crow	<i>Corvus macrorhynchos</i>	Wagler, 1827	LC	
61. Family Monarchidae (monarchs)					
351	Black-naped Monarch	<i>Hypothymis azurea</i>	Boddaert, 1783	LC	
352	Indian Paradise-flycatcher	<i>Terpsiphone paradisi</i>	Linnaeus, 1758	LC	
62. Family Dicaeidae (flowerpeckers)					
353	Thick-billed Flowerpecker	<i>Dicaeum agile</i>	Tickell, 1833	LC	
354	Pale-billed Flowerpecker	<i>Dicaeum erythrorhynchos</i>	Latham, 1790	LC	
355	Nilgiri Flowerpecker	<i>Dicaeum concolor</i>	Jerdon, 1840	LC	
63. Family Nectariniidae (sunbirds)					
356	Little Spiderhunter	<i>Arachnothera longirostra</i>	Latham, 1790	LC	
357	Purple-rumped Sunbird	<i>Leptocoma zeylonica</i>	Linnaeus, 1766	LC	
358	Crimson-backed Sunbird	<i>Leptocoma minima</i>	Sykes, 1832	LC	WG
359	Purple Sunbird	<i>Cinnyris asiaticus</i>	Latham, 1790	LC	
360	Long-billed Sunbird	<i>Cinnyris lotenius</i>	Linnaeus, 1766	LC	
64. Family Irenidae (fairy bluebirds and leafbirds)					
361	Asian Fairy-bluebird	<i>Irena puella</i>	Latham, 1790)	LC	
362	Golden-fronted Leafbird	<i>Chloropsis aurifrons</i>	Temminck, 1829	LC	
363	Jerdon's Leafbird	<i>Chloropsis jerdoni</i>	Blyth, 1844	LC	
65. Family Ploceidae (weavers)					
364	Streaked Weaver	<i>Ploceus manyar</i>	Horsfield, 1821	LC	
365	Baya Weaver	<i>Ploceus philippinus</i>	Linnaeus, 1766	LC	
66. Family Estrildidae (waxbills)					
367	Red Munia	<i>Amandava amandava</i>	Linnaeus, 1758	LC	
368	White-throated Munia	<i>Euodice malabarica</i>	Linnaeus, 1758	LC	
369	White-rumped Munia	<i>Lonchura striata</i>	Linnaeus, 1766	LC	
360	Scaly-breasted Munia	<i>Lonchura punctulata</i>	Linnaeus, 1758	LC	
370	Black-throated Munia	<i>Lonchura kelaarti</i>	Jerdon, 1863	LC	
371	Black-headed Munia	<i>Lonchura malacca</i>	Linnaeus, 1766	LC	
67. Family Passeridae (sparrows, snowfinches and allies)					
372	House Sparrow	<i>Passer domesticus</i>	Linnaeus, 1758	LC	
373	Yellow-throated Sparrow	<i>Gymnoris xanthocollis</i>	Burton, 1838	LC	

Sl.No.	English name	Species name	Authority	IUCN	END
68. Family Motacillidae (wagtails and pipits)					
374	Forest Wagtail	<i>Dendronanthus indicus</i>	Gmelin, JF, 1789	LC	
375	Tree Pipit	<i>Anthus trivialis</i>	Linnaeus, 1758	LC	
376	Olive-backed Pipit	<i>Anthus hodgsoni</i>	Richmond, 1907	LC	
377	Red-throated Pipit	<i>Anthus cervinus</i>	Pallas, 1811	LC	
378	Nilgiri Pipit	<i>Anthus nilghiriensis</i>	Sharpe, 1885	VU	WG
379	Richard's Pipit	<i>Anthus richardi</i>	Vieillot, 1818	LC	
380	Paddyfield Pipit	<i>Anthus rufulus</i>	Vieillot, 1818	LC	
381	Blyth's Pipit	<i>Anthus godlewskii</i>	Taczanowski, 1876	LC	
382	Tawny Pipit	<i>Anthus campestris</i>	Linnaeus, 1758	LC	
383	Long-billed Pipit	<i>Anthus similis</i>	Jerdon, 1840	LC	
384	Western Yellow Wagtail	<i>Motacilla flava</i>	Linnaeus, 1758	LC	
385	Grey Wagtail	<i>Motacilla cinerea</i>	Tunstall, 1771	LC	
386	Citrine Wagtail	<i>Motacilla citreola</i>	Pallas, 1776	LC	
387	White-browed Wagtail	<i>Motacilla maderaspatensis</i>	Gmelin, JF, 1789	LC	
388	White Wagtail	<i>Motacilla alba</i>	Linnaeus, 1758	LC	
69. Family Fringillidae (finches, euphonias and hawaiian honeycreepers)					
389	Common Rosefinch	<i>Erythrura erythrura</i>	Pallas, 1770	LC	
70. Family Emberizidae (old world buntings)					
390	Red-headed Bunting	<i>Granativora bruniceps</i>	von Brandt, JF, 1841	LC	
391	Black-headed Bunting	<i>Granativora melanocephala</i>	Scopoli, 1769	LC	
392	Grey-necked Bunting	<i>Emberiza buchanani</i>	Blyth, 1845	LC	
71. Family Stenostiridae (fairy flycatcher and crested -flycatchers)					
393	Grey-headed Canary-flycatcher	<i>Culicicapa ceylonensis</i>	Swainson, 1820	LC	
72. Family Paridae (tits, chickadees)					
394	Indian Great Tit	<i>Parus cinereus</i>	Vieillot, 1818	LC	
395	Indian Black-lored Tit	<i>Machlolophus xanthogenys</i>	Vigors, 1831	LC	
73. Family Alaudidae (larks)					
396	Rufous-tailed Lark	<i>Ammomanes phoenicura</i>	Franklin, 1831	LC	
397	Ashy-crowned Sparrow Lark	<i>Eremopterix griseus</i>	Scopoli, 1786	LC	
398	Jerdon's Bushlark	<i>Mirafra affinis</i>	Blyth, 1845	LC	
399	Greater Short-toed Lark	<i>Calandrella brachydactyla</i>	Leisler, 1814	LC	
400	Oriental Skylark	<i>Alauda gulgula</i>	Franklin, 1831	LC	
401	Malabar Lark	<i>Galerida malabarica</i>	Scopoli, 1786	LC	
74. Family Cisticolidae (cisticolas)					

SI.No.	English name	Species name	Authority	IUCN	END
402	Zitting Cisticola	<i>Cisticola juncidis</i>	Rafinesque, 1810	LC	
403	Golden-headed Cisticola	<i>Cisticola exilis</i>	Vigors & Horsfield, 1827	LC	
404	Grey-breasted Prinia	<i>Prinia hodgsonii</i>	Blyth, 1844	LC	
405	Jungle Prinia	<i>Prinia sylvatica</i>	Jerdon, 1840	LC	
406	Ashy Prinia	<i>Prinia socialis</i>	Sykes, 1832	LC	
407	Plain Prinia	<i>Prinia inornata</i>	Sykes, 1832	LC	
408	Common Tailorbird	<i>Orthotomus sutorius</i>	Pennant, 1769	LC	
75. Family Locustellidae (bush warblers)					
409	Rusty-rumped Warbler	<i>Locustella certhiola</i>	Pallas, 1811	LC	
410	Grasshopper Warbler	<i>Locustella naevia</i>	Boddaert, 1783	LC	
411	Broad-tailed Grass Warbler	<i>Schoenicola platyurus</i>	Jerdon, 1841	VU	WG
412	Bristled Grass Warbler	<i>Chaetornis striata</i>	Jerdon, 1841	VU	
76. Family Acrocephalidae (brush, reed and swamp warblers)					
413	Thick-billed Warbler	<i>Arundinax aedon</i>	Pallas, 1776	LC	
414	Booted Warbler	<i>Iduna caligata</i>	Lichtenstein, MHK, 1823	LC	
415	Sykes's Warbler	<i>Iduna rama</i>	Sykes, 1832	LC	
416	Blyth's Reed Warbler	<i>Acrocephalus dumetorum</i>	Blyth, 1849	LC	
417	Paddyfield Warbler	<i>Acrocephalus agricola</i>	Jerdon, 1845	LC	
418	Clamorous Reed Warbler	<i>Acrocephalus stentoreus</i>	Hemprich & Ehrenberg, 1833	LC	
77. Family Hirundinidae (swallows)					
419	Common House Martin	<i>Delichon urbicum</i>	Linnaeus, 1758	LC	
420	Streak-throated Swallow	<i>Petrochelidon fluvicola</i>	Blyth, 1855	LC	
421	Red-rumped Swallow	<i>Cecropis daurica</i>	Laxmann, 1769	LC	
422	Hill Swallow	<i>Hirundo tahitica</i>	Gmelin, 1789	LC	
423	Wire-tailed Swallow	<i>Hirundo smithii</i>	Leach, 1818	LC	
424	Barn Swallow	<i>Hirundo rustica</i>	Linnaeus, 1758	LC	
425	Eurasian Crag Martin	<i>Ptyonoprogne rupestris</i>	Scopoli, 1769	LC	
426	Dusky Crag Martin	<i>Ptyonoprogne concolor</i>	Sykes, 1832	LC	
427	Plain Martin	<i>Riparia paludicola</i>	Gray, JE, 1830	LC	
78. Family Pycnonotidae (bulbuls)					
428	Black Bulbul	<i>Hypsipetes leucocephalus</i>	Gmelin, 1789	LC	
429	Black-crested Bulbul	<i>Pycnonotus melanicterus</i>	Gmelin, 1789	LC	
430	Red-whiskered Bulbul	<i>Pycnonotus jocosus</i>	Linnaeus, 1758	LC	
431	Red-vented Bulbul	<i>Pycnonotus cafer</i>	Linnaeus, 1766	LC	
432	Yellow-throated Bulbul	<i>Pycnonotus xantholaemus</i>	Jerdon, 1845	VU	
433	White-browed Bulbul	<i>Pycnonotus luteolus</i>	Lesson, 1841	LC	

Sl.No.	English name	Species name	Authority	IUCN	END
434	Grey-headed Bulbul	<i>Brachypodius priocephalus</i>	Jerdon, 1839	NT	WG
435	Yellow-browed Bulbul	<i>Acritillas indica</i>	Jerdon, 1839	LC	
79. Family Phylloscopidae (old world leaf warblers)					
436	Hume's Leaf Warbler	<i>Abrornis humei</i>	Brooks, WE, 1878	LC	
437	Common Chiffchaff	<i>Phylloscopus collybita</i>	Vieillot, 1817	LC	
438	Tytler's Leaf Warbler	<i>Phylloscopus tytleri</i>	Brooks, WE, 1871	NT	
439	Tickell's Leaf Warbler	<i>Phylloscopus affinis</i>	Tickell, 1833	LC	
440	Green Leaf Warbler	<i>Seicercus nitidus</i>	Blyth, 1843	NE	
441	Greenish Leaf Warbler	<i>Seicercus trochiloides</i>	Sundevall, 1837	LC	
442	Large-billed Leaf Warbler	<i>Seicercus magnirostris</i>	Blyth, 1843	LC	
443	Western Crowned Warbler	<i>Seicercus occipitalis</i>	Blyth, 1845	LC	
80. Family Sylviidae (sylvia warblers, parrotbills and allies)					
444	Eastern Orphean Warbler	<i>Curruca crassirostris</i>	Cretzschmar, 1830	LC	
445	Lesser Whitethroat	<i>Curruca curruca</i>	Linnaeus, 1758	LC	
446	Yellow-eyed Babbler	<i>Chrysomma sinense</i>	Gmelin, JF, 1789	LC	
81. Family Zosteropidae (white- eyes)					
447	Oriental White-eye	<i>Zosterops palpebrosus</i>	Temminck, 1824	LC	
82. Family Timaliidae (scimitar babblers and allies)					
448	Indian Scimitar Babbler	<i>Pomatorhinus horsfieldii</i>	Sykes, 1832	LC	
449	Tawny-bellied Babbler	<i>Dumetia hyperythra</i>	Franklin, 1831	LC	
450	Dark-fronted Babbler	<i>Rhopocichla atriceps</i>	Jerdon, 1839	LC	
83. Family Pellorneidae (smaller babblers)					
451	Puff-throated Babbler	<i>Pellorneum ruficeps</i>	Swainson, 1832	LC	
84. Family Leiothrichidae (babblers, laughing-thrushes and allies)					
452	Quaker Tit Babbler	<i>Alcippe poioicephala</i>	Jerdon, 1841	LC	
453	Large Grey Babbler	<i>Argya malcolmi</i>	Sykes, 1832	LC	
454	Rufous Babbler	<i>Argya subrufa</i>	Jerdon, 1839	LC	WG
455	Jungle Babbler	<i>Turdoides striata</i>	Dumont, 1823	LC	
456	Yellow-billed Babbler	<i>Turdoides affinis</i>	Jerdon, 1845	LC	
457	Wynaad Laughing-thrush	<i>Garrulax delesserti</i>	Jerdon, 1839	LC	WG
458	Kerala Laughing-thrush	<i>Trochalopteron fairbanki</i>	Blanford, 1869	NT	WG
459	Black-chinned Laughing-thrush	<i>Trochalopteron cachinnans</i>	Jerdon, 1839	EN	WG
85. Family Sittidae (nuthatches, spotted creepers and wallcreeper)					
460	Chestnut-bellied Nuthatch	<i>Sitta castanea</i>	Lesson, 1830	LC	
461	Velvet-fronted Nuthatch	<i>Sitta frontalis</i>	Swainson, 1820	LC	
86. Family Sturnidae (starlings)					

462	Common Starling	<i>Sturnus vulgaris</i>	Linnaeus, 1758	LC	
463	Rosy Starling	<i>Pastor roseus</i>	Linnaeus, 1758	LC	
464	Brahminy Starling	<i>Sturnia pagodarum</i>	Gmelin, JF, 1789	LC	
465	Chestnut-tailed Starling	<i>Sturnia malabarica</i>	Gmelin, JF, 1789	LC	
466	Common Myna	<i>Acridotheres tristis</i>	Linnaeus, 1766	LC	
467	Jungle Myna	<i>Acridotheres fuscus</i>	Wagler, 1827	LC	
468	Southern Hill Myna	<i>Gracula religiosa</i>	Linnaeus, 1758	LC	
87. Family Muscicapidae (chats and flycatchers)					
469	Indian Robin	<i>Saxicoloides fulicatus</i>	Linnaeus, 1766	LC	
470	Oriental Magpie Robin	<i>Copsychus saularis</i>	Linnaeus, 1758	LC	
471	White-rumped Shama	<i>Kittacincla malabarica</i>	Scopoli, 1786	LC	
472	Asian Brown Flycatcher	<i>Muscicapa dauurica</i>	Raffles, 1822	LC	
473	Brown-breasted Flycatcher	<i>Muscicapa muttui</i>	Layard, EL, 1854	LC	
474	Rusty-tailed Flycatcher	<i>Muscicapa ruficauda</i>	Swainson, 1838	LC	
475	White-bellied Blue Flycatcher	<i>Cyornis pallidipes</i>	Jerdon, 1840	LC	WG
476	Tickell's Blue Flycatcher	<i>Cyornis tickelliae</i>	Blyth, 1843	LC	
477	Blue-throated Flycatcher	<i>Cyornis rubeculoides</i>	Vigors, 1831	LC	
477	Verditer Flycatcher	<i>Eumyias thalassinus</i>	Swainson, 1838	LC	
478	Nilgiri Flycatcher	<i>Eumyias albicaudatus</i>	Jerdon, 1840	NT	WG
480	White-bellied Shortwing	<i>Brachypteryx major</i>	Jerdon, 1844	EN	WG
481	Indian Blue Robin	<i>Larivora brunnea</i>	Hodgson, 1837	LC	
482	Bluethroat	<i>Luscinia svecica</i>	Linnaeus, 1758	LC	
483	Malabar Whistling Thrush	<i>Myophonus horsfieldii</i>	Vigors, 1831	LC	
484	Kashmir Flycatcher	<i>Ficedula subrubra</i>	Hartert & Steinbacher, 1934	VU	
485	Red-breasted Flycatcher	<i>Ficedula parva</i>	Bechstein, 1792	LC	
486	Taiga Flycatcher	<i>Ficedula albicilla</i>	Pallas, 1811	LC	
487	Yellow-rumped Flycatcher	<i>Ficedula zanthopygia</i>	Hay, 1845	LC	
488	Black-and-orange Flycatcher	<i>Ficedula nigrorufa</i>	Jerdon, 1839	NT	WG
489	Black Redstart	<i>Phoenicurus ochruros</i>	Gmelin, SG, 1774	LC	
490	Blue-capped Rock Thrush	<i>Monticola cinclorhyncha</i>	Vigors, 1831	LC	
491	Blue Rock Thrush	<i>Monticola solitarius</i>	Linnaeus, 1758	LC	
492	Siberian Stonechat	<i>Saxicola maurus</i>	Pallas, 1773	LC	
493	Pied Bushchat	<i>Saxicola caprata</i>	Linnaeus, 1766	LC	
494	Northern Wheatear	<i>Oenanthe oenanthe</i>	Linnaeus, 1758	LC	
495	Isabelline Wheatear	<i>Oenanthe isabellina</i>	Temminck, 1829	LC	

496	Desert Wheatear	<i>Oenanthe deserti</i>	Temminck, 1825	LC	
88. Family Turdidae (thrushes)					
497	Nilgiri Thrush	<i>Zoothera dauma</i>	Latham, 1790	LC	
498	Pied Thrush	<i>Geokichla wardii</i>	Blyth, 1843	LC	
499	Orange-headed Thrush	<i>Geokichla citrina</i>	Latham, 1790	LC	
500	Indian Blackbird	<i>Turdus simillimus</i>	Jerdon, 1839	NE	

B. Checklist of large and small Mammals found in Kerala

Sl. No.	Family	Common Name	Scientific Name
1	Erinaceidae	Madras Hedgehog	<i>Hemiechinus nudiventris</i> (Horsfield)
2	Soricidae	Common House Shrew	<i>Suncus murinus</i> (Linnaeus)
3		Savi's Pigmy Shrew	<i>Suncus. etruscus</i> (Savi)
4		Dayi's Shrew	<i>Suncus dayi</i> Dobson
5		Montane Shrew	<i>Suncus montanus</i> (Kelaart)
6		Kelaart's long -clawed Shrew	<i>Feroculus feroculus</i> (Kelaart)
7		Tupaiaidae	Indian Tree Shrew
8	Pteropodidae	Short -nosed Fruit Bat	<i>Cynopterus sphinx</i> (Vahl)
9		Lesser dog-faced Fruit Bat	<i>Cynopterus brachyotis</i> (Muller)
10		Great Indian Fruit Bat	<i>Pteropus giganteus</i> (Brunnich)
11		Indian Fulvous Fruit Bat	<i>Rousettus leschenaulti</i> (Desmarest)
12	Embellonuridae	Black- bearded Tomb Bat	<i>Taphozous melanopogon</i> Temminck
13		Long-winged Tomb Bat	<i>Taphozous longimanus</i> Hardwicke
14		Pouch bearing Bat	<i>Taphozous saccolaimus</i> Temminck
15	Megadermatidae	Large-eared Vampire Bat	<i>Megaderma lyra</i> E. Geoffroy
16		Malay False Vampire	<i>Megaderma spasma</i> Linnaeus
17	Hipposideridae	Fulvous Leaf- nosed Bat	<i>Hipposideros fulvus</i> Gray
18		Schneider's Leaf-nosed Bat	<i>Hipposideros speoris</i> (Schneider)
19		Dusky Leaf-nosed Bat	<i>Hipposideros ater</i> Templeton
20		Andersen's Leaf-nosed Bat	<i>Hipposideros pomona</i> Andersen
21	Rhinolophidae	Indian Horse-shoe Bat	<i>Rhinolophus rouxii</i> Temminck
22		Little Indian Horseshoe Bat	<i>Rhinolophus lepidus</i> Blyth
23		Lesser Woolly Horseshoe Bat	<i>Rhinolophus beddomei</i> Andersen
24	Molossidae	Egyptian Free Tailed Bat	<i>Tadarida aegyptiaca</i> (E. Geoffroy)
25	Vespertilionidae	Painted Bat	<i>Kerivoula picta</i> (Pallas)
26		Kelaart's Pipistrelle	<i>Pipistrellus ceylonicus</i> (Kelaart)
27		Least Pipistrelle	<i>Pipistrellus tenuis</i> (Temminck)
28		Chocolate Pipistrelle	<i>Pipistrellus affinis</i> (Dobson)
29		Dormer's Bat	<i>Pipistrellus dormeri</i> (Dobson)

Sl. No.	Family	Common Name	Scientific Name
30		Asiatic Greater Yellow House Bat	<i>Scotophilus heathii</i> Horsfield
31		Common Yellow Bat	<i>Scotophilus kuhlii</i> Leach
32		Bamboo Bat/ Flat-headed Bat	<i>Tylonecteris pachypus</i> (Temminck)
33		Peshwa's Bat	<i>Myotis horsfieldii</i> (Temminck)
34		Burmese Whiskered Bat	<i>Myotis montivagus</i> (Dobson)
35		Hairy-winged Bat	<i>Harpiocephalus harpia</i> (Temminck)
36	Lorisidae	Slender Loris	<i>Loris tardigradus</i> (Linnaeus)
37	Cercopithecidae	Bonnet Macaque	<i>Macaca radiata</i> (Geoffroy)
38		Lion-tailed Macaque	<i>Macaca silenus</i> (Linnaeus)
39		Common Langur	<i>Semnopithecus entellus</i> (Dufresne)
40		Nilgiri Langur	<i>Trachypithecus johnii</i> (J.Fischer)
41	Canidae	Jackal	<i>Canis aureus</i> Linnaeus
42		Indian Fox	<i>Vulpes bengalensis</i> (Shaw)
43		Indian Wild Dog/Dhole	<i>Cuon alpinus</i> (Pallas)
44	Ursidae	Sloth Bear	<i>Melursus ursinus</i> (Shaw)
45	Mustellidae	Clawless Otter	<i>Amblonyx cinereus</i> (Illiger)
46		Common/Eurasian Otter	<i>Lutra lutra</i> (Linnaeus)
47		Smooth-coated Otter	<i>Lutra perspicillata</i> L. Geoffroy
48		Nilgiri Marten	<i>Martes gwatkinsii</i> (Horsfield)
49	Viverridae	Palm civet/Toddy Cat	<i>Paradoxurus ermaproditus</i> (Pallas)
50		Brown Palm Civet	<i>Paradoxurus jerdoni</i> Blandford
51		Malabar Civet	<i>Viverra civettina</i> (Blyth)
52		Small Indian Civet	<i>Viverricula indica</i> (Desmarest)
53	Herpestidae	Common Mongoose	<i>Herpestes edwardsi</i> (Geoffroy)
54		Nilgiri Brown Mongoose	<i>Herpestes fuscus</i> Waterhouse
55		Ruddy Mongoose	<i>Herpestes smithi</i> Gray
56		Stripe-necked Mongoose	<i>Herpestes vitticollis</i> Bennett
57	Felidae	Tiger	<i>Panthera tigris</i> (Linnaeus)
58		Leopard/Panther	<i>Panthera pardus</i> (Linnaeus)
59		Leopard Cat	<i>Felis bengalensis</i> Kerr
60		Jungle Cat	<i>Felis chaus</i> Guldenstaedt
61		Rusty spotted Cat	<i>Felis rubiginosa</i> Geoffroy
62		Fishing Cat	<i>Felis viverrina</i> Bennett
63	Elephantidae	Asian Elephant	<i>Elephas maximus</i> Linnaeus
64	Suidae	Wild Boar	<i>Sus scrofa</i> Linnaeus
65	Tragulidae	Mouse Deer	<i>Tragulus meminna</i> (Erxleben)
66	Cervidae	Chital or Spotted Deer	<i>Axis axis</i> (Erxleben)
67		Sambar	<i>Cervus unicolor</i> Kerr

Sl. No.	Family	Common Name	Scientific Name
68		Barking Deer/Muntjac	<i>Muntiacus muntjak</i> (Zimmermann)
69	Bovidae	Four Horned Antelope	<i>Tetracerus quadricornis</i> (Blainville)
70		Gaur/Indian Bison	<i>Bos gaurus</i> H. Smith
71		Nilgiri Tahr	<i>Hemitragus hylocrius</i> (Ogilby)
72	Mantidae	Indian Pangolin	<i>Manis crassicaudata</i> Gray
73	Leporidae	Indian Hare/ Black-naped Hare	<i>Lepus nigricollis</i> F. Cuvier
74	Sciuridae	Three striped Palm Squirrel	<i>Funambulus palmarum</i> (Linnaeus)
75		Dusky Striped Squirrel	<i>Funambulus sublineatus</i> (Waterhouse)
76		Jungle Striped Squirrel	<i>Funambulus tristriatus</i> (Waterhouse)
77		Large Brown Flying Squirrel	<i>Petaurista philippensis</i> (Elliot)
78		Small Travancore Flying Squirrel	<i>Petinomys fuscocapillus</i> (Jerdon)
79		Indian Giant Squirrel	<i>Ratufa indica</i> (Erxleben)
80		Grizzled Giant Squirrel	<i>Ratufa macroura</i> (Pennant)
81	Platacanthomyidae	Malabar Spiny Dormouse	<i>Platacanthomys lasiurus</i> Blyth
82	Muridae	Indian Gerbil/ Antelope Rat	<i>Tatera indica</i> (Hardwicke)
83		Indian Mole Rat/ Lesser Bandicoot Rat	<i>Bandicota bengalensis</i> (Gray & Hardwicke)
84		Large Bandicoot Rat/ Pig Rat	<i>Bandicota indica</i> (Bechstein)
85		Common House Rat	<i>Rattus rattus</i> (Linnaeus)
86		Blanford's Rat/ White-tailed Wood Rat	<i>Rattus blanfordi</i> (Thomas)
87		Ranjini's Field Rat (Endemic to Kerala)	<i>Rattua ranjinae</i> Agarwal & Ghosal
88		Indian Long-tailed Tree Mouse	<i>Vandeleuria oleracea</i> (Bennett)
89		House Mouse	<i>Mus musculus</i> Linnaeus
90		Common Indian Field Mouse	<i>Mus booduga</i> (Gray)
91		Brown Spiny Mouse	<i>Mus platythrix</i> Bennett
92		Bonhote's Mouse	<i>Mus famulus</i> Bonhote
93	Hystriidae	Indian Porcupine	<i>Hystrix indica</i> Kerr
94	Dugongidae	Sea Cow/Dugong	<i>Dugong dugong</i> (Muller)
95	Delphinidae	Common Dolphin	<i>Delphinus delphis</i> Linnaeus
96		False Killer Whale	<i>Pseudorca crassidens</i> (Owen)
97		Plumbeous Dolphin	<i>Sousa chinensis</i> (Osbeck)
98		Spinner Dolphin	<i>Stenella longirostris</i> (Gray)
99		Bottlenosed Dolphin	<i>Tursiops truncatus</i> (Montagu)
100	Phocoenidae	Little Indian Porpoise	<i>Neophocaena phocoenoides</i> (G. Cuvier)
101	Physeteridae	Sperm Whale	<i>Physeter macrocephalus</i> Linnaeus
102		Owen's Pigmy Whale	<i>Kogia simus</i> (Owen)
103	Balaenopteridae	Blue Whale	<i>Blaenoptera musculus</i> (Linnaeus)
104		Bryde's Whale	<i>Blaenoptera edeni</i> Andersen
105		Minke Whale/ Piked Whale	<i>Blaenoptera acutorostrata</i> Lacepede

SI. No.	Family	Common Name	Scientific Name
106		Humpback Whale	<i>Megaptera novaengliae</i> (Borowski)

Source: Systematic List of Mammals of Kerala

(http://www.kerensis.nic.in/Database/Mammals_1286.aspx)

C. Major Threatened Reptile Species of Kerala State

	Binomial Name	Common Name	Endemism	IUCN Status
1	<i>Dermochelys coriacea</i> (Vandelli, 1761)	Leatherback		CR
2	<i>Eretmochelys imbricate</i> (Linnaeus, 1766)	Hawksbill Turtle		CR
3	<i>Ahaetulla perroteti</i> (Dum.&Bibr., 1854)	Western Ghats Bronzeback	WG	EN
4	<i>Caretta caretta</i> (Linnaeus, 1758)	Loggerhead sea turtle		EN
5	<i>Chelonia mydas</i> (Linnaeus, 1758)	Green Turtle		EN
6	<i>Cnemaspis wayanadensis</i> (Beddome, 1870)	Wayanad Day Gecko	K	EN
7	<i>Indotestudo forsteni</i> (Schlegel & Muller, 1845)	Travancore Tortoise	WG	EN
8	<i>Otocryptis beddomii</i> (Boulenger, 1885)	Indian Kangaroo Lizard	K	EN
9	<i>Pelochelys cantorii</i> (Gray, 1864)	Asian giant soft shell Turtle		EN
10	<i>Platyplectrurus madurensis</i> (Beddome, 1877)	Madurai Shieldtail	WG	EN
11	<i>Rhinophis travancoricus</i> (Boulenger, 1892)	Travancore Shieldtail	WG	EN
12	<i>Vijayachelys silvatica</i> (Henderson, 1912)	Cochin Forest Cane Turtle	WG	EN
13	<i>Cnemaspis indica</i> (Gray, 1846)	Nilgiri dwarf Gecko	WG	VU
14	<i>Cnemaspis indraneildasii</i> (Bauer, 2002)	Das's Day Gecko	WG	VU
15	<i>Crocodylus palustris</i> (Lesson,1831)	Mugger		VU
16	<i>Indotestudo travancorica</i> (Boulenger, 1907)	Travancore Tortoise	WG	VU
17	<i>Kaestlea laterimaculata</i> (Boulenger, 1887)	Side-spotted Ground Skink	WG	VU
18	<i>Lepidochelys olivacea</i> (Eschscholtz, 1829)	Olive Ridley		VU
19	<i>Melanophidium bilineatum</i> (Beddome, 1870)	Yellow-striped shieldtail	WG	VU
20	<i>Nilssonina leithii</i> (Gray, 1872)	Leiths soft shell turtle	PI	VU
21	<i>Oligodon brevicaudus</i> Gunther 1862)	Striped kukri snake	WG	VU
22	<i>Ophiophagus hannah</i> (Cantor, 1836)	King Cobra		VU
23	<i>Uropeltis phipsonii</i> (Mason, 1888)	Phipson'sShieldtail	WG	VU
24	<i>Ahaetulla dispar</i> (Gunther, 1864)	Gunther's Vine Snake	WG	NT
25	<i>Cnemaspis nairinger</i> (Max & Koshy, 1984)	Ponmudi Day Gecko	K	NT
26	<i>Cnemaspis ornata</i> (Beddome, 1870)	Ornate Day Gecko	WG	NT
27	<i>Cnemaspis sisparensis</i> (Theobald, 1876)	Sispara Day Gecko	K	NT
28	<i>Hemidactylus anamallensis</i> (Günther, 1875)	Anamalai Hill Gecko	WG	NT
29	<i>Melanochelys trijuga</i> (Schweigger, 1812)	Indian Black Turtle		NT
30	<i>Python molurus</i> (Linnaeus, 1758)	Asiatic Rock Python		NT
31	<i>Uropeltis bicatenata</i> (Cuvier, 1829)	Bicatenate Uropeltis	WG	NT

CR = Critically Endangered; EN = Endangered; NT = Near Threatened; VU = Vulnerable; K = Endemic to Kerala; WG = Endemic to Western Ghats; PI = Endemic to Peninsular India; Source: Kerala State Biodiversity Board

D. Butterflies of Kerala State

Family: Papilionidae		
	Scientific Name	Common Name
1	<i>Troides minos</i> (Cramer, 1779)	Southern Birdwing
2	<i>Pachliopta pandiyana</i> (Moore, 1881)	Malabar Rose
3	<i>Pachliopta aristolochiae</i> (Fabricius, 1775)	Common Rose
4	<i>Pachliopta hector</i> (Linnaeus, 1758)	Crimson Rose
5	<i>Graphium sarpedon</i> (Linnaeus, 1758)	Common Bluebottle
6	<i>Graphium doson</i> (C. & R. Felder, 1864)	Common Jay
7	<i>Graphium agamemnon</i> (Linnaeus, 1758)	Tailed Jay
8	<i>Graphium nomius</i> (Esper, 1785)	Spot Swordtail
9	<i>Graphium antiphates</i> (Cramer, 1775)	Five-bar Swordtail
10	<i>Papilio clytia</i> (Linnaeus, 1758)	Common Mime
11	<i>Papilio demoleus</i> (Linnaeus, 1758)	Lime Butterfly
12	<i>Papilio liomedon</i> (Moore, 1875)	Malabar Banded Swallowtail
13	<i>Papilio dravidarum</i> (Wood-Mason, 1880)	Malabar Raven
14	<i>Papilio helenus</i> (Linnaeus, 1758)	Red Helen
15	<i>Papilio polytes</i> (Linnaeus, 1758)	Common Mormon
16	<i>Papilio polymnestor</i> (Cramer, 1775)	Blue Mormon
17	<i>Papilio paris</i> (Linnaeus, 1758)	Paris Peacock
18	<i>Papilio Buddha</i> (Westwood, 1872)	Malabar Banded Peacock
19	<i>Papilio crino</i> (Fabricius, 1793)	Common Banded Peacock
Family: Pieridae		
1	<i>Catopsilia Pomona</i> (Fabricius, 1775)	Lemon Emigrant (Common Emigrant)
2	<i>Catopsilia pyranthe</i> (Linnaeus, 1758)	Mottled Emigrant
3	<i>Eurema brigitta</i> (Stoll, 1780)	Small Yellow (Small Grass Yellow)
4	<i>Eurema laeta</i> (Boisduval, 1836)	Spotless Grass Yellow
5	<i>Eurema hecabe</i> (Linnaeus, 1758)	Common Grass Yellow
6	<i>Eurema blanda</i> (Boisduval, 1836)	Three-spot Grass Yellow
7	<i>Eurema andersonii</i> (Moore, 1886)	One-spot Grass Yellow
8	<i>Co1ias nilagiriensis</i> (C. & R. Felder, 1859)	Nilgiri Clouded Yellow
9	<i>Delias eucharis</i> (Drury, 1773)	Common Jezebel
10	<i>Leptosia nina</i> (Fabricius, 1793)	Psyche
11	<i>Prioneris sita</i> (C. & R. Felder, 1865)	Painted Sawtooth
12	<i>Pieris canidia</i> (Sparrman, 1767)	Indian Cabbage White
13	<i>Cepora nerissa</i> (Fabricius, 1795)	Common Gull
14	<i>Cepora nadina</i> (Lucas, 1852)	Lesser Gull

15	<i>Anaphaeis aurota</i> (Fabricius,1793)	Caper White (Pioneer)
16	<i>Appias indra</i> (Moore,1858)	Plain Puffin
17	<i>Appias libythea</i> (Fabricius. 1775)	Striped Albatross
18	<i>Appias lycnida</i> (Cramer, 1779)	Chocolate Albatross
19	<i>Appias albino</i> (Felder)	Common Albatross
20	<i>Appias wardi</i> (Moore,1884)	Lesser Albatross
21	<i>Colotis amata</i> (Fabricius, 1775)	Small Salmon Arab
22	<i>Colotis etrida</i> (Boisduval, 1836)	Small Orange Tip
23	<i>Colotis aurora</i> (Cramer,1780)	Plain Orange Tip
24	<i>Colotis danae</i> (Fabricius, 1775)	Crimson Tip
25	<i>Colotis fausta</i> (Olivier, 1804)	Salmon Arab (Large Salmon Arab)
26	<i>Colotis phisadia</i> (Godart, 1819)	Blue-spotted Arab
27	<i>Colotis vestalis</i> (Butler, 1876)	White Arab
28	<i>Ixias marianne</i> (Cramer, 1779)	White Orange Tip
29	<i>Ixias pyrene</i> (Linnaeus, 1764)	Yellow Orange Tip
30	<i>Pareronia valeria</i> (Cramer,1776)	Common Wanderer
31	<i>Pareronia ceylanica</i> (C. & R. Felder, 1865)	Dark Wanderer
32	<i>Hebemoia glaucippe</i> (Linnaeus,1758)	Great Orange Tip
Family: Nymphalidae (Morphinae)		
1	<i>Discophora lepida</i> (Moore, 1858)	Southern Duffer
Family: Nymphalidae (Satyrinae)		
1	<i>Parantirrhoea marshalli</i> (Wood-Mason,1881)	Travancore Evening Brown
2	<i>Melanitis leda</i> (Linnaeus, 1758)	Common Evening Brown
3	<i>Melanitis zitenius</i> (Herbst, 1796)	Great Evening Brown
4	<i>Melanitis phedima</i> (Stoll, 1780)	Dark Evening Brown
5	<i>Elymnias hypermnestra</i> (Linnaeus, 1763)	Common Palmfly
6	<i>Lethe europa</i> (Fabricius, 1775)	Bamboo Tree Brown
7	<i>Lethe drypetis</i> (Hewitson,1868)	Tamil Tree Brown
8	<i>Lethe rohria</i> (Fabricius, 1787)	Common Tree Brown
9	<i>Mycalesis anaxias</i> (Hewitson, 1862)	White-bar Bushbrown
10	<i>Mycalesis perseus</i> (Fabricius, 1775)	Common Bushbrown
11	<i>Mycalesis mineus</i> (Linnaeus,1767)	Dark-brand Bushbrown
12	<i>Mycalesis subdita</i> (Moore)	Tamil Bushbrown
13	<i>Mycalesis igilia</i> (Fruhstorfer, 1909)	Small Long-brand Bushbrown
14	<i>Mycalesis visala</i> (Moore,1858)	Long-brand Bushbrown
15	<i>Mycalesis orcha</i>	Pale-brand Bushbrown
16	<i>Mycalesis patnia</i> (Moore, 1857)	Glad-eye Bushbrown
17	<i>Mycalesis oculus</i> (Marshall, 1881)	Red-disk Bushbrown

18	<i>Mycalesis adolphe</i> (Guerin-Meneville, 1843)	Red-eye Bushbrown
19	<i>Mycalesis davisoni</i> (Moore)	Lepcha Bushbrown
20	<i>Orsotriaena medus</i> (Fabricius, 1775)	Nigger
21	<i>Zipaeis saitis</i> (Hewitson, 1863)	Tamil Catseye
22	<i>Ypthima asterope</i> (Klug, 1832)	Common Three-ring
23	<i>Ypthima ceylonica</i> , (Hewitson, 1865)	Ceylon Four-ring
24	<i>Ypthima huebneri</i> (Kirby, 1871)	Common Four-ring
25	<i>Ypthima avanta</i> (Moore, 1875)	Jewel Four-ring
26	<i>Ypthima baldus</i> (Fabricius, 1775)	Common Five-ring
27	<i>Ypthima philomela</i> (Linnaeus, 1763)	Baby Five-ring
28	<i>Ypthima chenui</i> (Guerin-Meneville, 1843)	Nilgiri Four-ring
29	<i>Ypthima ypthimoides</i> (Moore, 1881)	Palni Four
30	<i>Polyura athamas</i> (Drury, 1773)	Common Nawab
31	<i>Polyura agrarian</i> (Swinhoe, 1887)	Anomalous Common Nawab
32	<i>Polyura schreiber</i> (Godart, 1824)	Blue Nawab
33	<i>Charaxes bemarkus</i> (Fabricius, 1793)	Tawny Rajah
34	<i>Charaxes solon</i> (Fabricius, 1793)	Black Rajah
35	<i>Acraea violae</i> (Fabricius, 1793)	Tawny Coster
36	<i>Cethosia nietneri</i> (C. & R. Felder, 1867)	Tamil Lacewing
37	<i>Vindula erota</i> (Fabricius, 1793)	Cruiser
38	<i>Cupha erymanthis</i> (Drury, 1773)	Rustic
39	<i>Phalanta phalantha</i> (Drury, 1773)	Leopard Butterfly (Common Leopard)
40	<i>Phalanta alcippe</i> (Stoll, 1782)	Small Leopard
41	<i>Cirrochroa thais</i> (Fabricius, 1787)	Tamil Yeoman
42	<i>Argyreus hyperbius</i> (Linnaeus, 1763)	Indian Fritillary
43	<i>Rohana parisatis</i> (Westwood, 1850)	Black Prince
44	<i>Euripus consimilis</i> (Westwood, 1850)	Painted Courtesan
45	<i>Neptis jumbah</i> (Moore, 1858)	Chestnut-streaked Sailer
46	<i>Neptis hylas</i> (Linnaeus, 1758)	Common Sailer
47	<i>Neptis clinia</i> (Moore, 1872)	Clear Sailer
48	<i>Neptis nata</i> (Moore, 1858)	Clear Sailer/Burmese Sailer
49	<i>Neptis soma</i> (Moore, 1858)	Sullied Sailer
50	<i>Neptis viraja</i> (Moore, 1872)	Yellowjack Sailer
51	<i>Pantoporia hordonia</i> (Stoll, 1790)	Common Lascar
52	<i>Pantoporia sandaka</i> (Butler, 1892)	Common Lascar
53	<i>Neptis columella</i> (Cramer, 1780)	Short-handed Sailer
54	<i>Athyma nefte</i> (Cramer, 1776)	Colour Sergeant
55	<i>Athyma selenophora</i> (Kollar, 1844)	Staff Sergeant

56	<i>Athyma ranga</i> (Moore,1858)	Blackvein Sergeant
57	<i>Athyma perius</i> (Linnaeus,1758)	Common Sergeant
58	<i>Limenitis procris</i> (Cramer,1777)	Commander
59	<i>Parthenos sylvia</i> (Cramer, 1775)	Clipper
60	<i>Tanaecia lepidea</i> (Butler, 1868)	Grey Count
61	<i>Euthalia telchinia</i> (Menetries, 1857)	Blue Baron
62	<i>Euthalia aconthea</i> (Cramer,1777)	Common Baron
63	<i>Euthalia 1ubentina</i> (Cramer, 1777)	Gaudy Baron
64	<i>Euthalia nais</i> (Forster,1771)	Red Baron (Baronet)
65	<i>Dophla evelina</i> (Stoll, 1790)	Red-spot Duke
66	<i>Byblia ithyia</i> (Drury,1773)	Joker
67	<i>Ariadne ariadne</i> (Linnaeus, 1763)	Angled Castor
68	<i>Ariadne merione</i> (Cramer,1777)	Common Castor
69	<i>Cyrestis thyodamas</i> (Boisduval, 1846)	Map Butterfly
70	<i>Libythea myrrha</i> (Godart,1819)	Club Beak
71	<i>Libythea 1epita</i> (Moore,1857)	Common Beak
72	<i>Junonia hierta</i> (Fabricius 1798)	Yellow Pans
73	<i>Junonia orithya</i> (Linnaeus, 1758)	Blue Pansy
74	<i>Junonia lemonias</i> (Linnaeus, 1758)	Lemon Pansy
75	<i>Junonia almana</i> (Linnaeus, 1758)	Peacock Pansy
76	<i>Junonia atlites</i> (Linnaeus, 1763)	Grey Pansy
77	<i>Junonia iphita</i> (Cramer,1779)	Chocolate Pansy
78	<i>Cynthia cardui</i> (Linnaeus, 1758)	Painted Lady
79	<i>Vanessa indica</i> (Herbst, 1794)	Indian Red Admiral
80	<i>Kaniska canace</i> (Linnaeus,1763)	Blue Admiral
81	<i>Hypolimnas misippus</i> (Linnaeus, 1764)	Danaid Eggfly
82	<i>Hypolimnas bolina</i> (Linnaeus, 1758)	Great Eggfly
83	<i>Doleschallia bisaltide</i> (Cramer, 1777)	Autumn Leaf
84	<i>Kalima horsfieldi</i> (Kollar, 1844)	South Indian Blue Oakleaf
85	<i>Kallima inachus</i> (Boisduval, 1846)	Orange Oakleaf
86	<i>Parantica aglea</i> (Stoll, 1782)	Glassy Blue Tiger (Glassy Tiger)
87	<i>Parantica nilgiriensis</i> (Moore,1877)	Nilgiri Tiger
88	<i>Tirumala limniace</i> (Cramer, 1775)	Blue Tiger
89	<i>Tirumala septentrionis</i> (Butler, 1874)	Dark Blue Tiger
90	<i>Danaus chrysippus</i> (Linnaeus, 1758)	Plain Tiger
91	<i>Danaus genutia</i> (Cramer, 1779)	Striped Tiger (Common Tiger)
92	<i>Euploea core</i> (Stoll, 1780)	Common Crow
92	<i>Euploea sylvester</i> (Fabricius, 1793)	Double-branded "Crow"

93	<i>Euploea klugii</i> (Moore,1858)	Brown King Crow
94	<i>Idea malabarica</i> (Moore, 1877)	Malabar Tree Nymph
95	<i>Abisera echerius</i> (Stoll, 1790)	Plum Judy
Family: Lycaenidae		
1	<i>Spalgis epius</i> (Westwood,1851)	Apefly
2	<i>Logania distanti</i> (Semper, 1889)	Mottle
3	<i>Castalius rosimon</i> (Fabricius, 1775)	Common Pierrot
4	<i>Caleta caleta</i> (Hewitson, 1876)	Angled Pierrot
5	<i>Discolampa ethion</i> (Westwood,1851)	Banded Blue Pierrot
6	<i>Tarucus ananda</i> (de Niceville, 1884)	Dark Pierrot
7	<i>Tarucus nara</i> (Kollar, 1844)	Striped Pierrot
8	<i>Tarucus callinara</i> (Butler,1866)	Spotted Pierrot
9	<i>Tarucus balkanicus</i> (Freyer,1844)	Little Tiger Blue
10	<i>Tarucus indicus</i> (Evans,1932)	
11	<i>Leptotes plinius</i> (Fabricius, 1793)	Zebra Blue
12	<i>Azanus ubaldus</i> (Stoll, 1782)	Bright Bulbul Blue
13	<i>Azanus uranus</i> (Butler, 1866)	Dull Babul Blue
14	<i>Azanus jesous</i> (Guerin-Meneville, 1847)	African Bulbul Blue
15	<i>Everes lacturnus</i> (Godart, 1824)	Indian Cupid
16	<i>Udara akasa</i> (Horsfield,1828)	White Hedge Blue
17	<i>Udara singalensis</i> (R. Felder, 1868)	Singalese Hedge Blue
18	<i>Acytolepis puspa</i> (Horsfield, 1828)	Common Hedge Blue
19	<i>Acytolepis lilacea</i> (Hampson, 1889)	Hampson's Hedge Blue
20	<i>Cyaniris albidisca</i> (Moore,1883)	Whitedisc Hedge Blue
21	<i>Celastrina lavendularis</i> (Moore, 1877)	Plain Hedge Blue
22	<i>Neopithecops zalmora</i> (Butler,1870)	Quaker
23	<i>Megisba malaya</i> (Horsfield,1828)	Malayan
24	<i>Pseudozizeeria maha</i> (Kollar,1844)	Pale Grass Blue
25	<i>Zizeeria karsandra</i> (Moore, 1865)	Dark Grass Blue
26	<i>Zizina otis</i> (Fabricius, 1787)	Lesser Grass Blue
27	<i>Zizula hylax</i> (Fabricius, 1775)	Tiny Grass Blue
28	<i>Chilades laius</i> (Cramer, 1782)	Lime Blue
29	<i>Chilades parrhasius</i> (Fabricius, 1793)	Small Cupid
30	<i>Chilades pandava</i> (Horsfield, 1829)	Plains Cupid
31	<i>Freyeria trochylus</i> (Freyer, 1845)	Grass Jewel
32	<i>Euchrysops cnejus</i> (Fabricius, 1798)	Gram Blue
33	<i>Catochrysops strabo</i> (Fabricius,1793)	Forget-me-not
34	<i>Catochrysops panormus</i> (Felder, 1860)	Silver Forget-me-not

35	<i>Lampides boeticus</i> (Linnaeus, 1767)	Pea Blue
36	<i>Jamides bochus</i> (Stoll, 1782)	Dark Cerulean
37	<i>Jamides ce1eno</i> (Cramer, 1775)	Common Cerulean
38	<i>Jamides alecto</i> (Felder, 1860)	Metallic Cerulean
39	<i>Nacaduba pactolus</i> (Felder, 1860)	Large Four-line Blue
40	<i>Nacaduba hermus</i> (Felder, 1860)	Pale Four-line Blue
41	<i>Nacaduba kurava</i> (Moore, 1858)	Transparent Six-line Blue
42	<i>Nacaduba calauria</i> (Felder, 1860)	Dark Ceylon Six-line Blue
43	<i>Nacaduba beroe</i> (Felder & Felder, 1865)	Opaque Six-line Blue
44	<i>Nacaduba berenice</i> (Herrich-Schäffer, 1869)	Rounded Six-line Blue
45	<i>Ionolyce helicon</i> (Felder, 1860)	Pointed Line-blue
46	<i>Prosotas nora</i> (Felder, 1860)	Common Line-blue
47	<i>Prosotas dubiosa</i> (Semper, 1879)	Tailless Line-blue
48	<i>Prosotas noreia</i> (Felder, 1868)	White-tipped Line-blue
49	<i>Petrelaea dana</i> (de Niceville, 1884)	Dingy Line-blue
50	<i>Talicauda nyseus</i> (Guerin-Meneville, 1843)	Red Pierrot
51	<i>Anthene emolus</i> (Godart, 1824)	Ciliate Blue
52	<i>Anthene lycaenina</i> (Felder, 1868)	Pointed Ciliate Blue
53	<i>Arhopala pseudocentaurus</i> (Doubleday, 1847)	Western Centaur Oakblue
54	<i>Arhopala amantes</i> (Hewitson, 1862)	Large Oakblue
55	<i>Arhopala alea</i> (Hewitson, 1862)	Kanara Oakblue
56	<i>Arhopala bazaloides</i> (Hewitson, 1878)	Tamil Oakblue
57	<i>Arhopala atrax</i> (Hewitson, 1862)	Indian Oakblue
58	<i>Arhopala abseus</i> (Hewitson, 1862)	Aberrant Oakblue
59	<i>Thaduka multicaudata</i> (Moore, 1879)	Many-tailed Oakblue
60	<i>Surendra quercetorum</i> (Moore, 1858)	Common Acacia Blue
61	<i>Zinaspas todara</i> (Moore, 1884)	Silver-streaked Acacia Blue
62	<i>Iraota timoleon</i> (Stoll, 1783)	Silver-streak Blue
63	<i>Amblypodia anita</i> (Hewitson, 1862)	Leaf Blue
64	<i>Spindasis vulcanus</i> (Fabricius, 1775)	Common Silverline
65	<i>Spindasis schistacea</i> (Moore, 1881)	Plumbeous Silverline
66	<i>Spindasis ictis</i> (Hewitson, 1865)	Shot Silverline
67	<i>Spindasis e1ima</i> (Moore, 1877)	Scarce Silverline
68	<i>Spindasis abnormis</i> (Moore, 1884)	Abnormal Silverline
69	<i>Spindasis lohita</i> (Horsfield, 1829)	Long-banded Silverline
70	<i>Apharitis lilacinus</i> (Moore, 1884)	Lilac Silverline
71	<i>Apharitis acamas</i> (Klug, 1834)	Tawny Silverline
72	<i>Loxura atymnus</i> (Stoll, 1780)	Yamfly

73	<i>Catapaecilma major</i> (Druce, 1895)	Common Tinsel
74	<i>Cheritra freja</i> (Fabricius, 1793)	Common Imperial
75	<i>Rathinda amor</i> (Fabricius, 1775)	Monkey Puzzle
76	<i>Horaga onyx</i> (Moore, 1858)	Common Onyx
77	<i>Horaga viola</i> (Moore, 1882)	Violet Onyx
78	<i>Zesius chrysomallus</i> (Hiibner, 1823)	Red Spot
79	<i>Ancema blanka</i> (De Niceville, 1894)	Silver Royal
80	<i>Creon cleobis</i> (Godart, 1824)	Broad-tail Royal
81	<i>Pratapa deva</i> (Moore, 1858)	White Royal
82	<i>Tajuria cippus</i> (Fabricius, 1798)	Peacock Royal
83	<i>Tajuria maculata</i> (Hewitson, 1865)	Spotted Royal
84	<i>Tajuria jehana</i> (Moore, 1884)	Plains Royal
85	<i>Tajuria melastigma</i> (De Niceville, 1887)	Branded Royal
86	<i>Eliotia jalindra</i> (Horsfield, 1829)	Banded Royal
87	<i>Hypolycaena nilgirica</i> (Moore, 1884)	Nilgiri Tit
88	<i>Hypolycaena othona</i> (Hewitson, 1865)	Orchid Tit
89	<i>Zeltus amasa</i> (Hewitson, 1865)	Fluffy Tit
90	<i>Deudorix epijarbas</i> (Moore, 1858)	Comelian
91	<i>Deudorix isocrates</i> (Fabricius, 1793)	Common Guava Blue
92	<i>Deudorix perse</i> (Hewitson, 1863)	Large Guava Blue
93	<i>Bindahara phocides</i> (Fabricius, 1793)	The Plane
94	<i>Rapala iarbus</i> (Fabricius, 1787)	Indian Red Flash
95	<i>Vadebra lankana</i> (Moore, 1879)	Malabar Flash
96	<i>Rapala manea</i> (Hewitson, 1863)	Slate Flash
97	<i>Rapala varuna</i> (Horsfield, 1829)	Indigo Flash
98	<i>Curetis thetis</i> (Drury, 1773)	Indian Sunbeam
99	<i>Curetis acuta</i> (Moore, 1877)	Dentate Sunbeam
100	<i>Curetis siva</i> (Evans, 1954)	Shiva Sunbeam
Family: Hesperidae		
1	<i>Bibasis jaina</i> (Moore, 1865)	Orange-striped Awl/Orange Awle
2	<i>Bibagig gomata</i> (Moore, 1866)	Pale Green Awlet
3	<i>Bibagig gena</i> (Moore, 1866)	Orange-tail Awl
4	<i>Hagora chromug</i> (Cramer, 1780)	Common Banded Awl
5	<i>Hagora taminatug</i> (Hubner, 1818)	White Banded Awl
6	<i>Hagora badra</i> (Moore, 1858)	Common Awl
7	<i>Hasora vitta</i> (Butler, 1870)	Plain Banded Awl
8	<i>Badamia exclamationig</i> (Fabriciug, 1775)	Brown Awl

9	<i>Choagepeg benjaminii</i> (Guerin-Meneville, 1843)	India Awking
10	<i>Celaenorrhinug leucocera</i> (Kollar , 1844)	Common Spotted Flat
11	<i>Celaenorrhinus ambareega</i> (Moore,1866)	Malabar Spotted Flat
12	<i>Celaenorrhinug ruficornis</i> (Mabille, 1879)	Tamil Spotted Flat
13	<i>Tagiadeg japetug</i> (Stoll, 1781)	Common Snow Flat
14	<i>Tagiades gana</i> (Moore, 1865)	Large/Suffused Snow Flat
15	<i>Tagiades litigiosa</i> (Moschler, 1878)	Water Snow Flat
16	<i>Gerosis bhagava</i> (Moore, 1866)	Common Yellow-breasted Flat
17	<i>Pseudocoladenia dan</i> (Fabricius, 1787)	Fulvous Pied Flat
18	<i>Coladenia indrani</i> (Moore, 1866)	Tricolour Flat
19	<i>Sarangesa dasahara</i> (Moore, 1866)	Common Small Flat
20	<i>Sarangesa purendra</i> (Moore, 1882)	Spotted Small Flat
21	<i>Tapena thwaitesi</i> (Moore,1881)	Angled Flat
22	<i>Odontoptilum angulatum</i> (Felder, 1862)	Banded Angle
23	<i>Odontoptilum ransonnetii</i> (Felder, 1868)	Golden Angle
24	<i>Caprona alida</i> (De Niceville, 1891)	Spotted Angle
25	<i>Caprona agama</i> (Moore, 1858)	Golden Angle (Spotted Angle)
26	<i>Gomalia elma</i> (Trimen, 1862)	African Mallow Skipper
27	<i>Spialia galba</i> (Fabricius, 1793)	Indian Grizzled Skipper
28	<i>Aeromachus pygmaeus</i> (Fabricius, 1775)	Pygmy Grass Hopper
29	<i>Aeromachus dubius</i> (Elwes & Edwards,1897)	Dingy Scrub Hopper
30	<i>Ampittia dioscorides</i> (Fabricius, 1793)	Bush Hopper
31	<i>Halpe homolea</i> (Hewitson, 1868)	Indian Ace
32	<i>Halpe porus</i> (Mabille,1877)	Moore's Ace
33	<i>Sovia hyrtacus</i> (De Niceville, 1897)	Bicolour Ace
34	<i>Thoressa honorei</i> (De Niceville,1887)	Madras Ace
35	<i>Thoressa astigmata</i> (Swinhoe,1890)	Unbranded Ace
36	<i>Thoressa sitala</i> (De Niceville, 1885)	Sitala Ace
37	<i>Thoressa evershedii</i> (Evans, 1910)	Evershed's Ace
38	<i>Iambrix salsala</i> (Moore,1866)	Chestnut Bob
39	<i>Psolos fuligo</i> (Mabille,1876)	Coon
40	<i>Notocrypta paralysos</i> (Wood-Mason & De Niceville,1881)	Common Banded Demon
41	<i>Notocrypta curvifascia</i> (Felder, 1862)	Restricted Demon
42	<i>Salanoemia sala</i> (Hewitson, 1866)	
43	<i>Udaspes folus</i> (Cramer, 1775)	Grass Demon
44	<i>Ametta mercara</i> (Evans,1932)	Coorg Forest Hopper
45	<i>Ametta vindhiana</i> (Moore,1884)	Vindhyan Bob
46	<i>Suastus gremius</i> (Fabricius, 1798)	Indian Palm Bob

47	<i>Suastus minutus</i> (Moore, 1877)	Small Palm Bob
48	<i>Cupitha purreea</i> (Moore, 1877)	Wax Dart
49	<i>Baracus vittatus</i> (Felder, 1862)	Hedge Hopper
50	<i>Hyarotis microsticta</i> (Wood-Mason & de Niceville, 1887)	
51	<i>Hyarotis adrastus</i> (Stoll, 1780)	Tree Flitter
52	<i>Quedara basiflava</i> (De Niceville, 1889)	Yellow-base Tree Flitter
53	<i>Gangara thyrsis</i> (Fabricius, 1775)	Giant Red-eye
54	<i>Erionota thrax</i> (Linnaeus, 1767)	Palm Red-eye
55	<i>Matapa aria</i> (Moore, 1866)	Common Red-eye
56	<i>Taractrocera maeuius</i> (Fabricius, 1793)	Common Grass Dart
57	<i>Taractrocera ceramas</i> (Hewitson, 1868)	Tamil Grass Dart
58	<i>Oriens concinna</i> (Elwes & Edwards, 1897)	Tamil Dartlet
59	<i>Potanthus pallida</i> (Evans, 1932)	Pallid Dart
60	<i>Potanthus pseudomaesa</i> (Moore, 1881)	Pseudomaesa Dart
61	<i>Potanthus confucius</i> (Felder, 1862)	Confucian Dart
62	<i>Potanthus pava</i> (Fruhstorfer, 1911)	Pava Dart
63	<i>Potanthus palnia</i> (Evans, 1914)	Palni Dart
64	<i>Telicota colon</i> (Fabricius, 1775)	Pale Palm Dart
65	<i>Telicota ancilla</i> (Herrich-Schaffer, 1869)	Dark Palm Dart
66	<i>Parnara bada</i> (Moore, 1878)	African Straight Swift
67	<i>Gegenes nostradamus</i> (Fabricius, 1793)	Dingy Swift
68	<i>Borbo bevani</i> (Moore, 18)	Bevan's Swift
69	<i>Borbo cinnara</i> (Wallace, 1866)	Rice Swift
70	<i>Pelopidas subochracea</i> (Moore, 1878)	Large Branded Swift
71	<i>Pelopidas agna</i> (Moore, 1866)	Dark Branded Swift
72	<i>Pelopidas mathias</i> (Fabricius, 1798)	Small Branded Swift
73	<i>Pelopidas conjuncta</i> (Herrich-Schaffer, 1869)	Conjoined Swift
74	<i>Pelopidas assamensis</i> (de Niceville, 1882)	Great Swift
75	<i>Pelopidas thrax</i> (Hubner, 1821)	White-banded Swift
76	<i>Polytremis lubricans</i> (Herrich-Schaffer, 1869)	Contiguous Swift
77	<i>Baoris farri</i> (Moore, 1878)	Paintbrush Swift
78	<i>Caltoris canaraica</i> (Moore, 1884)	Kanara Swift
79	<i>Caltoris kumara</i> (Moore, 1878)	Blank Swift
80	<i>Caltoris philippina</i> (Herrich-Schaffer, 1869)	Philippine Swift

Annexure 4
HYDROLOGY

A. Hydrological Environment Impact Zones

HYDROLOGICAL ENVIRONMENT IMPACT ZONES-SHSR-TVPM-KSRGD								
HEIZ no	DESCRIPTION	IMPACT GRADE	WS- AREA- KM2	FLOOD Q MAX m3/sec		REMARKS	RAIL LEVEL m	Flood level marks
				RATIONAL I=2.38cm/hr, C=0.25	RYVE'S C=21			
1	Veli Kayal	*	62	103	329	BRIDGE (B)	16.000	
2	Thettiyar	*	53	88	296	B	18.000	
7	Mamom River	**	104	172	464	B	20.915	
27	Kallada River	**	1632	2699	2911	B	19.448	
32	Achankovil	**	1388	2296	2613	B	17.797	
33	Venmany BRDG/ PADDY	*	0.69	1	16	B	13.011	
38	Pamba River	**	2034	3364	3050	B	17.570	
40A	Manimala	*	812	1343	1393	B	15.664	
48B	Panachikkad Brdg	*	6.09	10		B		
50	Meenachil River	**	1151	1904	2306	B	28.175	
54	Moovattupuzha River	**	1424	2355	2658	B	14.712	
62	Kadamprayar-1	*	43	71	258	B	8.382	
63	Kadamprayar	***	25	41	180	B	7.420	
64	Kadamprayar	*	43	71	258	B	5.949	
65	Kadamprayar-2	***	43	71	258	B/EKM STN	5.949	
66	Kadamprayar-5	*	43	71	258	B	5.949	
68	Kadaprayar-7	**	8	13	84	B	4.555	
71	Periar River	**	5104	8443	8893	B	17.371	
74	Manjali Thodu	***	149	246	590	B	10.707	
78	Chalakudy River	**	1615	2671	3028	B	6.584	
89	NANDHIPURAM THODU	**				B	4.000	
90	Karuvannur Puzha	**	1023	1692	2132	B	4.000	
91	Paddy/ Kadiyankulangara Canal	*	3	5	44	B	4.581	
96	Thannikudam Puzha	***	91	151	425	B	10.545	
117	Bharathapuzha	**	6080	10057	6662	B	6.716	8.1

121	River Tirur	*	48.35	80	279	B	11.183	
122	River Poorapuzha	*	1289.2	2132	2488	B	12.91	
123	Kadalundy	*	1213	2006	2389	B	6.000	
124	River-Kadalundi-li	*	14	23	122	B	15.571	
125	Chaliyar River	**	2893	4785	4264	B	13.488	
126	Kallayi River	*	60	99	322	B	12.811	6.3
127	Korapuzha	*	619	1024	1525	B	14.484	
130	Kuttiyadi River	*	574	949	1450	B	15.429	
134	Mahe River	*	376	622	1094	B	14.252	
139	Ancharakandy River	*	15	25	128	B	14.320	
143	Valapattanam River	*	1843	3049	3157	B	12.308	
146	Pazhayangadi River	*	525	868	1367	B	10.901	
147	Ramapuram	*	35	58	225	B	9.033	
149	Ezhimalai/ Chankurichal River	*	275	455	888	B	8.139	
150	Kavvayi River	*	96	159	440	B	4.000	
152	River	*	392	648	1125	B		
153	Tejaswini River	*	524	867	1365	B		
154	Nileswaram River	*	180	298	669	B		
155	Chittari-River	*	83	137	400	B		
156	Bakel River	*	26	43	184	B		
158	Uduma-River	***	113	187	491	B		
159	Chandragiri River	***	1388	2296	2613	B		
131	Deleted							
136	Deleted							
144	Kannapuram River Crossing	**	400	662	1140	B	9.483	
3	Murukumpuzha	*	3.18	5	45	BANKING (BNK)	14.849	
5	Thodu/Near Cutting	*	0.6	1	15	BNK	15.318	
29	Pond Water Logged	*	0.03	0	2	BNK	44.344	
49	River/Tributary-E	*	0.04	0	2	BNK	28.175	
61	Kadamprayar	*	43	71	258	BNK	7.420	
102	Paddy/Thodu /Kecheri	**	1.78	3	31	BNK	27.371	
106	Paddy/Thodu /Kecheri	**	6.6	11	74	BNK	5.742	
93	Canal/Thodu Cross	**	2.67	4	40	BNK	10.591	
133	Deleted							
140	River Crossing	*	18	30	144	BNK	18.497	
142	River Crossing	*	323	534	989	BNK	19.470	
151	Paddy/Thodu Cross	*	1.8	3	31	BNK		
160	Field/Paddy	*	2.89	5	43	BNK		
160 A	Field/Paddy	***	14.1	23	123	BNK		
6	Mamom Tributary	**	1.72	3	30	BNK	19.818	
145	Small Valley-E	*		0	0	BNK	10.901	
11	Valley/Paddy-E	**	0.07	0	4	BNK	28.094	

12	Thodu(Major)/Paddy-East&West Drainage	***	10	17	97	BNK	36.944	
13	Small Paddy Crossing	*	0.98	2	21	BNK	50.235	
14	Paddy/Marshy Land	*		0	0	BNK	52.392	
15	Paddy	*	0.23	0	8	BNK	38.544	
16	Small Paddy	*	0.21	0	7	BNK	38.542	
17	Paddy	*	0.31	1	10	BNK	38.684	
18	Small Paddy	*	0.05	0	3	BNK	41.684	
19	Kip Canal Cross	*	4	7	53	BNK	40.184	
20	Low Laying Pady/Big T	**	4	7	53	BNK	17.312	
22	Paddy/Thodu		2.7	4	41	BNK	19.549	
23	SENSITIVE –AYATHIL THODU-Tributaries-WET LAND	***	15.3	25	129	BNK / KOLLAM STN	7.845	
24	Paddy/Thodu	**	15.3	25	129	BNK	27.654	
26	Chittumala Chira	*	11	18	104	BNK	17.347	
28	Pond	*	32	53	212	BNK	33.157	
30	Paddy/Thodu	**	18	30	144	BNK	19.660	
31	Paddy/Thodu	*	18.48	31	147	BNK	23.600	
69	Paddy/Thodu	*	0.78	1	18	BNK	5.441	
107	Paddy/Thodu	*	5	8	61	BNK	10.617	1.45
35	Sensitive Paddy Thodu	*	1.55	3	28	BNK	23.450	
36	Small Paddy	*	5.45	9	65	BNK	27.457	
37	Paddy/Thodu	***	23.61	39	173	BNK	25.613	8.5
39	Paddy Thodu Puncha	***	3.91	6	52	BNK/ CHGNR STN	13.552	
40	Thodu	*	0.46	1	13	BNK	13.500	
41	Paddy	*	4	7	53	BNK	12.775	
42	Paddy Along Thodu Sensitive	***	0.87	1	19	BNK	14.238	3.9
43	Paddy Along Thodu	*	24	40	175	BNK	7.562	
44	Small Paddy	*	0.37	1	11	BNK	10.169	
45	Paddy Along Thodu	**	0.51	1	13	BNK	20.155	4.6
46	Paddy/Thodu	**	4	7	53	BNK	22.318	6.45
47	Paddy/Thodu	***	2.33	4	37	BNK	15.659	3.6
48	Thodu/Paddy Big-E	***	5	8	61	BNK	26.175	
48A	Thodu/Paddy Big-E	**	1.5	2	28	BNK		
51	Meenachil River Bank	*	0.35	1	10	BNK	12.824	
52	Small Paddy	*	0.08	0	4	BNK		
53	Paddy/Thodu	*	2.39	4	38	BNK	14.583	
55	Paddy/Thodu-E	*	0.87	1	19	BNK	12.164	
56	Paddy/Thodu-E	**	1.09	2	22	BNK	10.962	
57	Paddy/Thodu	*	1.1	2	22	BNK	20.097	
58	Paddy/Thodu	*	1	2	21	BNK	21.157	
60	Thodu Along Paddy	*	2.22	4	36	BNK	10.473	
67	Paddy/Thodu	**	18	30	144	BNK	13.626	
70	Paddy/Marshy Land	**	0.56	1	14	BNK	5.441	
72	Thodu/Paddy/ Marshy	*	1.7	3	30	BNK	17.267	
73	Cial/Flood Reach	*	12	20	110	BNK	16.105	

75	Paddy/Thodu	**	2.6	4	40	BNK	12.667	
76	Paddy/ Thodu	**	9.23	15	92	BNK	4	
77	Paddy Thodu	**	2	3	33	BNK	4	
79	Paddy/Water Logged	*	0.14	0	6	BNK	9.584	
80	Paddy/Thodu	***	48	79	277	BNK	10.084	
82	Water Logged Paddy	**	1.09	2	22	BNK	6.401	
84	Paddy/Thodu Cross	*	1	2	21	BNK	14.256	
86	Thoducross/ Paddy	*	11.3	19	106	BNK	7.992	
87	Thodu Cross/Paddy	**	11	18	104	BNK	8.453	
88	Paddy/Thodu Cross	*	5	8	61	BNK	4	
92	Paddy/Thodu Small	*	1.2	2	24	BNK	4.581	
95	Thodu/Old Rail Bridge	*	14.3	24	124	BNK	14.454	
97	Small Paddy/Thodu	**	58	96	315	BNK	10.777	
98	Small Paddy	*	0.44	1	12	BNK	13.027	
99	Paddy/Thodu	**	0.44	1	12	BNK	15.2	
100	Small Paddy/Thodu	**	0.32	1	10	BNK	15.2	
101	Paddy/Thodu	**	0.18	0	7	BNK	18.678	
104	Marshy/Paddy	***	3.7	6	50	BNK	7.287	
105	Paddy/Thodu	***	1.16	2	23	BNK	10.617	
108	Side Of Paddy	**	2	3	33	BNK	14.6	
109	Paddy/Thodu	***	73	121	367	BNK	5.999	
110	Side Of Paddy	*	1.6	3	29	BNK	5.999	
111	Paddy/Thodu	**	0.04	0	2	BNK	5.999	
113	Small Paddy	***	3.4	6	47	BNK	17.375	
114	Paddy/Thodu Cross	***	13	22	116	BNK	16.471	
115	Small Paddy	*	1.07	2	22	BNK	11.964	
116	Paddy	*		0	0	BNK	9.969	
118	Paddy/ Thodu	**	28	46	194	BNK	6.716	
119	Paddy Near V/D	**	18	30	144	BNK	11.699	
128	Deleted							
129	Deleted							
132	Deleted							
135	River-Thalassery	**	8.7	14	89	BNK	12.814	
137	Deleted							
138	Marshy Land	**	1.2	2	24	BNK	22.185	
148	Paddy/Marshy Land	*	7.43	12	80	BNK	8.139	
157	Paddy Small	**	0.73	1	17	BNK		
25	Paddy /Valley	*	1.4	2	26	BNK	36.743	
81	Paddy/Thodu	*	1.11	2	23	BNK	10.906	
83	Small Paddy	*	0.42	1	12	BNK	6.401	
85	Paddy/Thodu	*	0.07	0	4	BNK	17.169	
120	Rivulet Existing Bdg D/S	*	49	81	281	BNK	11.445	
4	Kadinamkulam Kayal	*	4	7	53	VIADUCT (VD)	17.563	
8	Vamanapuram River	**	648	1072	1573	VD	17.156	
9	Vamanapuram River	**	648	1072	1573	VD	20.687	
10	Vamanapuram River	**	648	1072	1573	VD	20.687	
21	Ithikkara River	*	624	1032	1533	VD	17.52	
34	Paddy/Thodu(Big)	*	0.58	1	15	VD	19.505	

49A	Keezhkundu-Tributory-Meenachil	*				VD		
89A	NANDHIPURAM THODU-VD Nearby	*				VD	4.000	
94	CANAL/THODU CROSS-VD Nearby	**	14.38	24	124	VD	6.000	
103	Kecheri River	*	382	632	1106	VD	14.004	
112	Kannirmukku Puzha	*	38	63	237	VD	8.489	
141	Deleted							
59	Deleted							
LEGEND								
*	MODERATE IMPACT 91zones - 30 bridge and 7 viaduct							
**	HIGH IMPACT 51zones -15 bridge and 4 viaduct (some of Viaducts are omitted due to lesser impact)							
***	VERY HIGH IMPACT 22zones -63,65,74,89,96,158&159 are proposed bridge sites(7)							

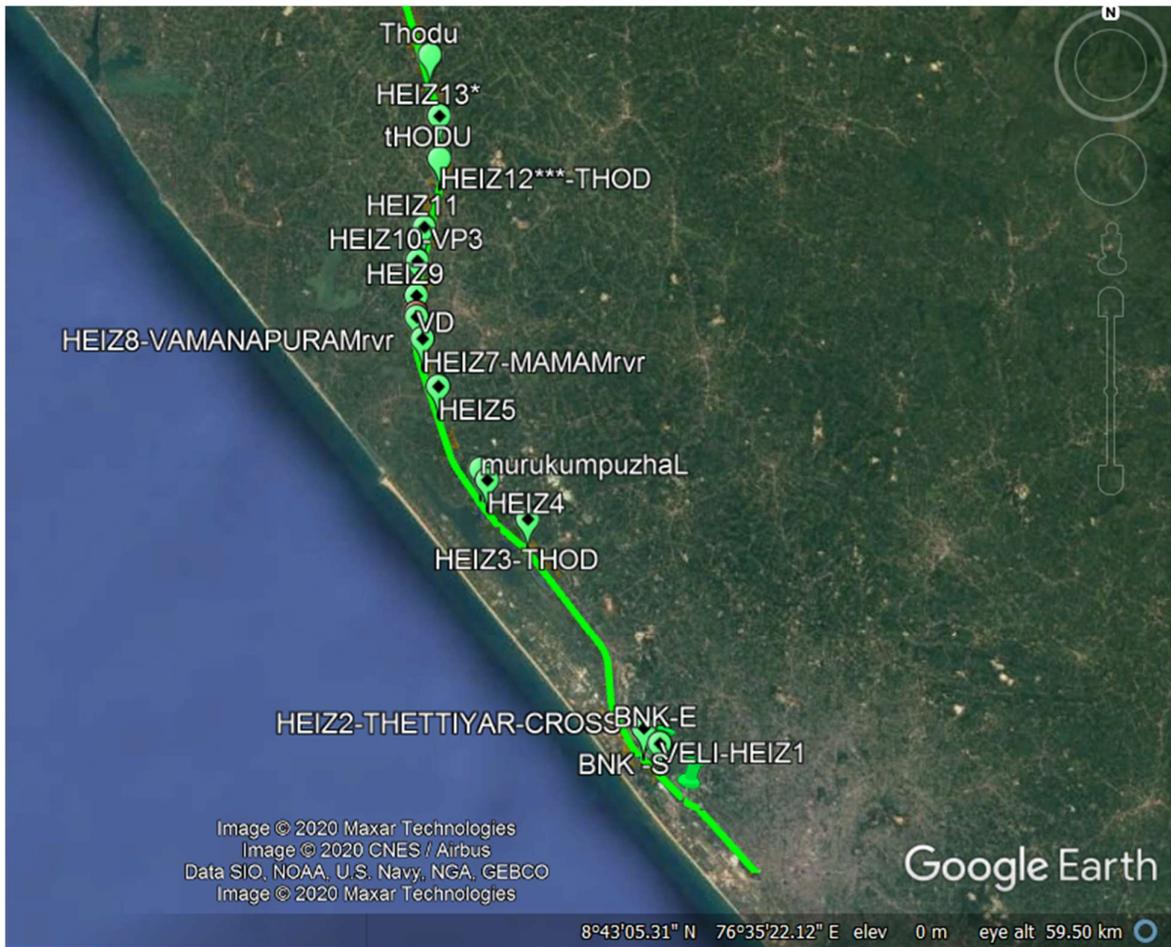
The following table shows the HEI Zones which were highly prone to flooding with a stream or thodu crossing and as per SHSR-report no bridge or viaduct are proposed. It is recommended to reconsider these points and providing appropriate cross drainage to avoid flood risk.

Zones	Place	Watershed Area(km ²)	Flood Discharge (m ³ /sec)	Present Proposal of SHSR	Recommended Proposal
HEIZ 3 *	Murukumpuzha	3.18	5.00	Banking	Bridge/Culvert
HEIZ 5*	Eala near Mudapuram	0.60	1.00	Banking	Bridge/Culvert
HEIZ 12 ***	Parakkulam	10.00	17.00	Banking	Bridge/VD
HEIZ 20 **	Meenadu	4.00	7.00	Banking	Bridge/Culvert
HEIZ 26 **	Maruthoor	11.00	18.00	Banking	Bridge/VD
HEIZ 30 **	Thottuva	18.00	30.00	Banking	Bridge/VD
HEIZ 31 *	Kallappanchira	18.48	31.00	Banking	Bridge
HEIZ 37 ***	Kurichimuttam	23.61	39.00	Banking	Bridge
HEIZ 39 *	Koipuram	3.91	6.00	Banking	Culvert
HEIZ 46 **	Vakathanam	4.00	7.00	Banking	Culvert
HEIZ 47***	Pathyapally	2.33	4.00	Banking	Bridge/Culvert
HEIZ 53 ***	Vadakunnampuzha	2.39	4.00	Banking	Bridge/Culvert

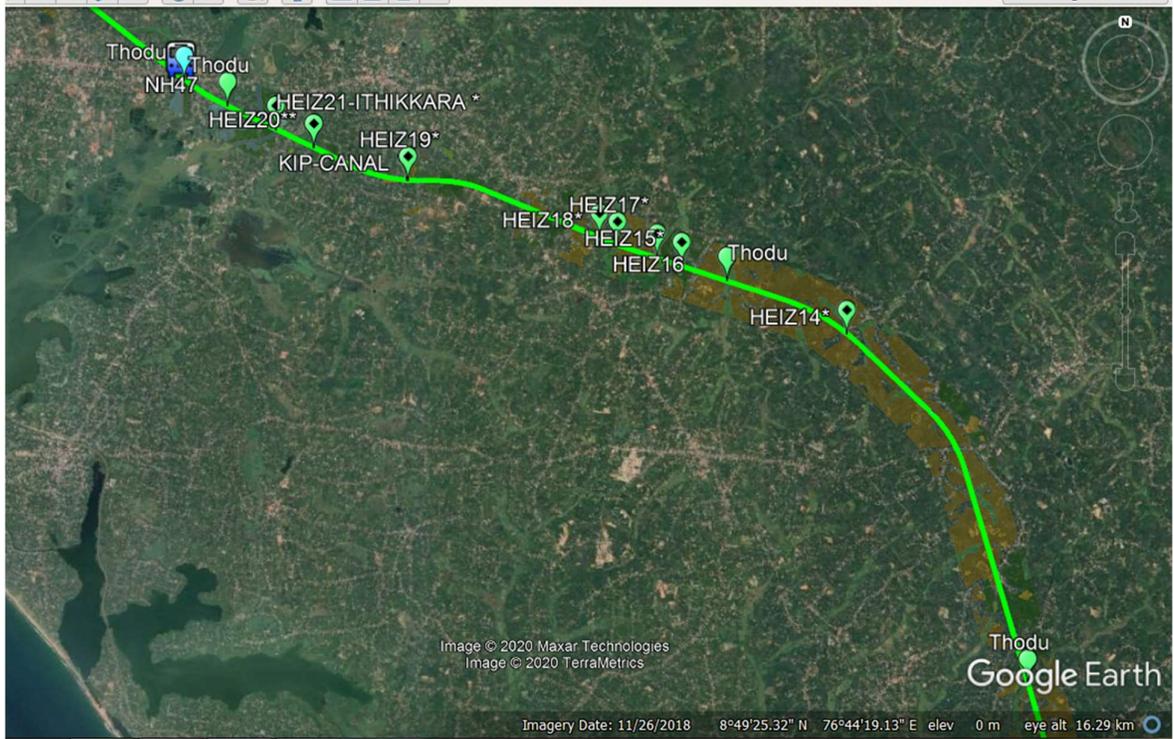
HEIZ 61 ***	Chottanikkara-Kadambrayar/3 croses	43.00	71.00	Banking	River deviation/Bridges
HEIZ 80 ***	Edayattoor	48.00	79.00	Banking	Bridge
HEIZ 87 **	Kaduppassery	11.00	18.00	Banking	Bridge
HEIZ 96 **	Thannikudam River	91.00	151.00	Banking	Bridge
HEIZ 97 **	Peramangalam	58.00	96.00	Banking	Bridge
HEIZ 102 **	Eranallur	1.78	3.00	Banking	Culvert
HEIZ 106 **	Panthalloor-Near Viaduct	6.60	11.00	Banking	Extend VD
HEIZ 108 **	Porkulam	2.00	3.00	Banking	Culvert
HEIZ 109***	Othallur west	73.00	121.00	Banking	Bridge
HEIZ 113 ***	Kolathara	13.00	6.00	Banking	Bridge/Culvert
HEIZ 114 ***	Maravanchery	13.00	22.00	Banking	Bridge
HEIZ 118 **	Thirunavaya	28.00	46.00	Banking	Bridge
HEIZ 120 **	Kattachira-Upstream Bridge /Old rail line	49.00	81.00	Banking	Bridge

B. Hydrological Environment Impact Zones – Google Earth

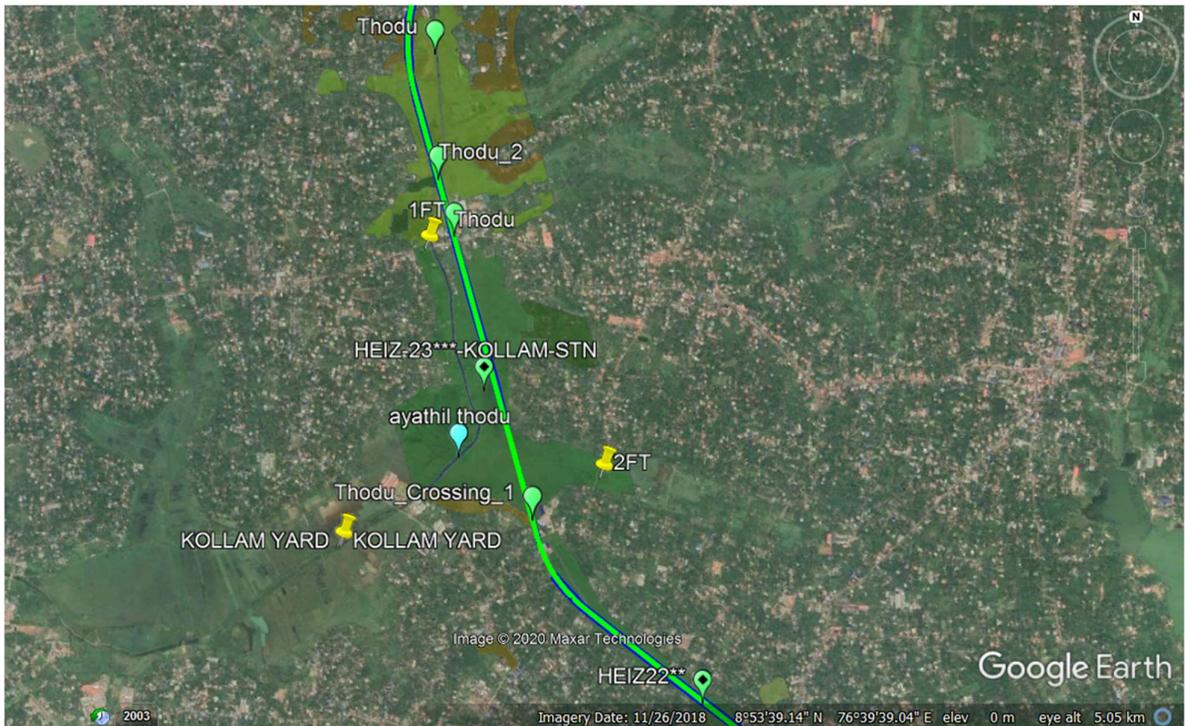
Google-Map-HEIZ (location)-screen shot -1



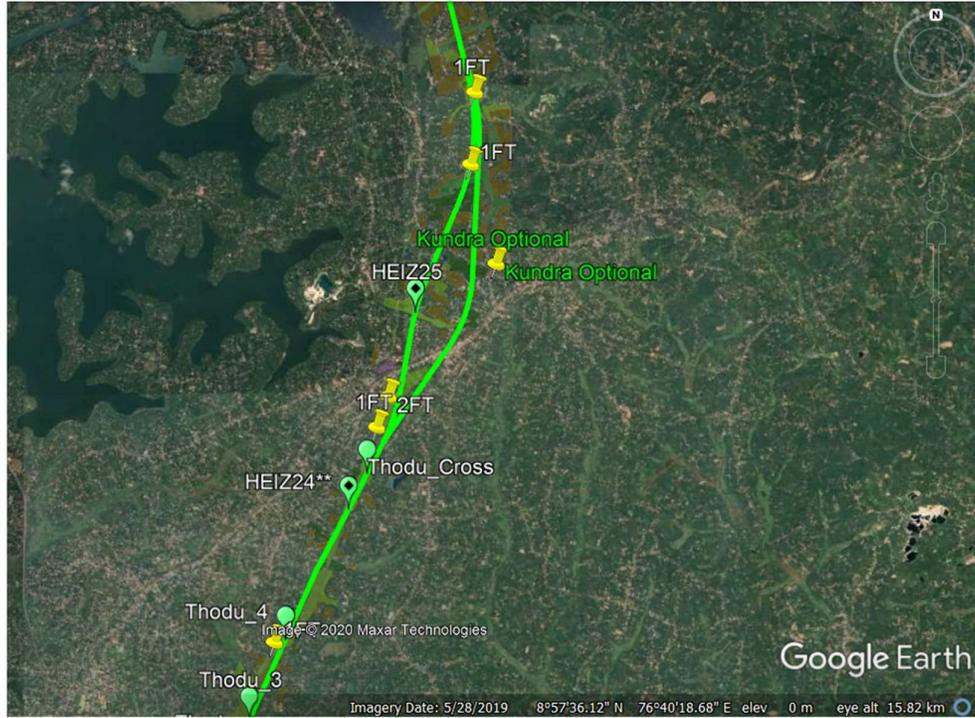
Google-Map-HEIZ (location)-screen shot -2



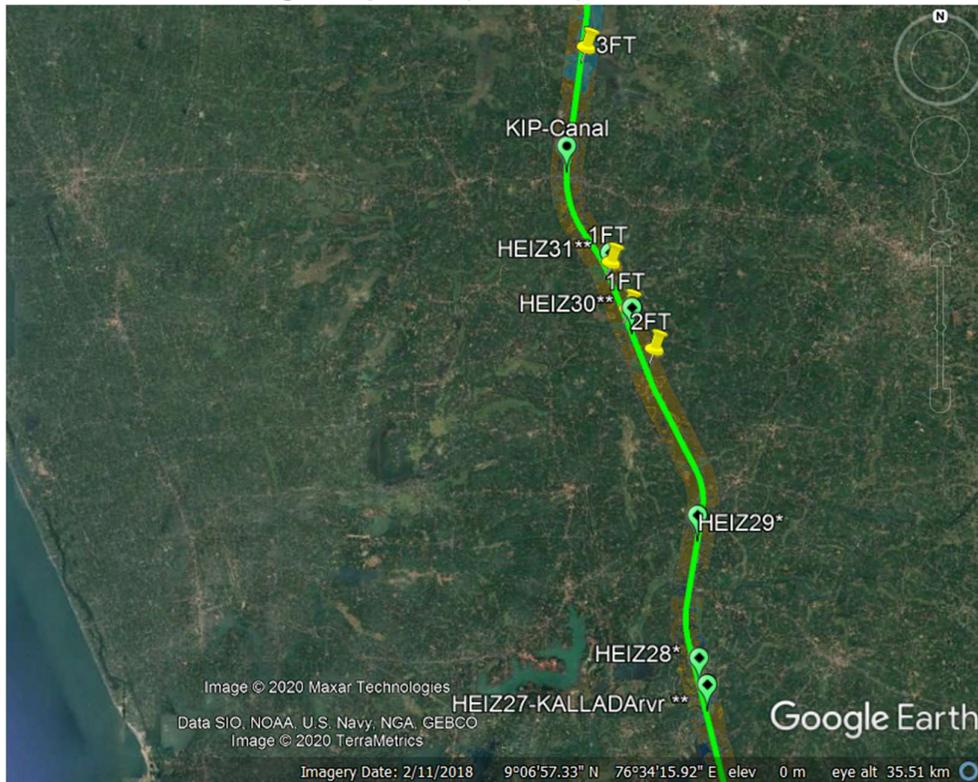
Google-Map-HEIZ (location)-screen shot-3



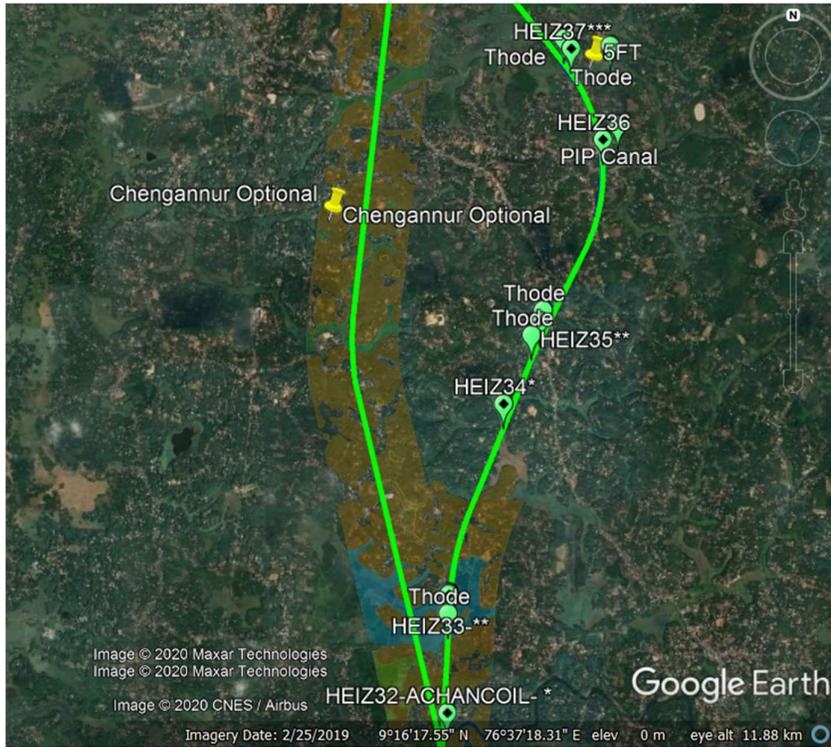
Google-Map-HEIZ (location)-screen shot-4



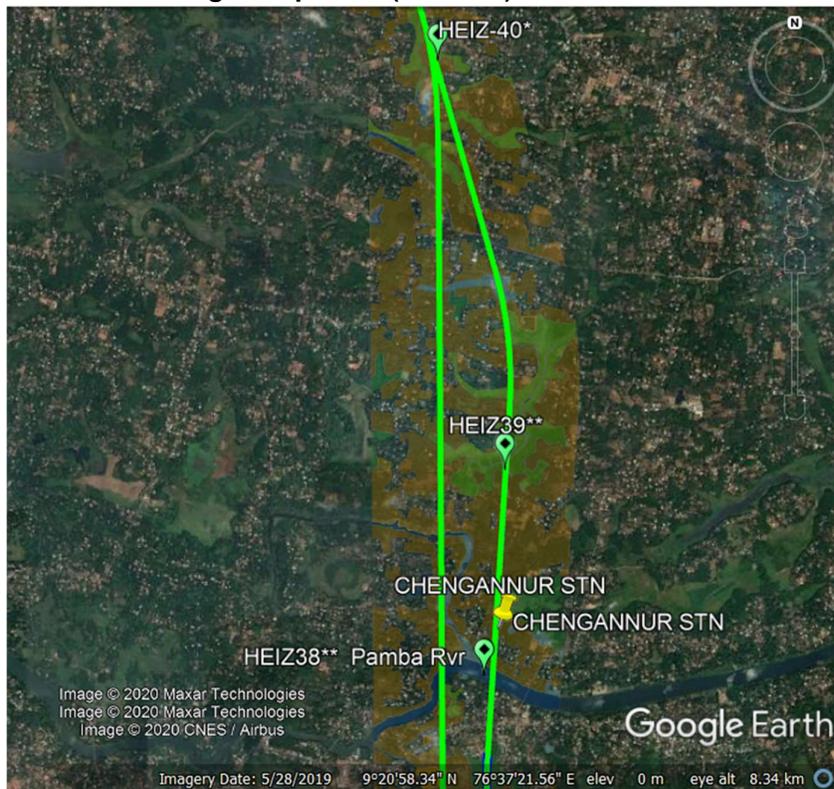
Google-Map-HEIZ (location)-screen shot-5



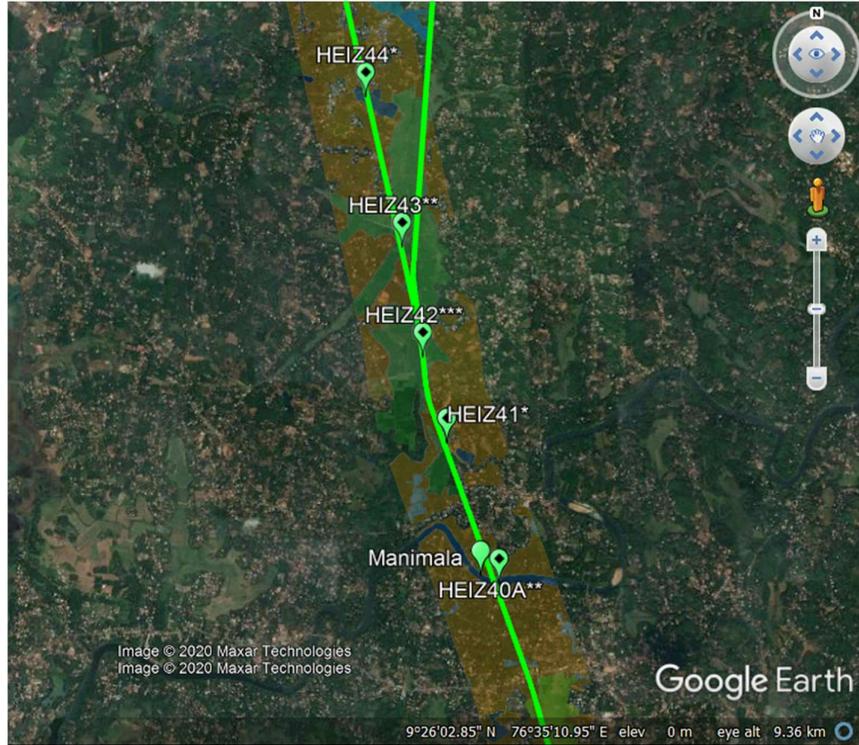
Google-Map-HEIZ (location)-screen shot-6



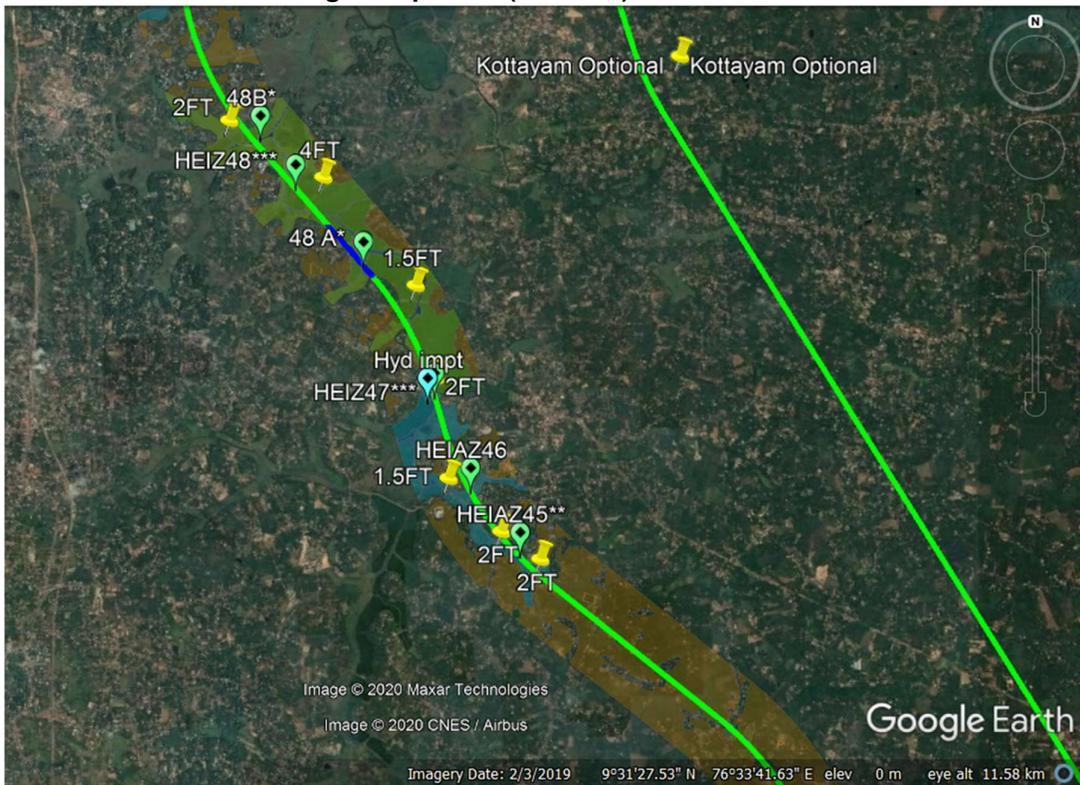
Google-Map-HEIZ (location)-screen shot-7



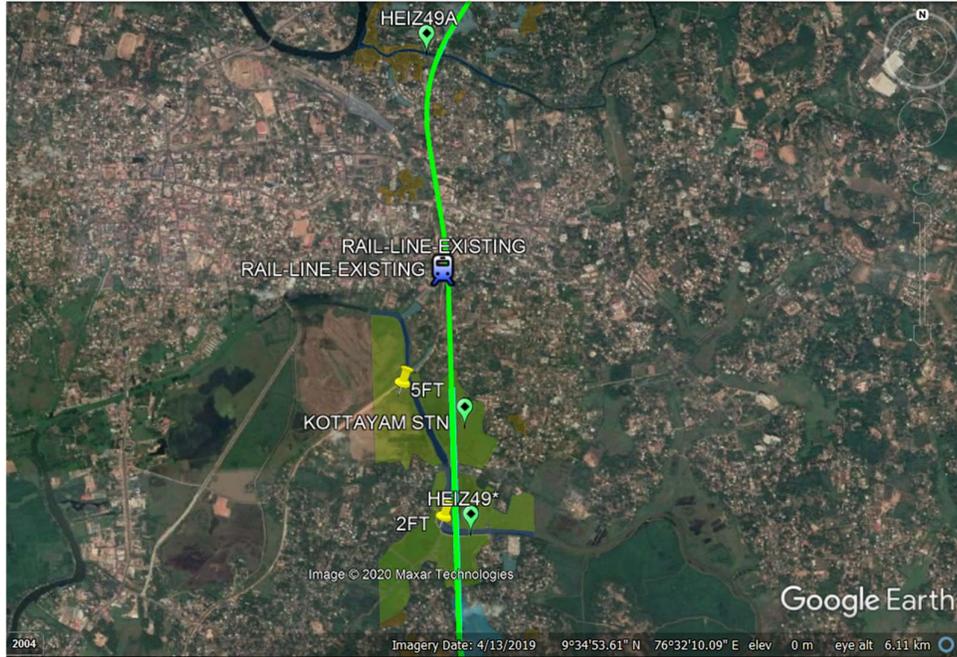
Google-Map-HEIZ (location)-screen shot-8



Google-Map-HEIZ (location)-screen shot-9



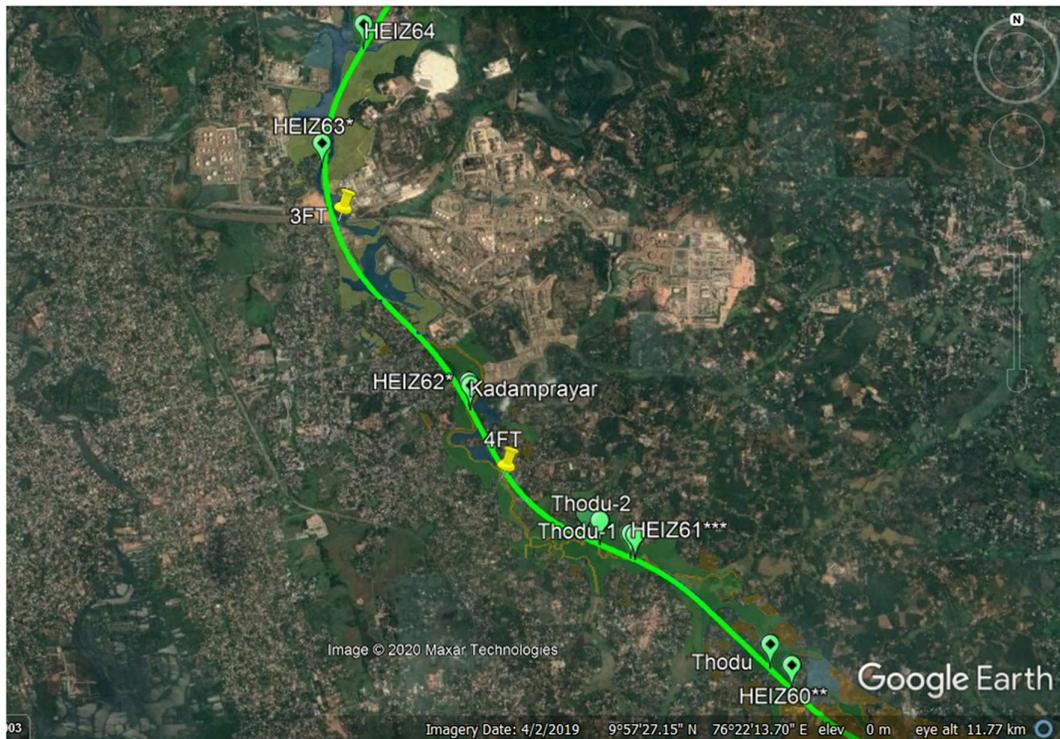
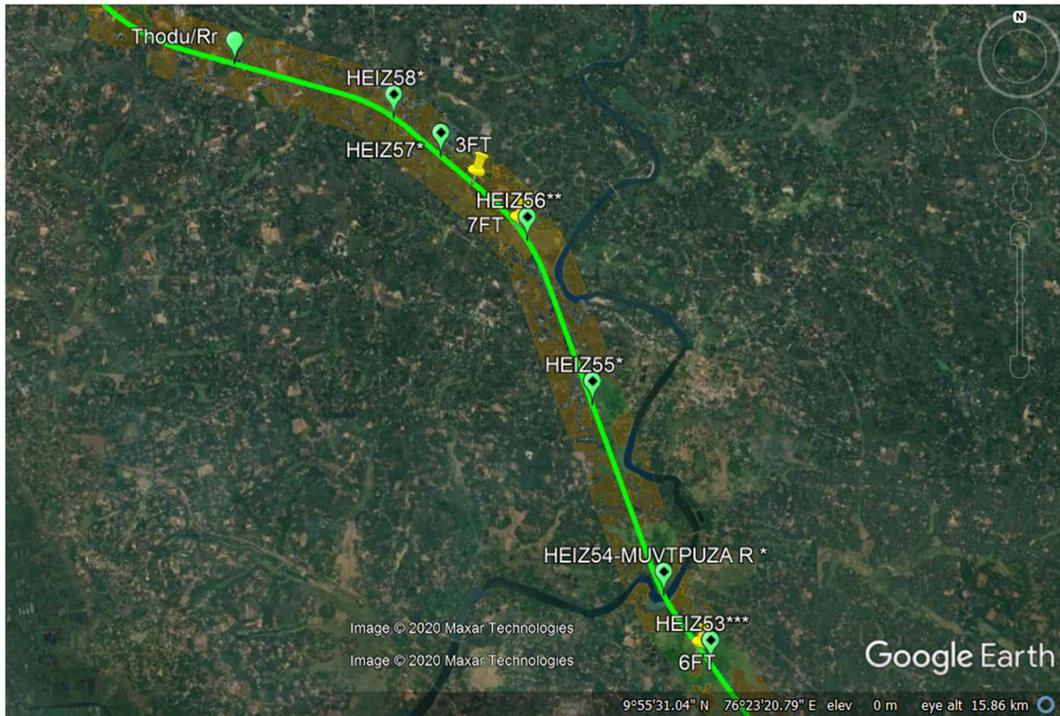
Google-Map-HEIZ (location)-screen shot-10



Google-Map-HEIZ (location)-screen shot-11



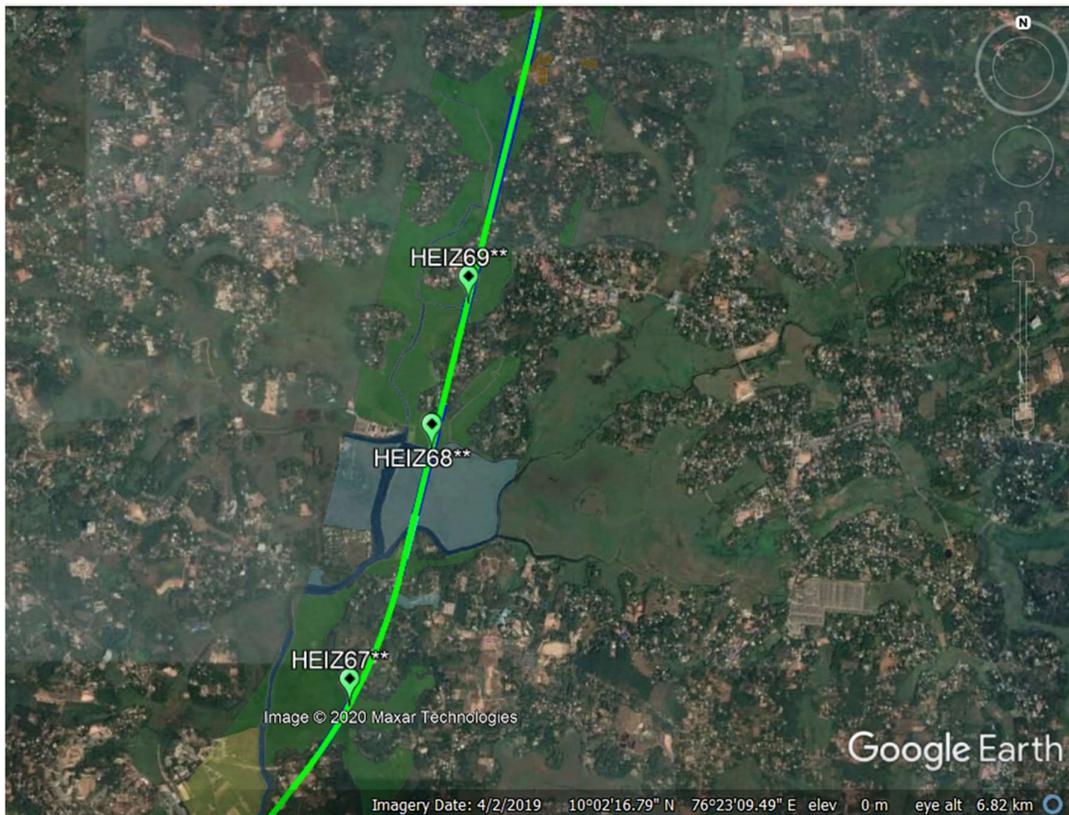
Google-Map-HEIZ (location)-screen shot-12-13



Google-Map-HEIZ (location)-screen shot-14



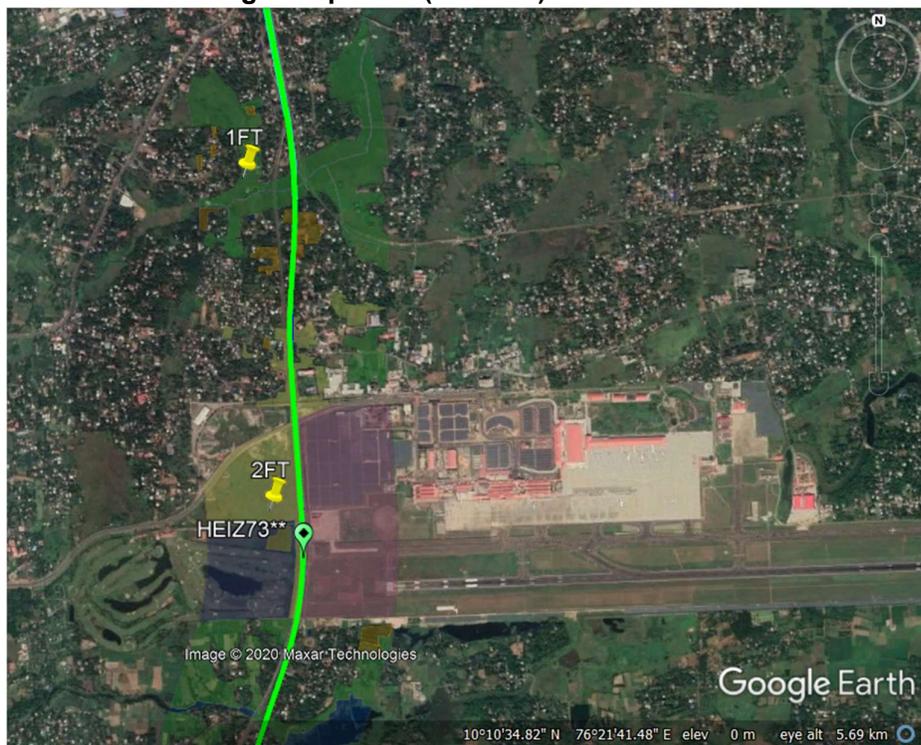
Google-Map-HEIZ (location)-screen shot-15



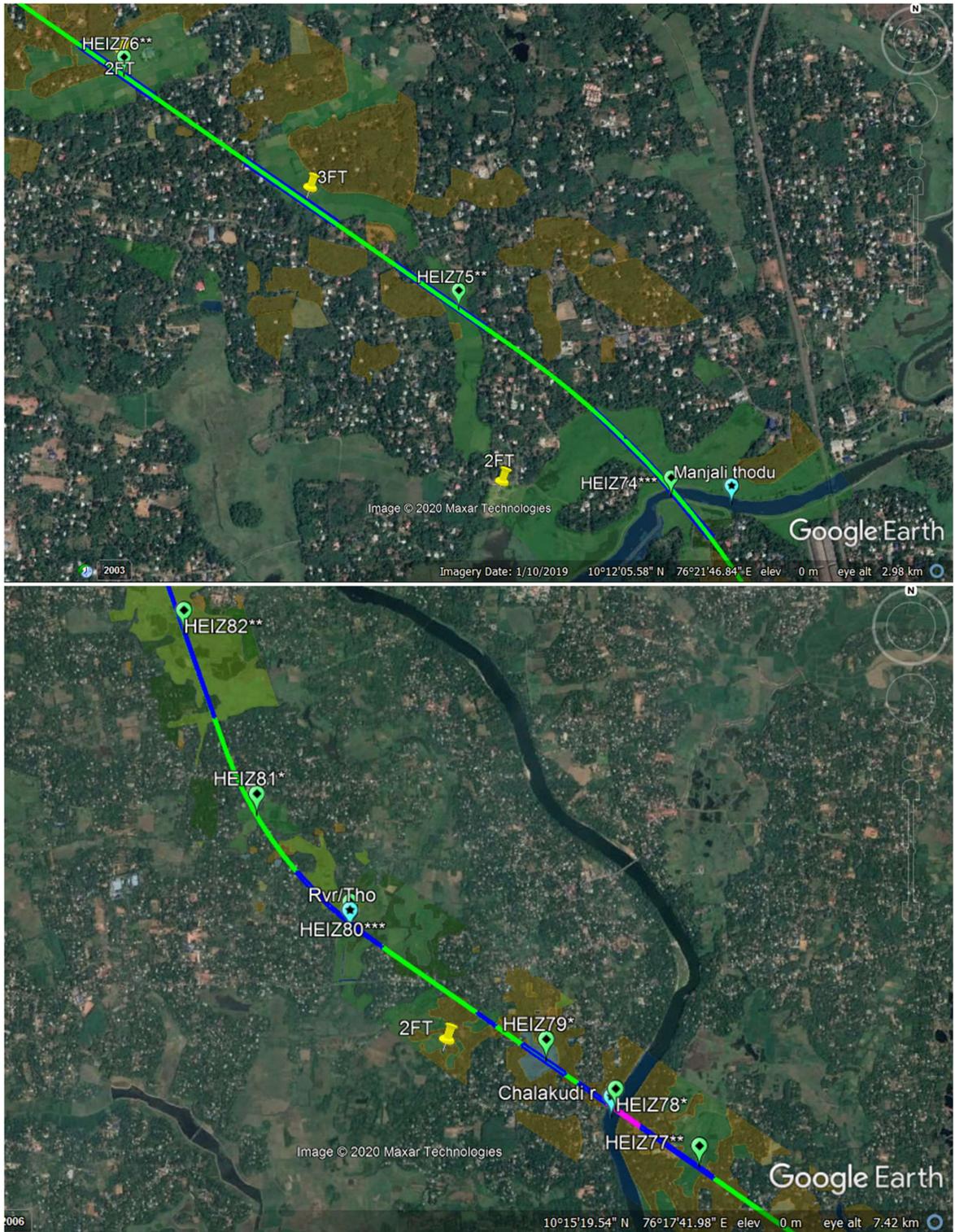
Google-Map-HEIZ (location)-screen shot16



Google-Map-HEIZ (location)-screen shot-17



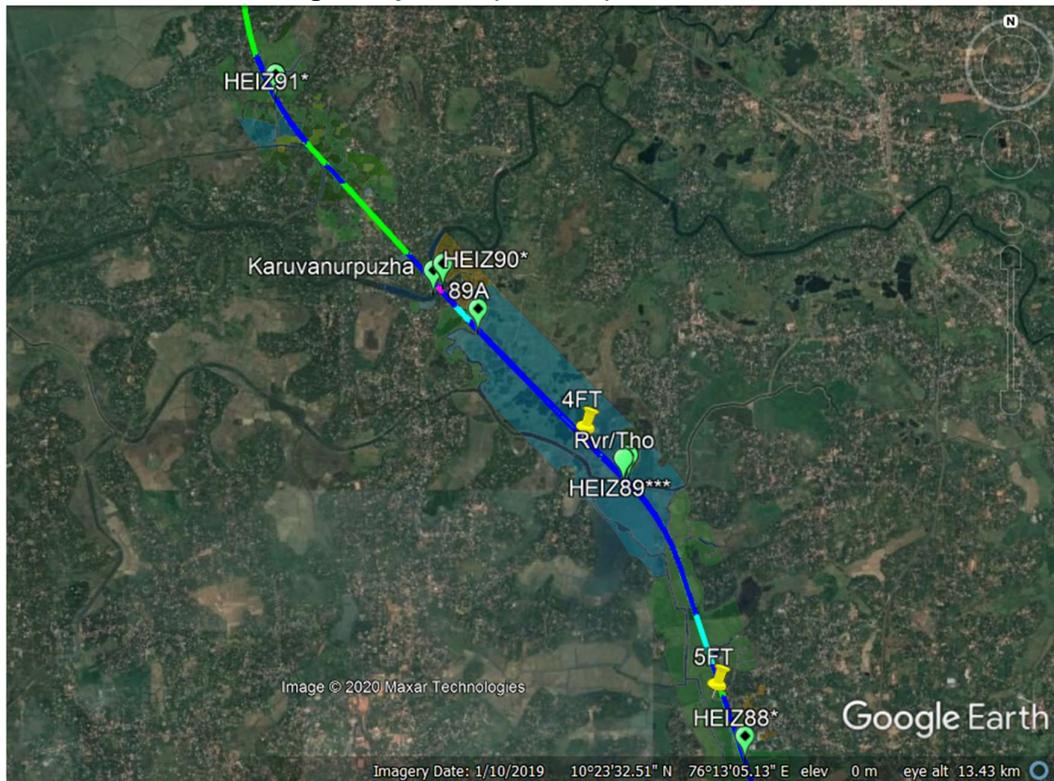
Google-Map-HEIZ (location)-screen shot-18-19



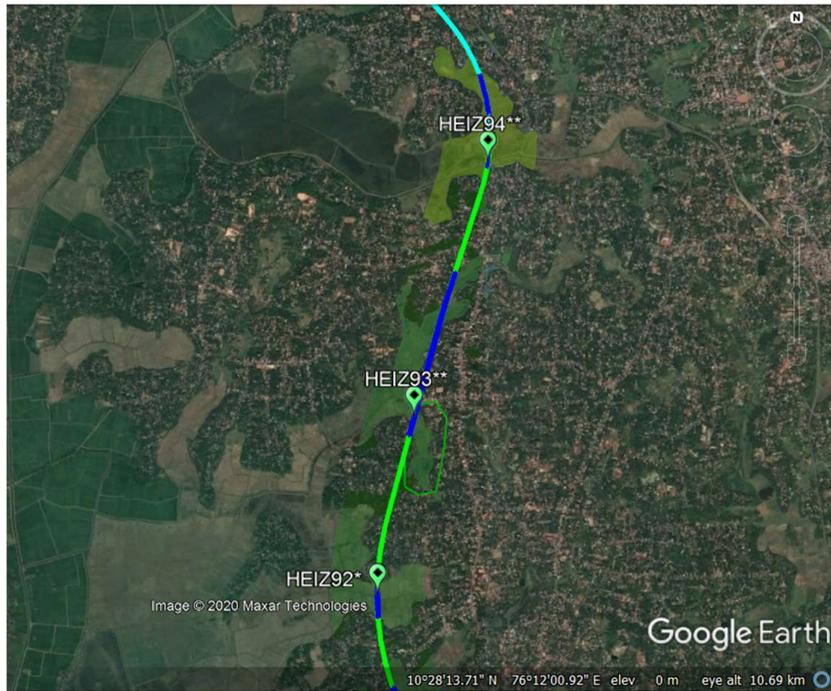
Google-Map-HEIZ (location)-screen shot-20



Google-Map-HEIZ (location)-screen shot-21



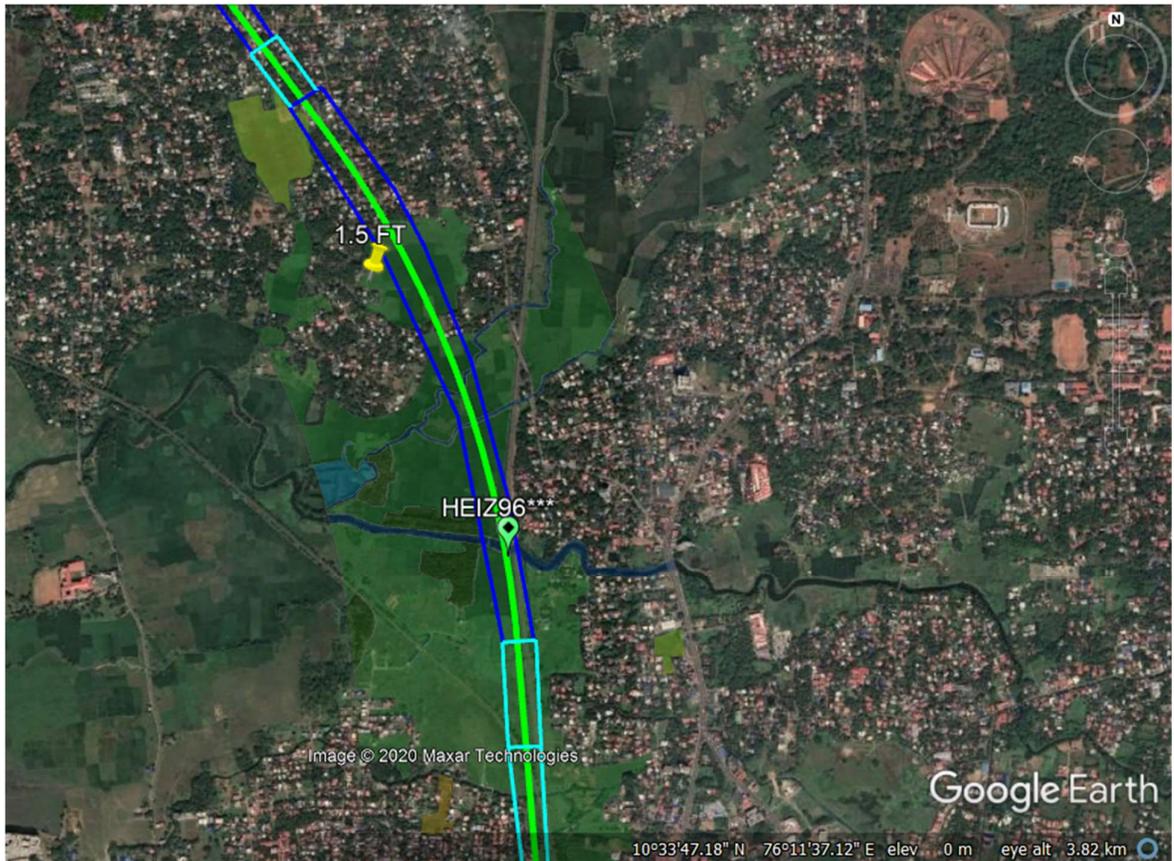
Google-Map-HEIZ (location)-screen shot-22



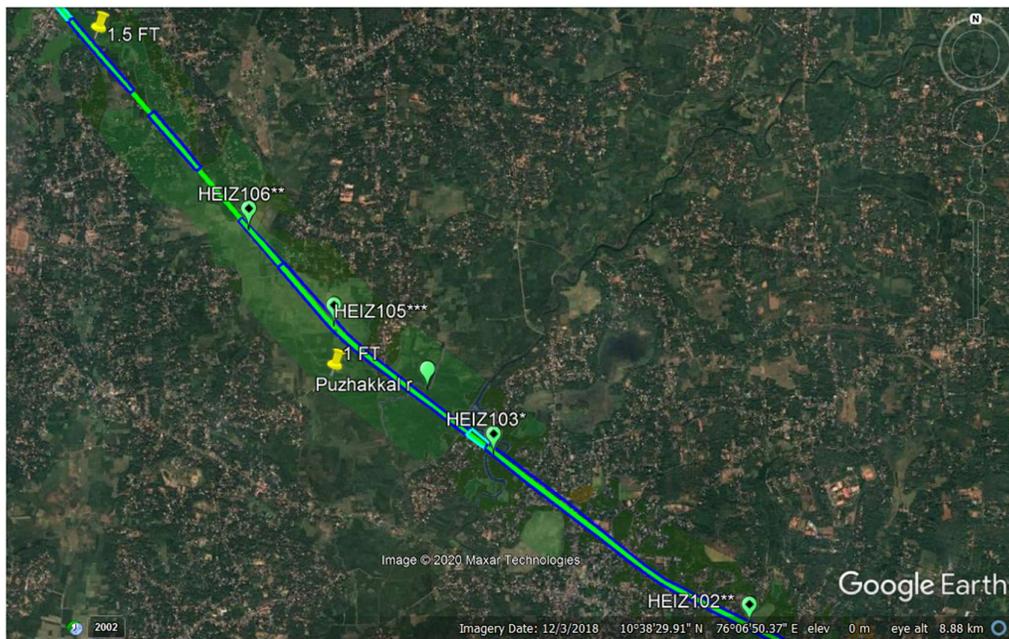
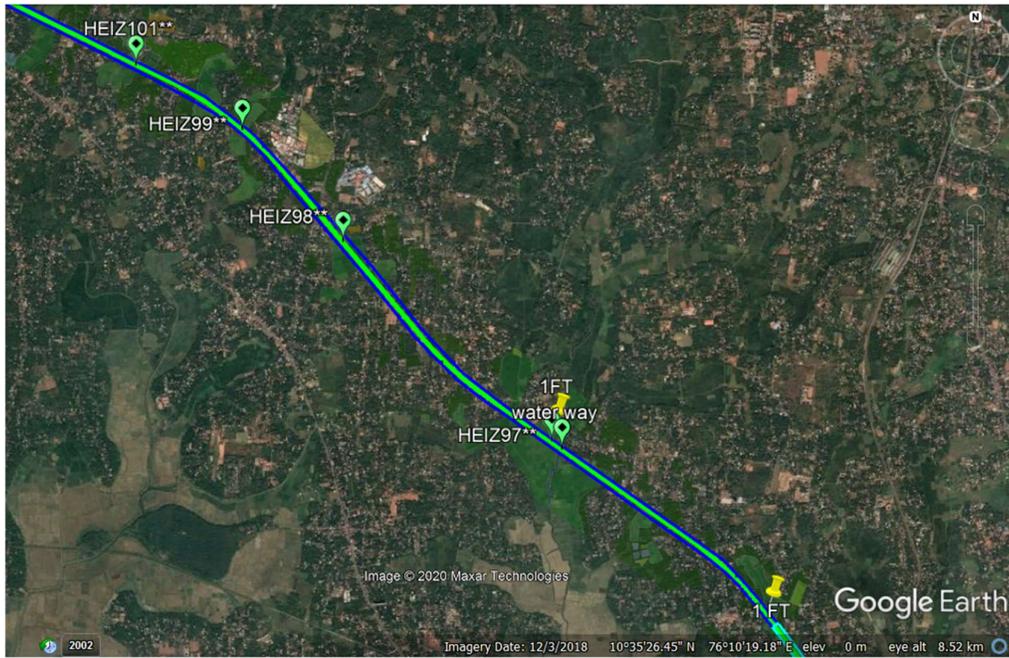
Google-Map-HEIZ (location)-screen shot-23



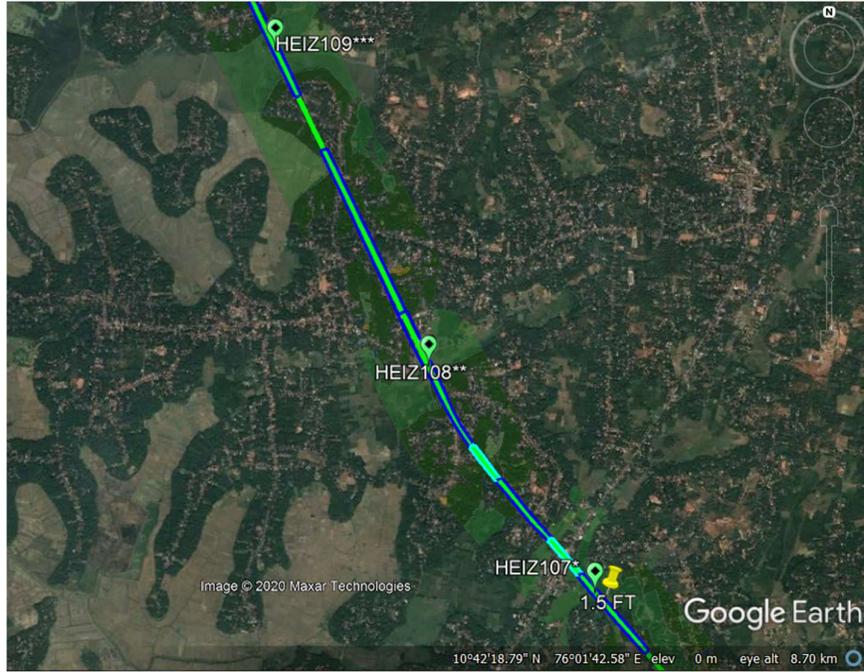
Google-Map-HEIZ (location)-screen shot-24



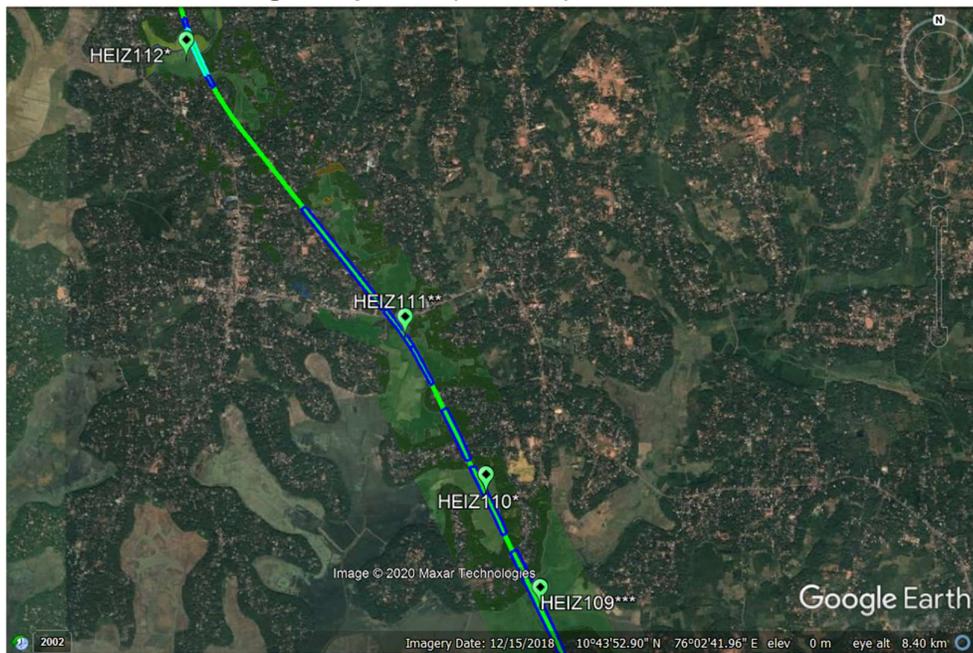
Google-Map-HEIZ (location)-screen shot-25-26



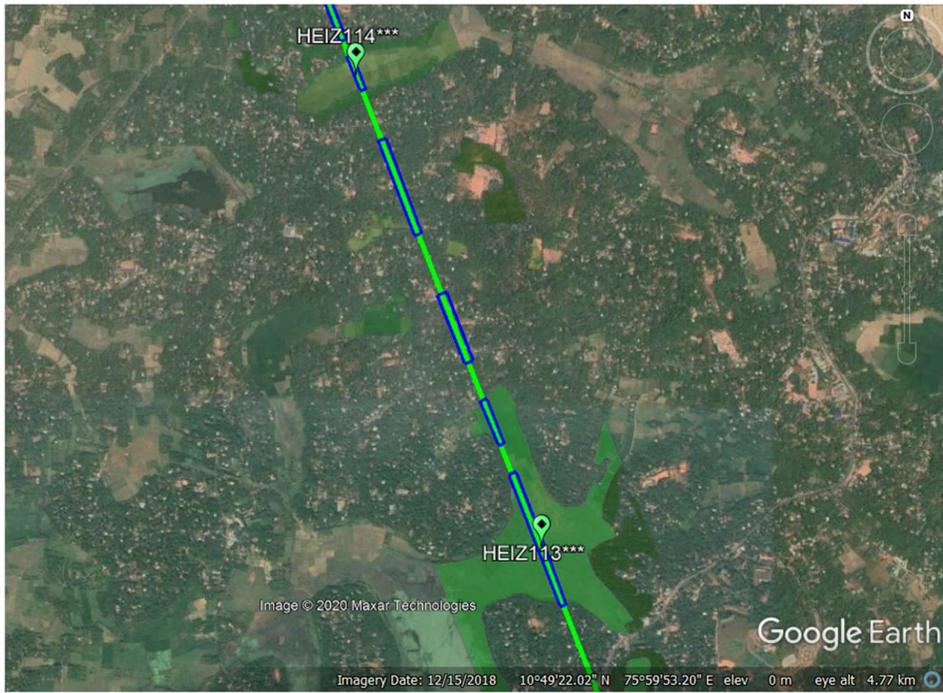
Google-Map-HEIZ (location)-screen shot-27



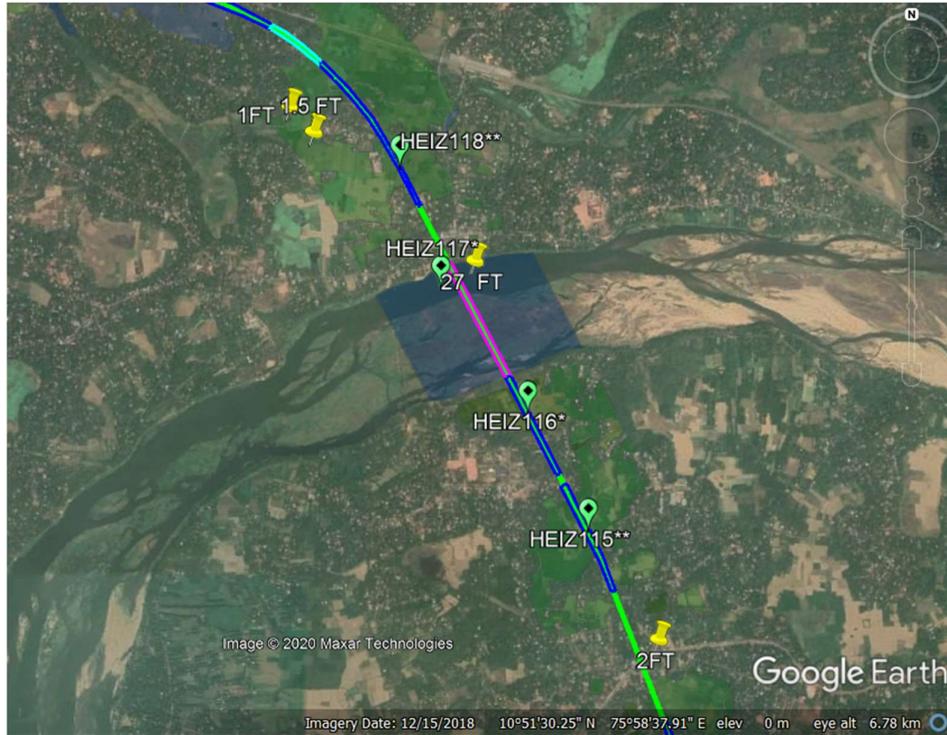
Google-Map-HEIZ (location)-screen shot-28



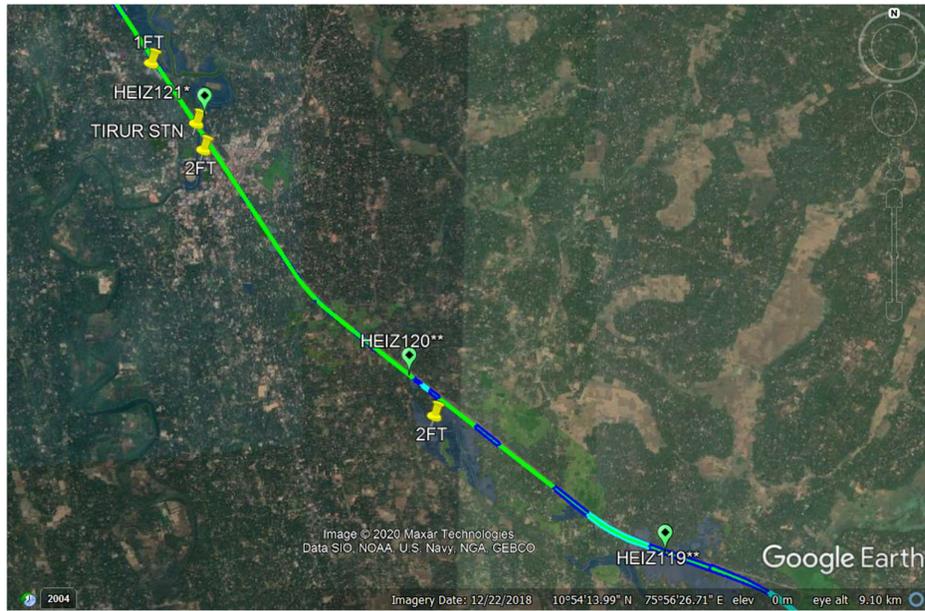
Google-Map-HEIZ (location)-screen shot-29



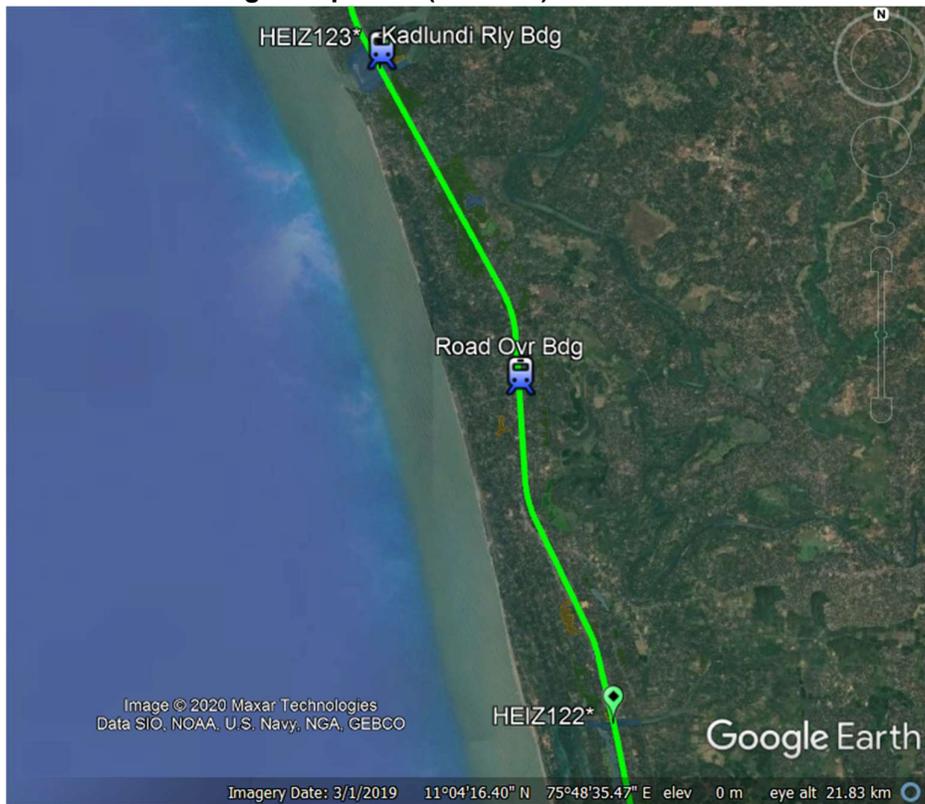
Google-Map-HEIZ (location)-screen shot-30



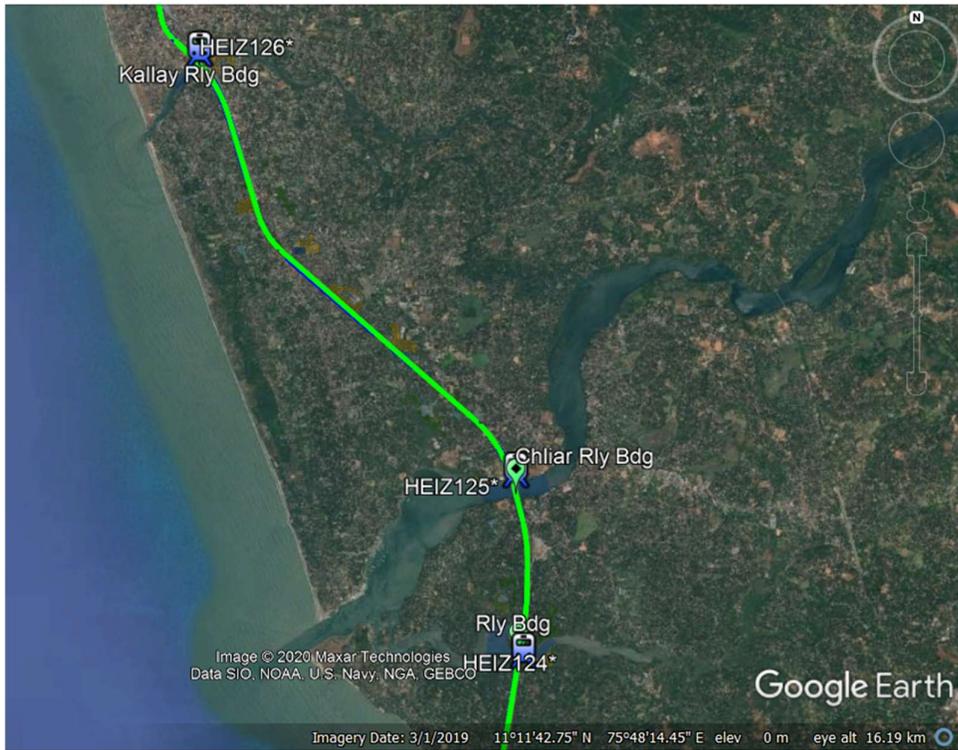
Google-Map-HEIZ (location)-screen shot-31



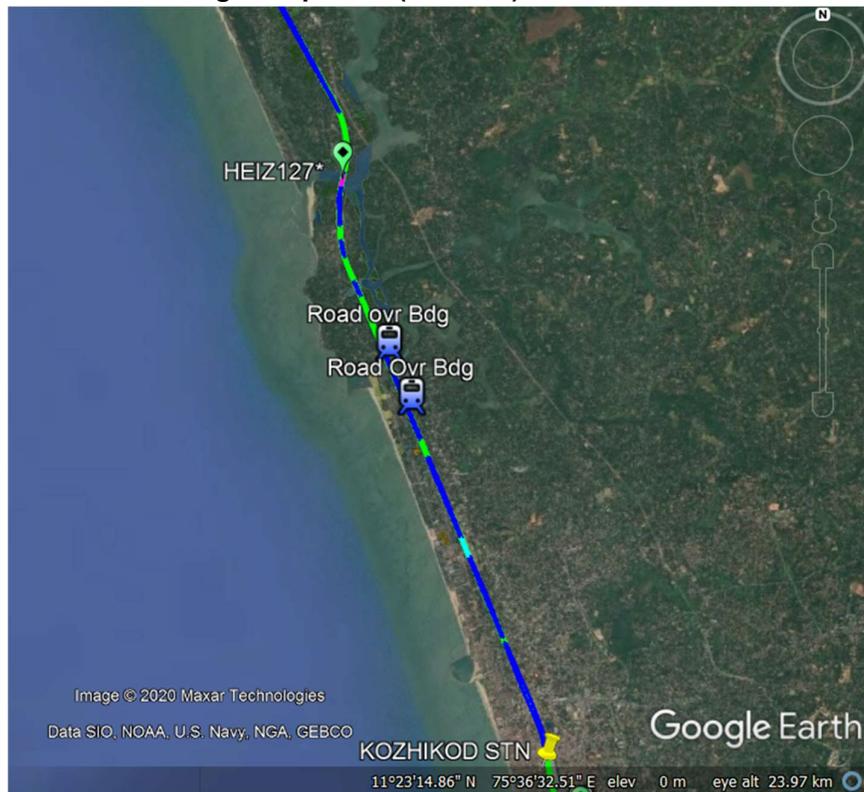
Google-Map-HEIZ (location)-screen shot-32



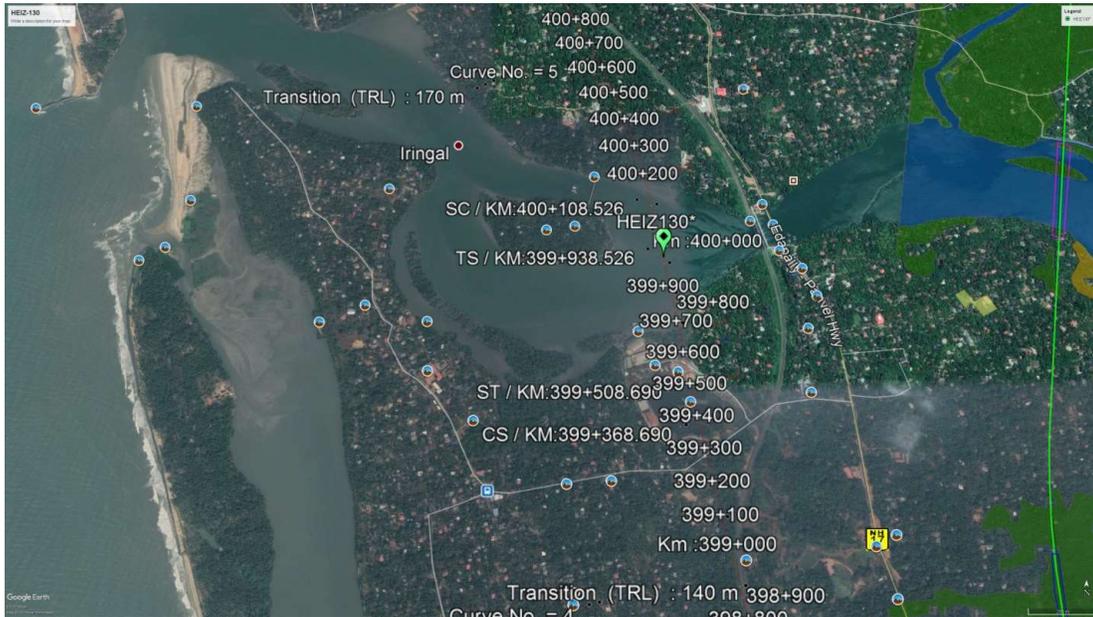
Google-Map-HEIZ (location)-screen shot-33



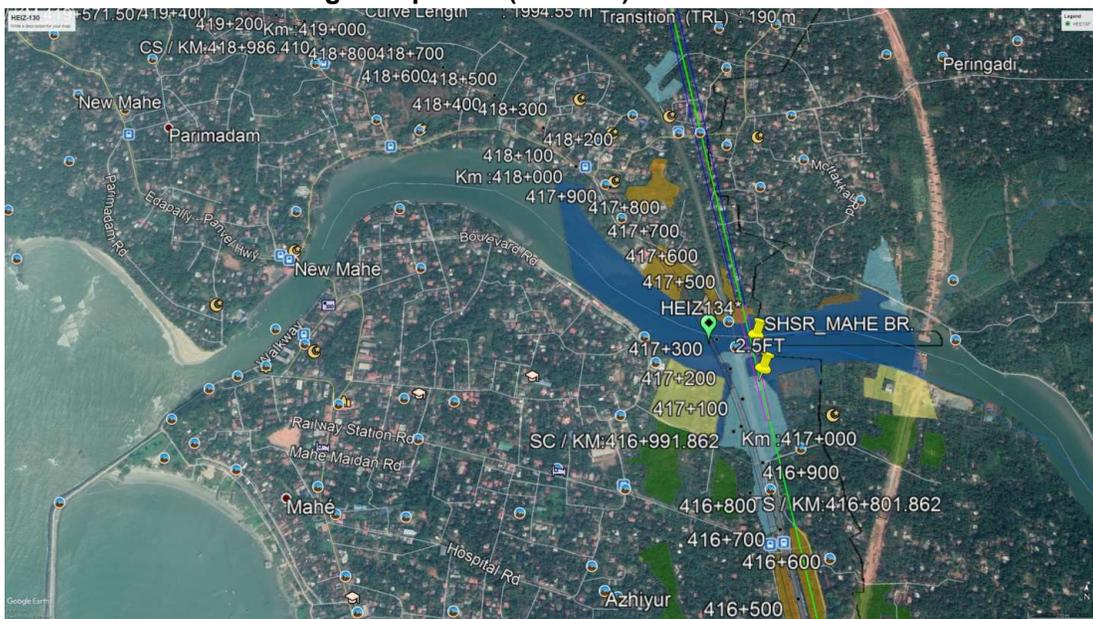
Google-Map-HEIZ (location)-screen shot-34



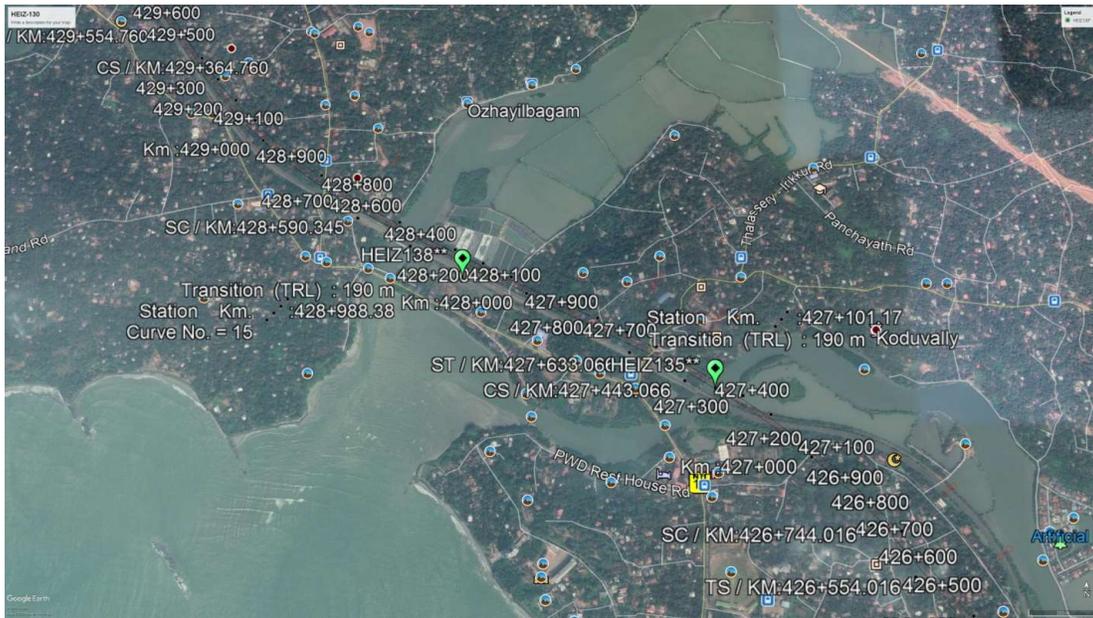
Google-Map-HEIZ (location)-screen shot-35



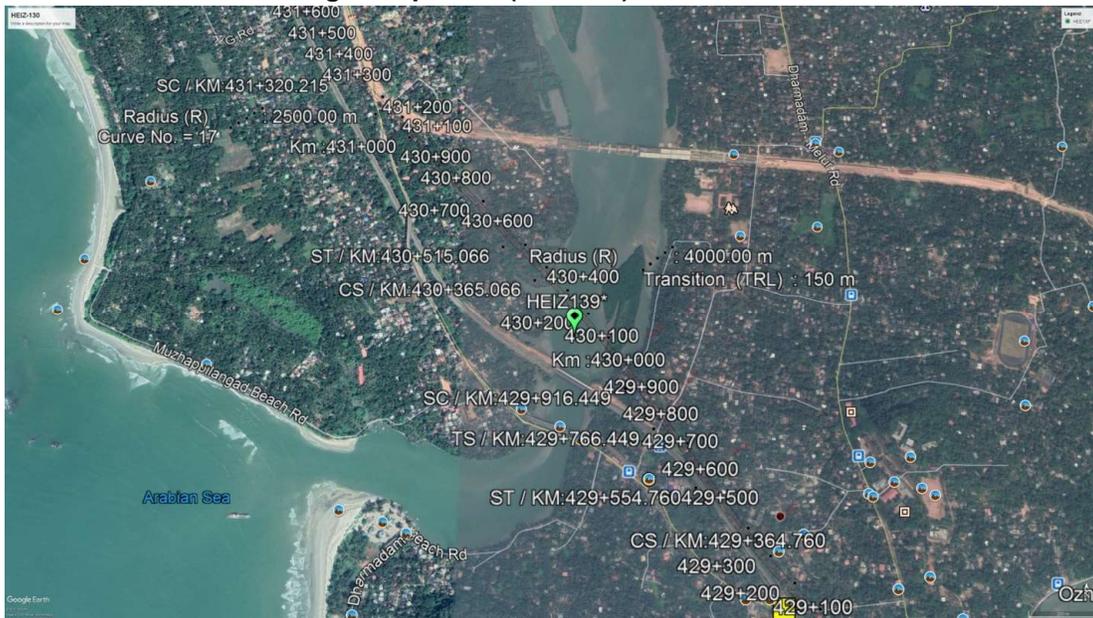
Google-Map-HEIZ (location)-screen shot-36



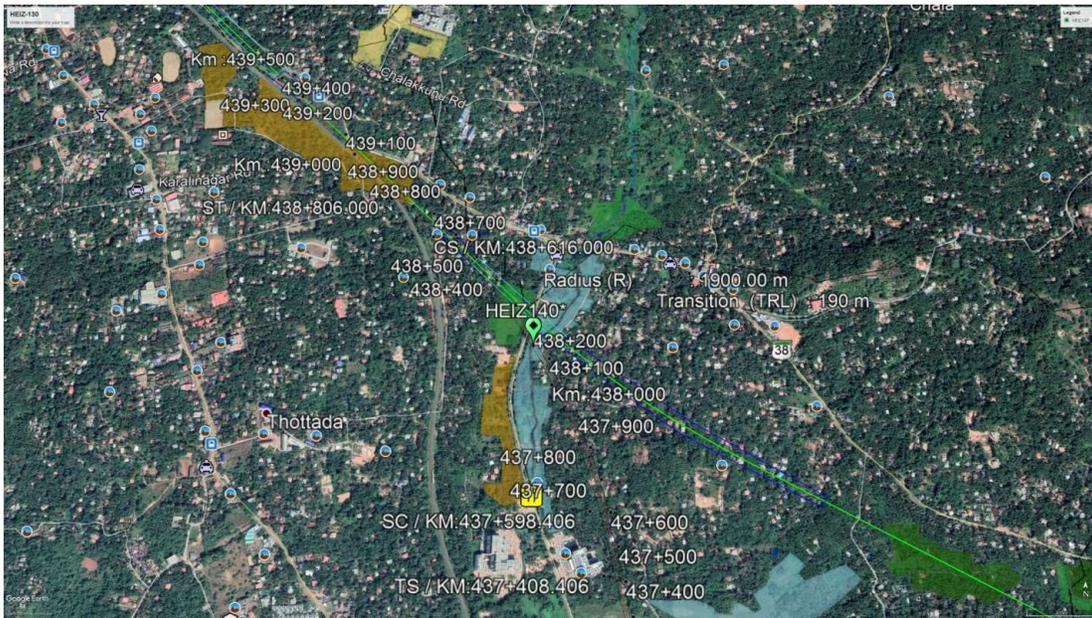
Google-Map-HEIZ (location)-screen shot-37



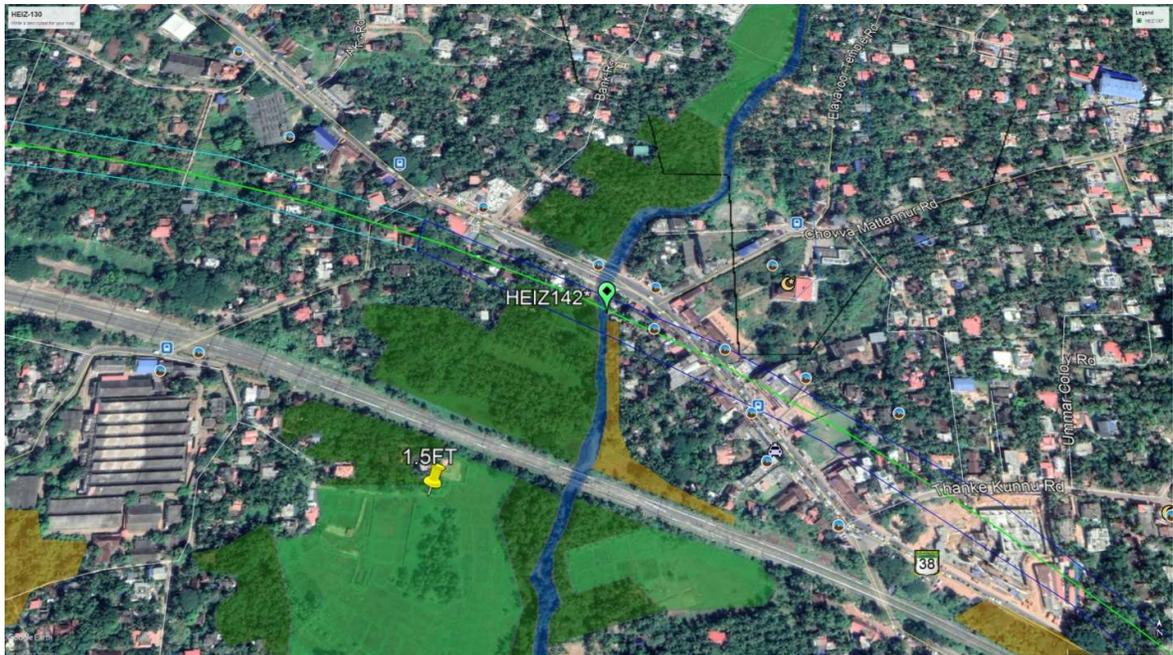
Google-Map-HEIZ (location)-screen shot-38



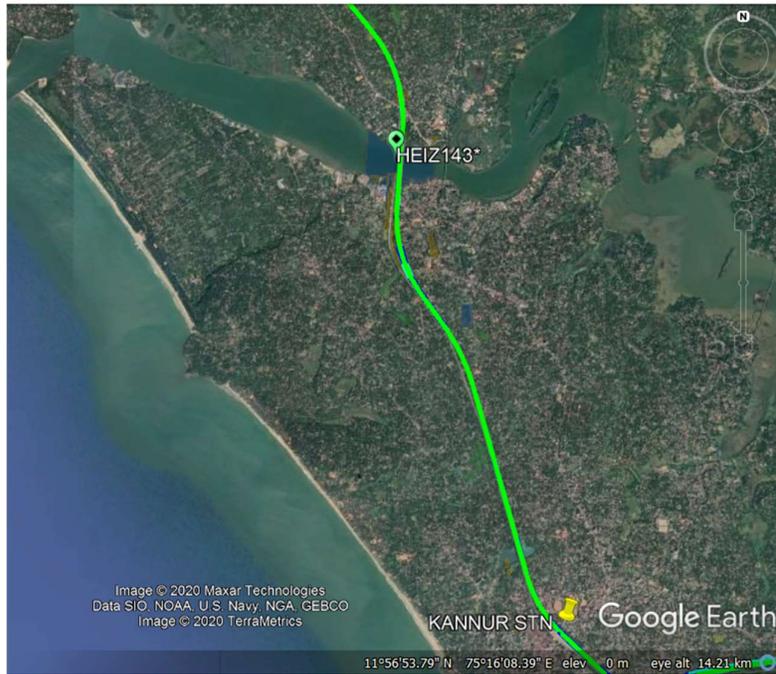
Google-Map-HEIZ (location)-screen shot-39



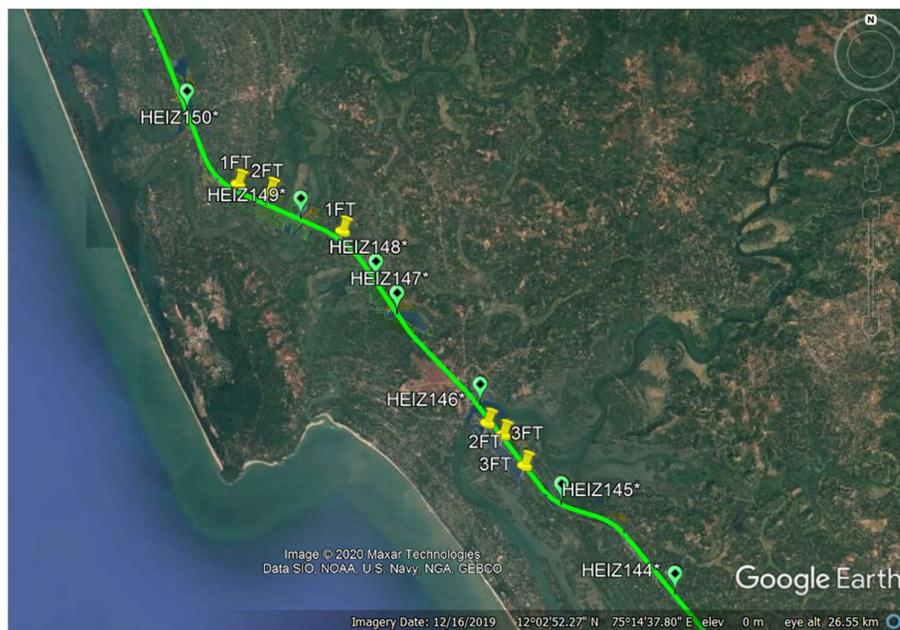
Google-Map-HEIZ (location)-screen shot-40



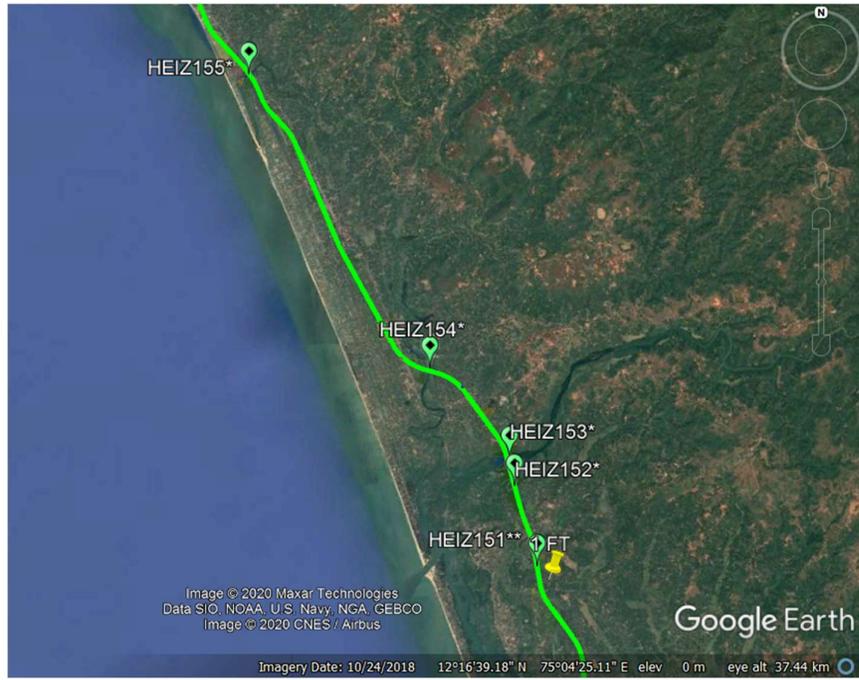
Google-Map-HEIZ (location)-screen shot-41



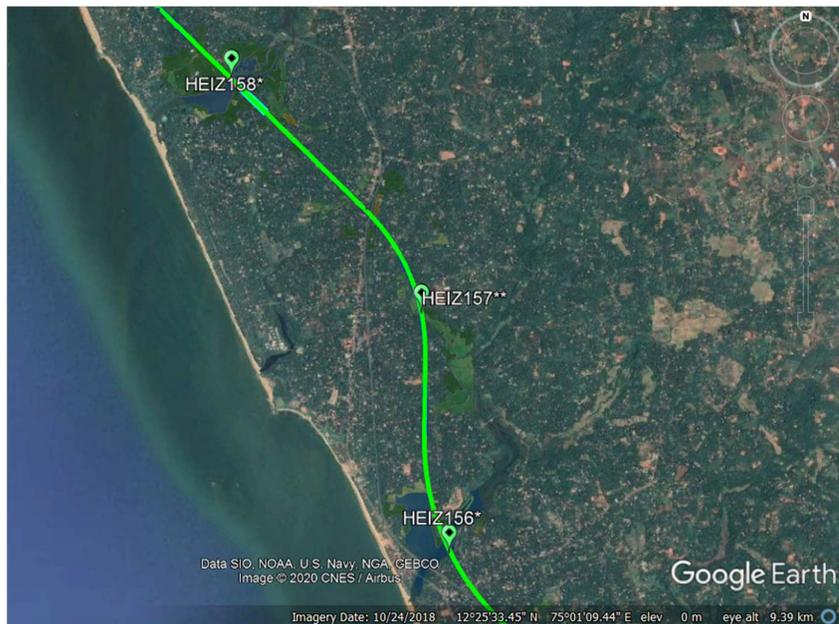
Google-Map-HEIZ (location)-screen shot-42



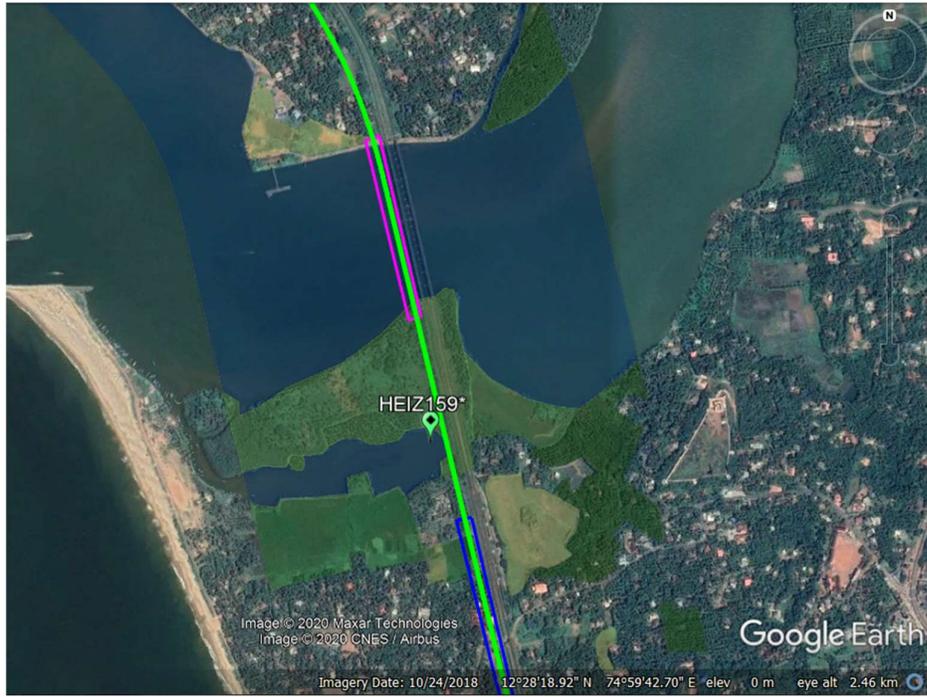
Google-Map-HEIZ (location)-screen shot-43



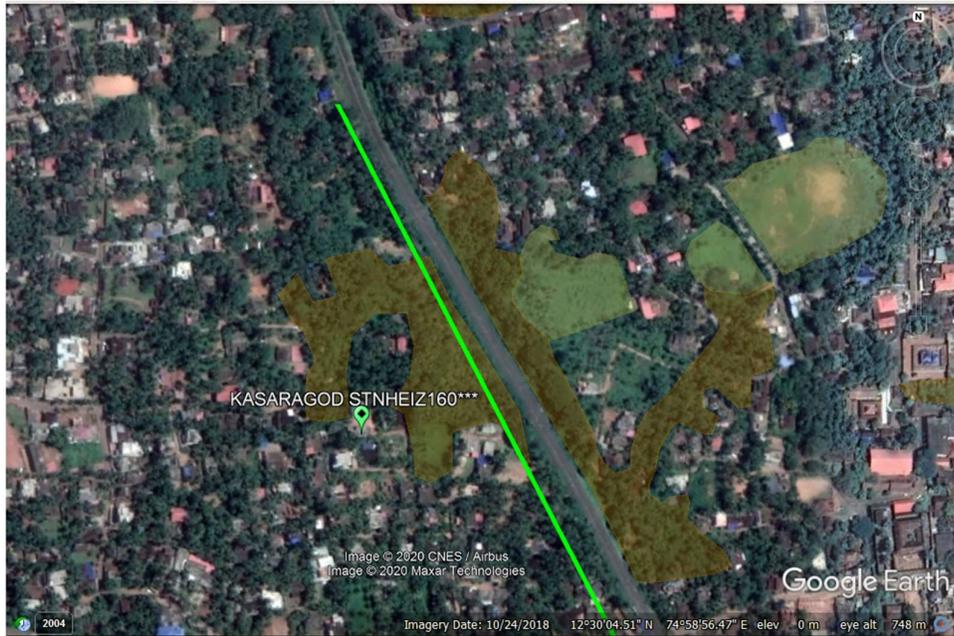
Google-Map-HEIZ (location)-screen shot-44



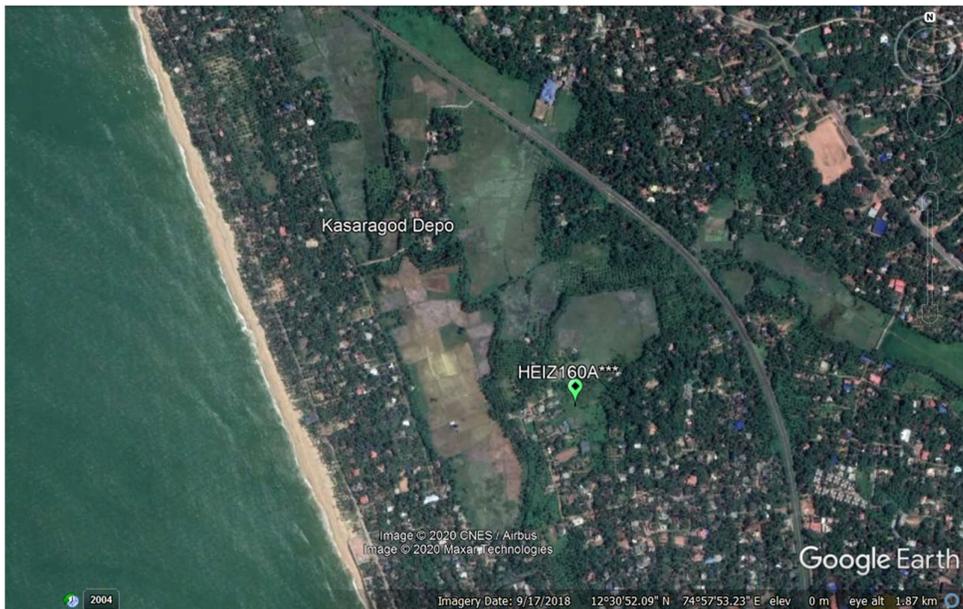
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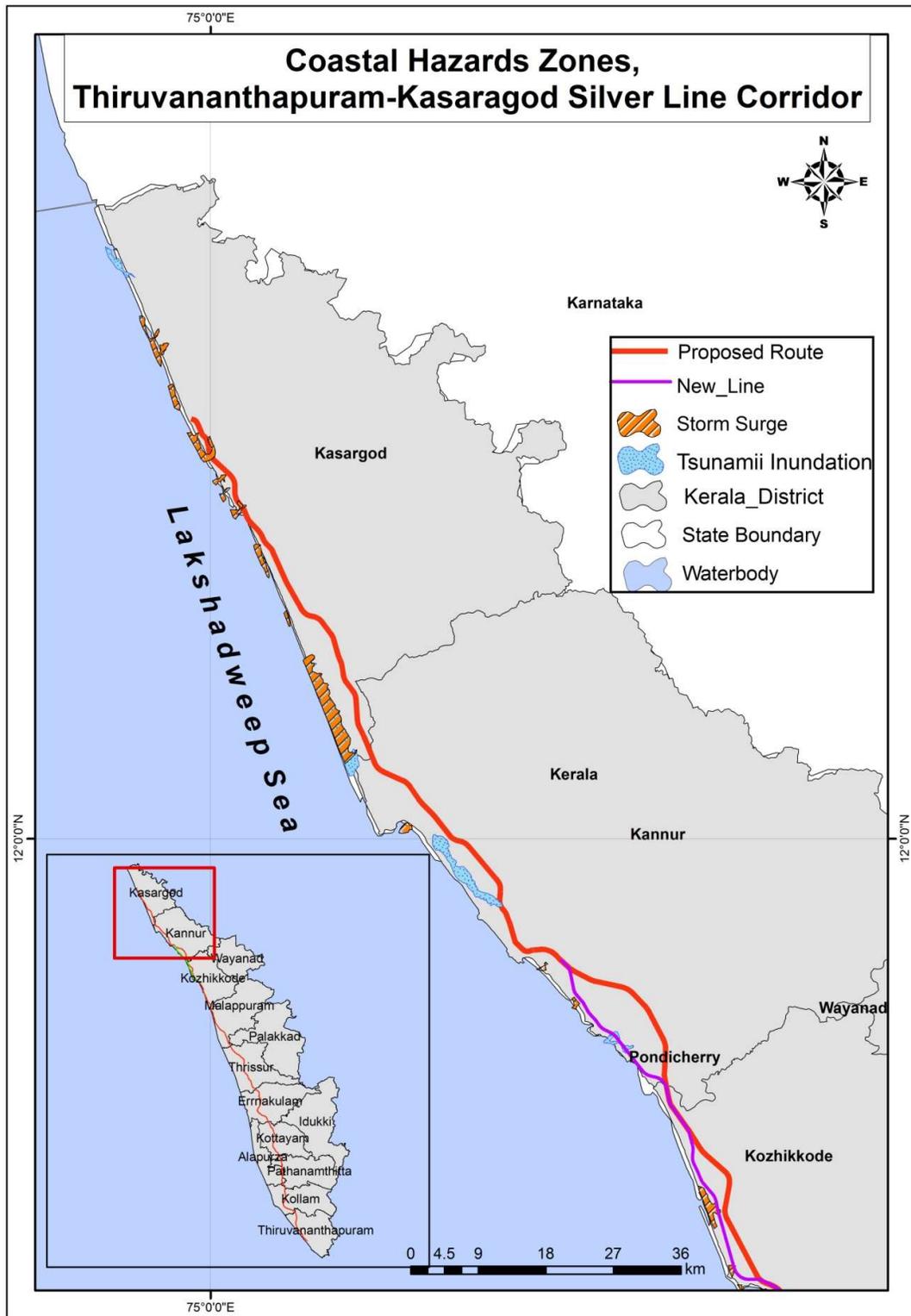


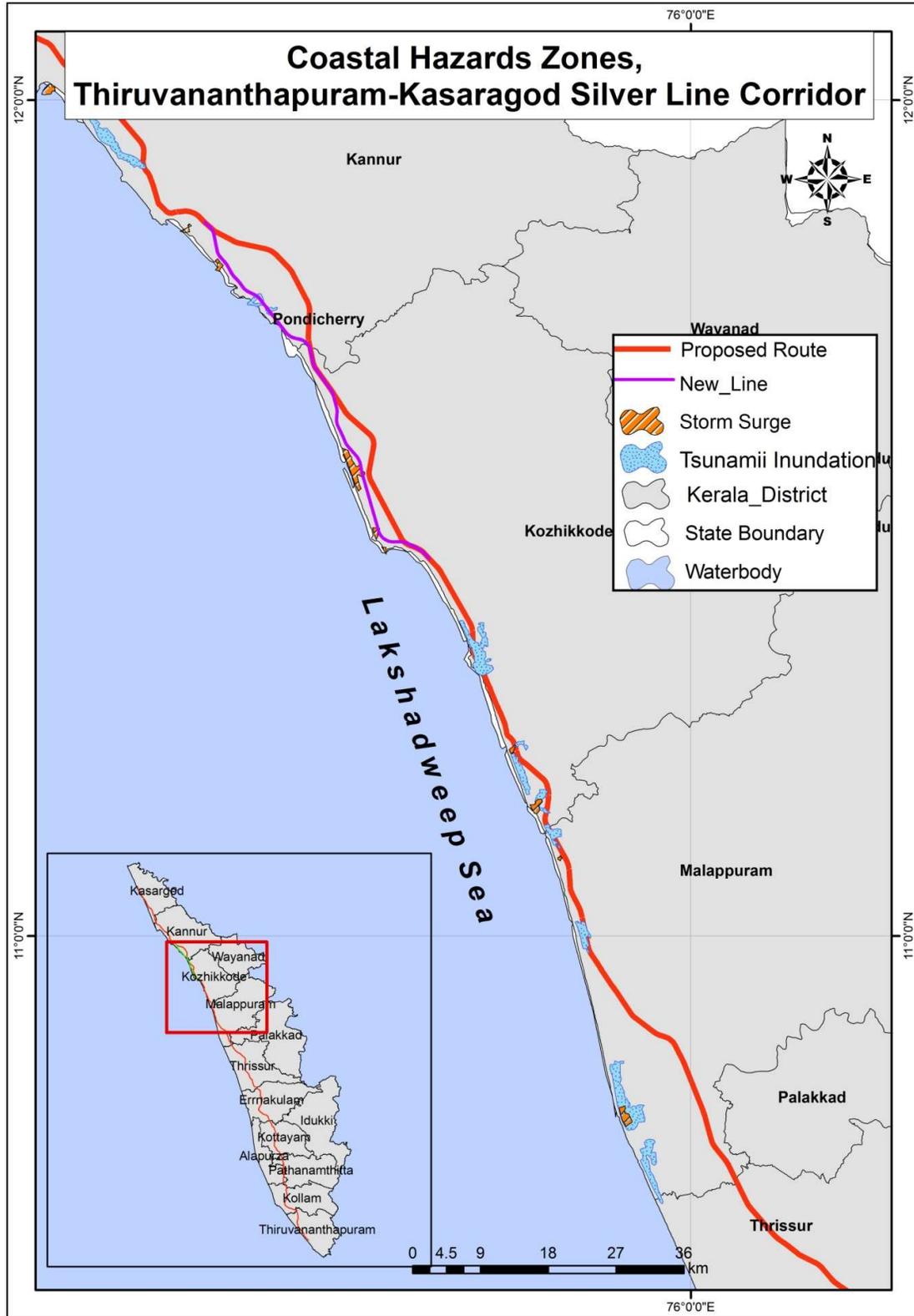
Google-Map-HEIZ (location)-screen shot-46

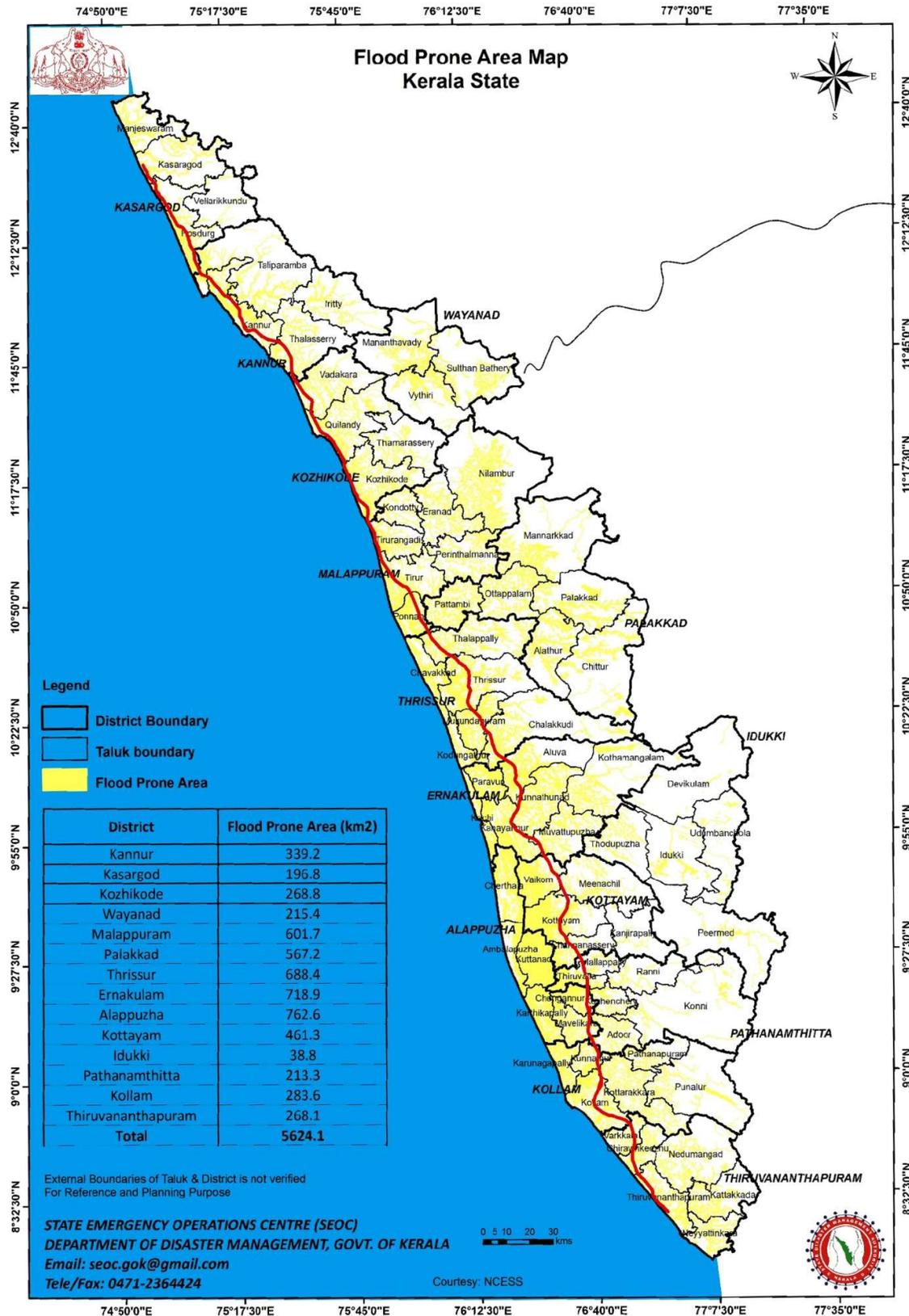


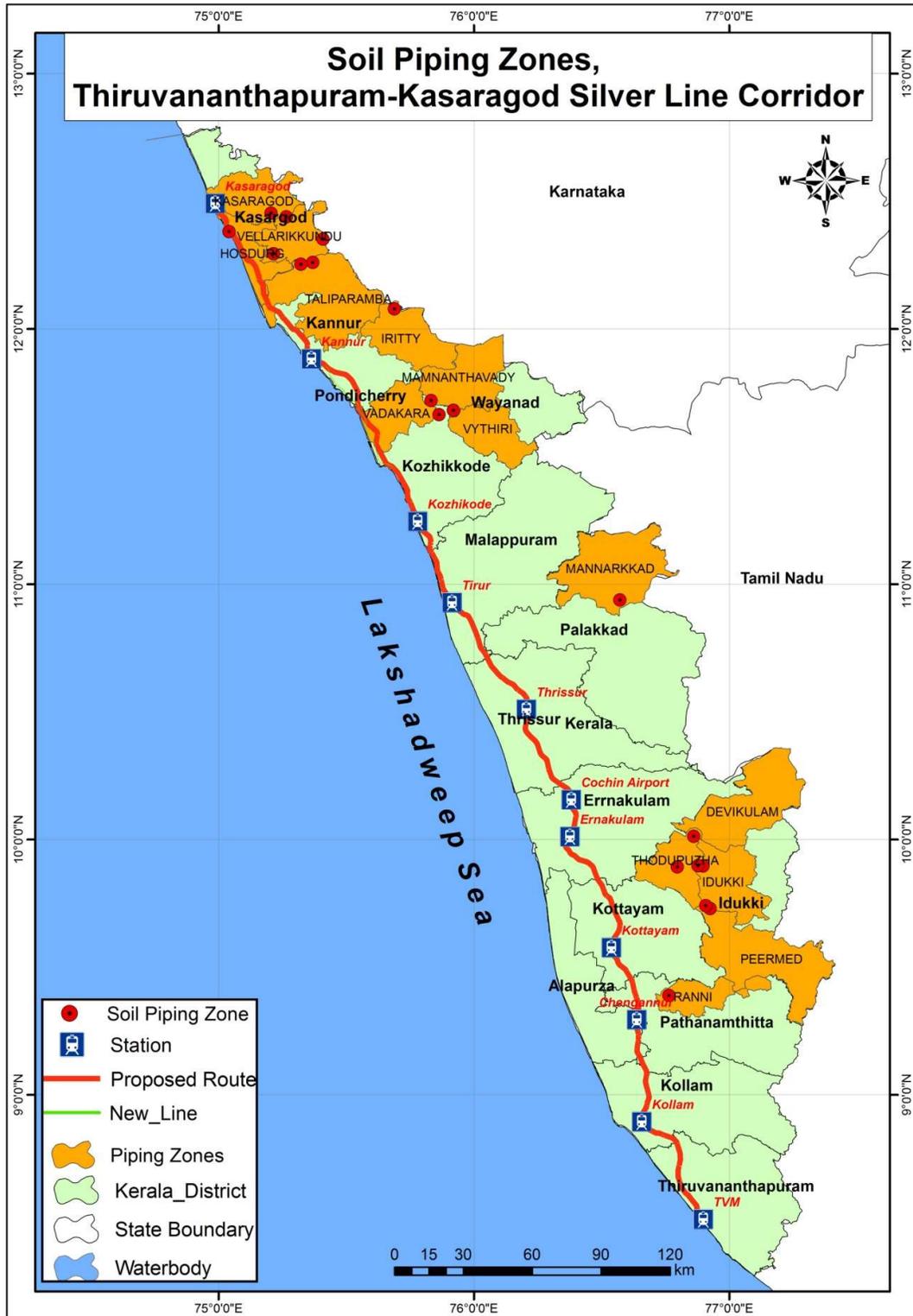
Google-Map-HEIZ (location)-screen shot-47











Annexure 5

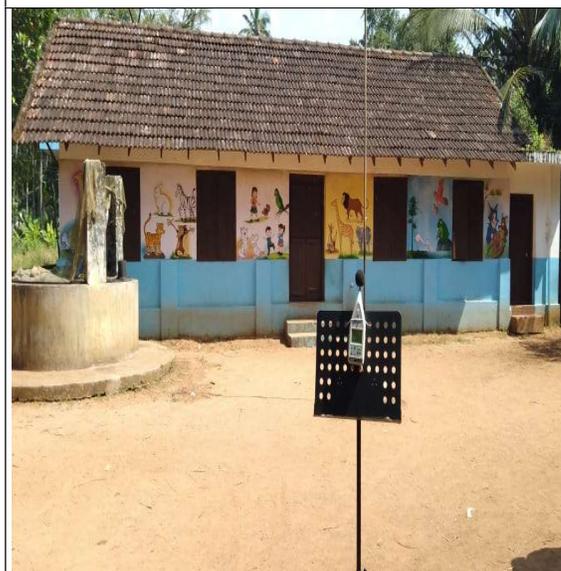
Environmental Monitoring Photographs



Ambient Air Quality Monitoring Station at Thiruvananthapuram



Ambient Air Quality Monitoring Station at Thrissur



Ambient Noise Quality Monitoring



Water Sampling



Soil Sampling