	KLM	CNGR	KTM	EKM	TSR	TIR	KKD	KNR	KGD
DISTANCE FROM TVM	55	108.7	142.2	194.9	259	316.45	357.4	448.173	530.29
RUNNING TIME FROM TVM	24	48	1H 3M	1H 26M	1H 54M	2H 19M	2H 37M	3H 16M	3H 52M

PEOPLE'S PARTICIPATORY ENVIRONMENTAL IMPACT ANALYSIS

OF

SILVERLINE
THE SEMI HIGH SPEED RAIL PROJECT OF KERALA

ABSTRACT

The PEIA a novel approach in the field of EIA, a demanding and multifaceted undertaking involving the collaborative efforts of experts from various disciplines, including environmental science, earth science, life science, biodiversity, and social science, along with the dedicated contributions of volunteers from the KSSP and the active participation of the local community.

KERALA SASTHRA SAHITHYA PARISHAD

SilverLine

The Semi High Speed Rail Project of Kerala

People's Participatory Environmental Impact Analysis

(PEIA)

KERALA SASTHRA SAHITHYA PARISHAD

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Contents

Forward

The Kerala Sasthra Sahithya Parishad (KSSP) is pleased to release the People's Participatory Environmental Impact Assessment (PEIA) on the K-Rail – SilverLine Project of KRDCL. The PEIA is the culmination of a comprehensive and participatory process that involved a wide range of stakeholders, including environmental experts, social activists, and affected communities.

The SilverLine project is a proposed semi-high-speed rail corridor that would connect Thiruvananthapuram in the south of Kerala to Kasargod in the north. While the Cabinet of the Kerala Government approved the SilverLine project in July 2020, it was only after a year, as fieldwork of the Project was about to begin, that significant opposition arose. Concerns have been raised about the project's environmental impact, social impact, and financial viability.

Similar to other recent debates that have emerged in Kerala society, the SilverLine debate has also drawn sharp divisions, with one side vehemently supporting the project, the other aggressively opposing it, and various shades of both views filling the middle ground. Discussions were also triggered among civil society, environmental workers, and social scientists, with social media flooding with facts, aspirations, and even abuses.

However, this debate has missed an opportunity to provide the general public with access to facts and to enable them to form an informed opinion on matters that impact their well-being. In fact, the SilverLine project, if completed, has the potential to affect many generations to come and influence Kerala's future development in numerous ways.

As a people's science movement, the KSSP has been studying Kerala's transport system for many years. Over the past 25 years, following organizational interventions in various developmental issues and incorporating expert inputs, KSSP has also developed a Transport Policy for Kerala that aligns with the state's development perspective.

KSSP initially published a digital pamphlet and issued an official press release regarding the SilverLine project on July 1, 2021. In the press release, KSSP urged the state government to halt project work temporarily until a comprehensive Environmental Impact Assessment (EIA) is prepared, and the Detailed Project Report (DPR) is released. KSSP also called for a thorough public discussion among the public.

Meanwhile, an RTI request for the DPR was rejected on the grounds of copyright issues. As a result, KSSP formed a committee to formulate a preliminary opinion on the project. The committee gathered details from appropriate sources and prepared an initial report on the project. In August 2021, KSSP published a Malayalam pamphlet titled "കെ റെയിലും കേരളത്തിലെ ഗതാഗതവും" (K-Rail and Kerala's Transport).

The pamphlet primarily focused on the project's economic, financial, social, technical, and political aspects, excluding environmental issues. Based on the findings, the pamphlet summarised KSSP's position on the project as "SilverLine is not a priority for Kerala's transport system".

In the absence of a comprehensive EIA, it was difficult to assess the project's impact on the environment. Consequently, a Technical Committee (TC) was formed to prepare an EIA in a participatory mode. Members of the TC were chosen to include individuals with diverse areas of expertise relevant to the study's scope.

Field survey and Geo-tagging of the entire 530 km SilverLine stretch was completed during the summer of 2022 in a participatory manner by over 1,000 trained volunteers. The Parisara Vishyasamithi (Environment Subject Committee), IT sub-committee, and GIS department of IRTC, in conjunction with Jilla Committees of KSSP, oversaw the entire activity. The Technical Committee promptly corroborated the vast amount of data collected from the field with secondary data from various sources to ensure its accuracy.

Subsequently, the Technical Committee undertook an extensive process of statistical and analytical work, focus group discussions, and interdisciplinary communions to finalize the report. After receiving approval from the Executive Committee of KSSP and formal approval from the General Council, the report is now being placed before the people of Kerala.

This report, the PEIA, can be marked as a unique attempt in the history of Citizen Science Initiatives in the country. I shall take this opportunity to appreciate and thank all KSSP workers who toiled in the field, the experts in the Technical Committee who dedicated a huge amount of their personal time, and the external experts who shared their scholarly comments at various stages of forming this report.

We present this report before the esteemed intelligentsia of the State. It is our hope that the PEIA will provide the general public with the essential information they need for informed decision-making. KSSP believes that this will be helpful in initiating a public dialogue that will eventually lead to the democratic selection of the most suitable, people centric developmental solutions.

20 November 2023,
Thiruvananthapuram.

B Ramesh,
President, KSSP.

Acknowledgments

The preparation of the People's Participatory Environmental Impact Assessment (PEIA), a novel approach in the field of EIA, was a demanding and multifaceted undertaking. This endeavor involved the collaborative efforts of experts from various disciplines, including environmental science, earth science, life science, biodiversity, and social science, along with the dedicated contributions of volunteers from the Kerala Sasthra Sahithya Parishad and the active participation of the local community. Technical experts in traffic engineering were also consulted to ensure the comprehensive assessment of the project's potential impacts. Given the extensive scope of this project, it is not feasible to acknowledge each individual contributor. However, we would like to extend our deepest gratitude to a few individuals who played pivotal roles in this study.

We are immensely grateful to Dr. R. Ajayakumar Varma, Prof. A. Bijukumar, Prof. T.K. Prasad, and Dr. Retheesh Krishnan for their unwavering support and astute guidance throughout the various stages of this study. Their expertise and insights were invaluable in shaping the direction and quality of our work.

Words cannot adequately express our gratitude to the members of the Expert Panel Dr. K.P. Kannan, Dr. R.V.G. Menon, Dr. K.P. Aravindan, Dr. C.P.Rajendran for their meticulous evaluation and timely advice. Their rigorous scrutiny and insightful feedback played a critical role in refining the quality and credibility of our study.

We also extend our heartfelt appreciation to the scientists of the Centre for Geoinformatics, IRTC, Palakkad, for their technical expertise and assistance. Their contributions were instrumental in enhancing the accuracy and comprehensiveness of our data analysis.

We are deeply indebted to Mr. Sunil Dev for his invaluable support in the statistical analysis of field data. His expertise in data analysis was crucial in ensuring the robustness and reliability of our findings.

The success of this study is a testament to the unwavering support and guidance provided by the President, General Secretary, and Executive Committee members of the Kerala Sasthra Sahithya Parishad who held office during the period of the study. We are deeply grateful for their unwavering commitment to this project.

We extend our sincere appreciation to the office bearers of Jilla, Mekahala, and Units of KSSP for their dedicated involvement in data collection. Their commitment and hard work were essential in ensuring the successful completion of this crucial aspect of the study.

Finally, we wholeheartedly thank the numerous volunteers who generously donated their time and effort to make the field data collection process a resounding success. Their dedication and unwavering commitment to this project were truly inspiring. Without their contributions, this study would not have been possible.

We are truly humbled by the overwhelming support and contributions of all individuals involved in this study. Their unwavering commitment and expertise have been instrumental in making this project a success.

Chapter I: Introduction

The Government of Kerala, through the Kerala Rail Development Corporation Ltd. (KRDCL), proposes to develop a semi-high-speed rail connectivity from Thiruvananthapuram to Kasaragod as a solution to the increasing congestion in the transport network of Kerala. The project, known as K-Rail – Silver Line project (Map. 1.1) has triggered serious discussions on its financial, environmental and social impacts.

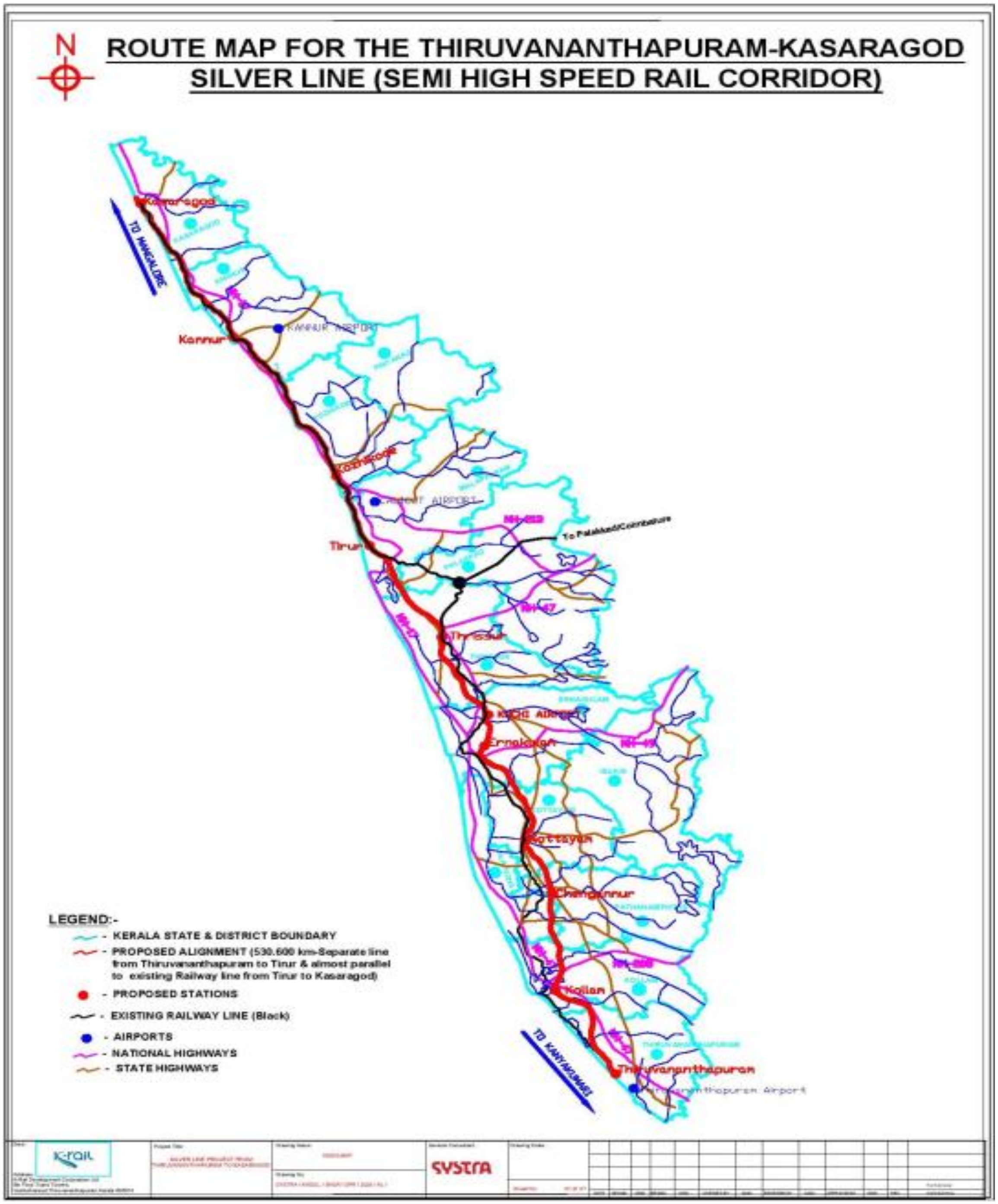
The need for such a project at this juncture is questioned by many people and some alternatives are also being discussed. In this situation an evaluation of the environmental systems through which the rail track passes, based on which an assessment of its implications on the environment and social systems is warranted. Such a study is helpful to take an informed view of the environmental damages that may affect the fragile geomorphology and environmental sustainability of the State. This will also help to critically evaluate the comprehensive EIA being undertaken for the project by KRDCL. It is in this context, Kerala Sasthra Sahithya Parishad (KSSP) has undertaken this study with the participation of its volunteers, scientist and technologist members.

With the advancement of science and technology, there have been conscious efforts to manage development in harmony with the environment. Policies and legislations have been introduced internationally and nationally to promote better management of development ensuring sustainability and environmental viability.

Environment Impact Assessment (EIA) has become one of the most used environmental management tools. This was as an important outcome of the 1992 Rio Declaration. It assesses the impact of a project on the bio-geophysical environment and the health and well-being of human beings and suggests alternatives and environment management options. International and national funding agencies normally insist on EIA as a prerequisite for funding. UNEP (2004) defines EIA as “a tool used to identify the environmental, social and economic impacts of a project prior to decision-making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers".

In India, Environmental clearance along with EIA is made mandatory for all notified projects as per EIA notification (2006), as listed in the Schedule of the notification. However, being a railway project Environmental clearance is not mandatory for the K-Rail – SilverLine project. It is worth recalling that the exemption of railway projects from EIA (2006) and further dilution of EIA notification in 2020 were criticised as a step back from the climate resilience and SDG goals. At the same time, most of the approving authorities normally consider the environmental impacts of the project during the approval process. International agencies like World Bank, ADB, JICA, etc. always insist on EIA reports while funding major projects.

Kerala comes within the mountainous monsoonal tropical landscape of the Southern Western Ghats. The rich landscape subunits, river basins and ecosystems form foundations for the diversity of natural resources, culture and economic production. But at the same time these are very fragile since they are bonded with ecosystem and hydrological connectivity.



Map. 1.1. Route Map of SilverLine. (*Source: SilverLine Project, DPR page 21, SilverLine (Semi-High-Speed Rail Project) Executive Summary - Version 2.1)*

Multiple concerns over the SilverLine project including its economic viability, social concerns and environmental consequences have created serious anxiety in society, especially in the backdrop of climate change-induced floods the State had recently experienced. This demands a detailed look into the environmental impacts of the project through an EIA process. A comprehensive EIA requires the establishment of an environmental baseline, identification of key impacts, prediction of changes, consideration of alternatives, environment management plan, post-implementation monitoring, etc. The present study does not attempt such a comprehensive EIA that is required for KRDCL for getting funds or environmental clearance. What is attempted here is an evaluation of the enviro-geomorphological system of the regions through which the rail track and associated construction activities take place. It also tries to identify the possible damages and disastrous events that may occur in the environmental fabric of the State due to various activities envisaged in the SilverLine project.

1.1. The K-Rail – SilverLine Project

The proposed K-Rail – SilverLine project extends the entire stretch of Kerala from Thiruvananthapuram to Kasaragod for a distance of 529.45 km (distance between Thiruvanadapuram station centre to Kasaragod station centre as per the DPR). This project is being executed by KRDCL, a joint venture by Govt. of Kerala and Ministry of Railways, Govt. of India.

The KRDCL is established to develop railway infrastructure in the State. According to KRDCL the SilveLine project will ease the transport between the north and south ends of the State and reduce the travel time to 4 hrs. As a result, it is aiming to substantially reduce road accidents, traffic congestion and carbon emission in addition to job creation, development of new townships and tourism development.

Feasibility Report was submitted to the Ministry of Railways, Govt. of India (K-Rail, 2019) which accorded 'In Principle Approval' for taking up pre-investment activities for the project. Later, the DPR (K-Rail, 2020) for the project was prepared. This was preceded with a rapid EIA. As per the government and KRDCL, a comprehensive EIA is under preparation. The DPR is submitted to the Ministry of Railways for approval. After the approval from the Ministry of Railways, further clearances and approval from the NITI Aayog, extended Railway Board, Cabinet Committee on Economic Affairs and final approval from Union Cabinet are required before implementation.

1.2. Relevance of the study

In addition to the project activities such as the construction of rail track which includes embankments, cuttings, viaducts, cut and cover, bridges, tunnels, stations, yards and numerous underpasses and demolition of numerous buildings on either side of the rail within a 30 m project zone, the SilverLine project envisages construction of a large number of connecting roads and few townships.

The project passes through a large extent of flood plains which were devastated during the 2018 and 2019 floods. As the largest linear infrastructure project in Kerala, the SilverLine project evoked wider and more serious discussions on its viability and impacts among the general public, political parties, technocrats, scientists, social scientists and environmentalists. Political protests also erupted in the state.

The stand-alone nature of the railway line, the standard gauge which cannot be integrated into the existing railway network, the possible environmental and social impacts of the project, the inaccuracies in the project budget and business plan, the underestimated budget and many other technical deficiencies of the DPR itself were highlighted by the critics of the project (Shaji, 2021; Sridhar, 2022; Balakrishnan, 2022). But the state government moved ahead with land acquisition and social impact study of the project without considering the opposition of people at the local level.

At this stage the KSSP examined the available documents and the initial rapid EIA conducted for the project by KRDCL and held discussions with a broad spectrum of experts and the public. A workshop was also conducted in which experts from various fields including the Managing Director of K-Rail participated. Based on the reviews and discussions, KSSP arrived at an interim conclusion that the K-Rail – SilverLine project is not the priority for improving the State’s transport sector since the major transportation demands in the State are not in the Thiruvananthapuram - Kasaragod direction. It also felt that the arguments for the project considering its social, environmental and economic impacts are not based on facts.

Accepting the need for a better and faster rail transport system which can considerably contribute to reducing carbon emissions, KSSP urged the government and K-Rail (KRDCL) to look for alternatives which are socially, environmentally and economically more viable and at the same time ensure better and faster rail connectivity in the state.

Further, Kerala Sasthra Sahithya Parishad also decided to conduct an environment and social impact evaluation of the SilverLine project with people's participation. The data collection and initial impact evaluation were carried out at the field level by more than 1000 trained volunteers of KSSP from November to December 2021 under the guidance of an expert committee formed exclusively for this. It was expected that the study will provide insight into the social and environmental impacts due to the implementation of the project.

1.3. Analysis of Detailed Project Report (DPR)

As mentioned, a Detailed Project Report, which is preceded by the preparation of a feasibility study, is one of the essential requirements for the approval and implementation of any developmental project (EIA, 2006). It should have a very comprehensive and elaborate outline of the specific project. It should also include essential information such as the resources needed and tasks to be carried out at different stages of the project. Technology and design aspects, economic and financial aspects, social and environmental aspects, and sustainability aspects with sufficient supporting data are essential components of a DPR. The requirements and risks should also be highlighted in detail.

The KRDCL engaged SYSTRA, a French company, to prepare a DPR for the SilverLine Project, which was submitted to the Central Government for approval. This DPR was returned to KRDCL for modifications, pointing out that the DPR was incomplete and lacked many details. The SYSTRA website shows that they have ample experience in high-speed rail line projects.

As per the DPR, the objectives of the project are:

- To provide a reliable, comfortable, safer, sustainable, and affordable transportation system in Kerala.
- To bring about a guaranteed improvement in the transport sector in the state.
- To improve the economy and life of the population in the state.
- To reduce the transportation time between cities and across the state.
- To provide a model transportation system having eco-friendliness, energy prudence, and economic sense so that it becomes a model system for the whole country.

1.3.1. Salient features of the project

1. The 529.45 km long K-Rail – Silverline project that proposes to connect Thiruvananthapuram to Kasaragod passes through Thiruvananthapuram, Kollam, Alappuzha, Pathanamthitta, Kottayam, Ernakulam, Thrissur, Malappuram, Kozhikode, Kannur and Kasaragod districts. Elsewhere end to end length is given as 532.185 km in DPR. Eleven stations are proposed at places like Thiruvananthapuram, Kollam, Chengannur, Kottayam, Ernakulam, Kochi Airport, Thrissur, Tirur, Kozhikode, Kannur and Kasaragod. The semi high-speed train which is designed to run at a maximum speed of 200 km/hr is expected to reduce travel time in Thiruvananthapuram – Kasaragod segment, from 12 hours to just 4 hours. The proposed SilverLine rail line passes through a different alignment away from the existing rail line from Thiruvananthapuram to Tirur while the line from Tirur to Kasaragod will run parallel to and close to the existing rail line. There will be roads parallel to the rail track and it will have underpasses every 500 m.
2. The project is expected to be completed in 6 years from the date of in-principle approval from the Govt. of India. As per the DPR, the project was expected to get the in-principle approval in 2019 and the completion of the project was expected by 2025.
3. The rail line will be in standard gauge at 1435 mm width.
4. The major reason for proposing the SilverLine project as given in the DPR is the over-utilisation and other limitations of the existing railway line. The existing Ernakulam-Kottayam-Kayamkulam section is utilised beyond its capacity (110%). Shornur-Kasaragod section utilisation is 80% of its capacity.
5. The high-speed rail proposed between Thiruvananthapuram and Kannur in 2012 by the DMRC was for 430 km and the estimated cost was Rs 90,633 crores. It was proposed as an elevated rail line considering the topography, rainfall intensity, and environmental challenges of Kerala and that proposal was more ideal. But considering the cost, the new line with embankments and cuttings is proposed.

6. The DPR emphasises that the high-speed rail will be environmentally feasible only if the projected diversion volume of traffic is materialised. *(This is important where there are predictions of changes to the technology of all transport modes such as cars, and even aeroplanes, powered by electricity.)*
7. The DPR states that the SilverLine will become unattractive to the travellers if there is a possibility of increasing the speed in the existing line by completing the doubling work, adding a third line and straightening the existing curves. *(The ticket charges will also not increase at par with SilverLine.)*
8. Considering an increase in the number of airport travellers, city feeder services linking the SilverLine and the travellers from the proposed townships, the projected number of travellers is as follows:

Table 1.1. Projected daily Ridership

Period	Projected Ridership
2025-26	79,934
2029-30	94,672
2031-42	1,32,944
2052-53	1,58,946

9. A total of 74,973 tourists comprising 8,135 domestic and 66,838 foreign are expected as yearly travellers in SilverLine.
10. The basic structure of the proposed construction activities consists of embankments, cutting, cut and cover, tunnels, bridges and viaducts. It will have 11 stations and 2 yards. Township development in and around selected stations is also envisaged, details of which are not provided in the DPR.

Table 1.2. Project activities *(other than buildings)*

No.	Project activity	Length in KM	Percentage
1	Tunnel	11.52 km	2.17%
2	Bridges	12.99 km	2.44%
3	Viaduct	88.41 km	16.61%
4	Embankment	292.72 km	55.00%
5	Cutting	101.73 km	19.12%
6	Cut and cover	24.78 km	4.66%

No.	Project activity	Length in KM	Percentage
7	**TOTAL**	**532.15 km**	**100%**

11. The alignment of the proposed SilverLine from Thiruvananthapuram to Tirur having length of 321 km will be aligned away from the existing line whereas the remaining alignment from Tirur to Kasaragod will be adjacent to the existing rail line.
12. Kollam, Chengannur, Kottayam, Tirur, Kannur and Kasargod stations will have two levels, the platform on the lower level and a concourse in the upper level. Thiruvananthapuram, Ernakulam and Thrissur stations will have three floors, platforms on the first floor and the concourse on the other floors. The platform and the concourse will be underground at Kozhikode.
13. The SilverLine will have a multi model integration like that of London, Paris, Singapore, Hongkong, etc. It will have integration with metro, light metro, bus, tram, taxi, water metro, etc.
14. Land requirement and width for the proposed activities:
    Land requirement is not considered for the underground tunnel. Additional land is required for the service roads on either side of the line, stations, yards, townships. Engineering workshops will be at Kollam, Kannur and Thrissur. Godowns and ballast depots will be at Kollam, Kottayam, and Kozhikode West Hill.
    Land requirement for track - 1,082 ha
    Land requirement for service roads - 76 ha

Table 1.3. Nature of land required for the stations

District	Area (ha)	Type of Land
Thiruvananthapuram	16.77	Plain land
Kollam	53.68	Wetlands
Chengannur	14.18	Plain land
Kottayam	15.51	Wetlands
Kochi	16.97	Plain land
Thrissur	36.48	Wetland
Tirur	13.04	Plain land
Kozhikode	19.13	Plain land
Kannur	13.75	Inhabited areas

Kasaragod	46.66	Inhabited areas
Total	**246.00 ha**	

Table 1.4. Land requirement for the rail alignment

No	Category	Length(km)	Width(m)	Area (ha)
1	Viaduct	88.41	15	81.57
2	Tunnel	11.52	—	—
3	Embankment	292.72	20	673.00
4	Cutting	101.73	25	251.25
5	Cut and cover	24.78	25.40	76.21
	Total	**519.16**	**85.40**	**1,082.03**

Table 1.5. Total land requirement

No.	Category	Area (ha)
1	Alignment	1,082.00
2	Stations	246.00
3	Depot	44.00
4	Service stations	10.00
5	Service Road	76.00
	Total	**1,458 .00**

There will be RORO facilities at Thiruvananthapuram (Kazhakkuttam), Kollam, Ernakulam, Pazhanganad and Thrissur (Muriyad) for goods transportation.

15. Height of the embankments will be varying from 2 m to 8 m. On either side there will be a 2.5 m high concrete wall overlained by barbed wire fencing. Cutting will also have the same fencing.
16. Viaducts are proposed for 116 locations. 65 large bridges and 300 small bridges are proposed. Tunnels are of three types. Four tunnels are through hills; the urban tunnel at

Kozhikode, and an underwater tunnel across Kallayi River. New Austrian Tunneling Method (NATM) is proposed for the construction of tunnels. The DPR mentions that the project will affect the hydrogeology and landscape especially due to ground tunnels and concrete structures.

17. The cost estimate is Rs.63940.67 crores. Details are given below (in crores of rupees):

Table 1.6. Estimated cost details

No.	Proposed Activity	Estimated Cost (Cr)
1	Land acquisition	13,265.30
2	Tunnel, viaduct and embankment	9,785.62
3	Bridges	663.84
4	ROB, RUB, Subways, etc.	4,425.29
4	Fencing, parking etc.	2,220.28
5	Station construction	973.00
6	Depot, Machinery	1,300.00
7	Track building	3,694.40
8	Traction and power supply	2,390.00
9	Signalling etc.	2,525.04
10	Rolling stock	4,656.00
11	Staff quarters	100.00
12	Others	818.50
13	Training	75.00
14	Price escalation	8,722.76
15	Taxes	5,135.14
16	Design and PMC	3,026.43
17	Miscellaneous	164.08
	TOTAL	**63,940.67**

18. Details of the fund sourcing (Rupees in crores)

Table 1.7. Sourcing of Fund

No.	Category	Amount (Rs. in Crores)
1	Railway cash capital	2,150.00
2	Railway land	975.00
3	Capital by Govt of Kerala	3,252.64
4	Capital mobilisation from public	4,251.71
5	Loan	33,699.80
6	Central tax deposit	3,188.73
7	Land acquisition by Kerala Govt.	11,837.25
8	Deposit for land by Govt of Kerala	1,525.00
9	Tax deposit by Govt of Kerala	2,896.00
10	Other sources from Govt of Kerala	164.08
	Total	**63,940.21**

19. The development model of K-Rail envisages a trans-oriented development (TOD) having high quality public transportation networks, real estate developments, reducing the travel time and distance for workers and day to day travellers, ultimately evolving an urban development model for the transformation of Kerala into a Metro city having modern offices, restaurants, hotels, and shopping malls.
20. As per the DPR the aim of the project is value creation, value capturing, and value realisation.
21. K-Rail envisages the possibilities for new revenue generation. For example, different types of development taxes, such as converting wetland to plain land, land use taxes for residential, commercial, industrial purposes, and land value increase due to the proposed development are some of the revenue-generating opportunities proposed. So betterment levies, vacant land tax, development charges, transfer of development right fees, etc. will

be new revenue sources. These are already existing in metro cities and can be introduced as per the projected development through the SilverLine project.

22. There are possibilities for developing smart cities near SilverLine stations. Mumbai metropolitan railway-guided development is also quoted in the DPR.
23. Acquiring thousands of hectares of land for SPV model development is also considered as part of the project.
24. K-Rail expects Rs 813.38 crores in 2025 and in 2031- 32 Rs 1,635 crores through property development.
25. K-Rail expects another income from Transactions Velocity, Rs 269.18 crores in 2025 and Rs 550.85 crores by 2054.
26. Even though the PPP model is envisaged, there is no assurance of 15-16% return on the investment, hence it is proposed that the Govt. should do the investment for the project.
27. SilverLine project will be implemented in two stages- 1st stage Thiruvananthapuram to Thrissur - 260 km; 2nd stage Thrissur to Kasargod. - 270 km
28. First-stage completion is expected by 4-4.5 years and full implementation by 6-6.5 years.
29. The Ballast requirement is estimated as 28,60,000 m^3. Procurements of this quantity will not be possible from quarries of Kerala, and it is suggested to depend on quarries in Karnataka and Tamil Nadu. The 20 mm and 40 mm metals for the concreting and dry mix needs to be sourced from Tamil Nadu and Karnataka. Eraniyal and Aralvaimozhi in Kanyakumari dist., Madhukkara in Coimbatore dist., Mangalapuram, K Puthur in Karnataka are the locations suggested in the DPR for sourcing the Ballast.
30. The DPR proposes 10 locations for quarrying in Attingal, Kundara, Mahadevapuram, Kanayannoor, Naduvattom,Vellarkkad, Kundil taluks in Kerala.
31. The DPR suggests 9 benefits for the projects, travel time saving, reduction in transportation costs, reducing pollution, reducing road accidents, reducing congestion in the roads, benefits of overall development and improvements, health expenditure reductions and cost escalation for the land, etc. If the benefits are calculated and converted into financial terms, then the yearly profit will be Rs 8,580 crores in 2026 and 16,088 crores in 2050. These are the justification for the financial viability of the project and supporting evidence for the project.
32. The IRR for the initial 30 years will be 5.84% and subsequently for 50 years it will be 8.49% considering the revenue from advertisement, building rent, property development etc.
33. Out of the total land requirement of 1,343 hectares, 253.45 hectares are paddy land which is about 18.9%. As claimed in the DPR, 30 hectares of paddy land will be added by redevelopment and 10 hectares as new paddy land, thus the loss of paddy land will be reduced to 15%. There is no assurance in the DPR that the rail will pass through the viaduct in all the paddy land areas.
34. Another major component of the proposed project is solar energy production. It is projected that from the rooftop of station buildings 15 MW, Depot buildings 5 MW, and track-side fencing 80 MW which generate a total of 100 MW solar energy.

35. Carbon reduction is the other major claim. By 2028 1.10 million metric tonnes of carbon and 10 million metric tonnes of carbon by 2050 will be reduced as a result of the project's impact.
36. Horizontal curve radius 1850 m and vertical curve radius 17,500 m are fixed as the minimum.
37. Even though EIA is not required for Indian railway projects, the SilverLine project requires EIA prepared by an accredited agency for availing foreign technology and foreign investment. As per the norms of the JAICA and other funding agencies like World Bank and ADB, large investment infrastructures are included in the category A for which EIA is mandatory as mentioned in the Rapid EIA report of SilverLine.
38. For the EIA study, 500m on either side has been considered as the zone of influence (section 3.1, page 34 of the EIA report). It also says that data on flora in and around 15 m on both sides of the rail alignment is provided by K Rail (section 3.11.1, page 101 of EIA report). Field data to supplement the available data was collected very close to the proposed rail alignment.
39. The Rapid EIA was done by the Centre for Environment Development, Thiruvananthapuram. The REIA itself states that several things need to be studied and there are several limitations to that study. So the Govt has decided to do a new comprehensive EIA study. *(That in effect meant the rejection of the REIA study)*
40. The rapid EIA of Silver Line has recommended modification of the proposed embankments through 34 watersheds.

1.3.2. DPR – Shortcomings from an Environmental perspective

The main drawback of the DPR for a project of massive investment like the SilverLine project is the lack of a comprehensive EIA study. The rapid EIA attached to the DPR has numerous deficiencies. For example, the information about major projects already implemented in the vicinity of the K-Rail – SilverLine project and the additional impacts that will be added upon to the already occurred impacts is not provided in the REIA. The DPR does not properly and convincingly address the cumulative environmental impacts over the expected construction period and the possible overrun of the construction period due to delays.

One of the major environmental concerns is the disasters unleashed by climate change, such as cyclonic storms, floods, droughts, and landslides. Their frequency and intensity are increasing. The DPR does not adequately consider and address this issue.

The DPR also lacks adequate detail on the following issues:

- Floods and high-intensity rains
- Increase in built-up area and loss of biodiversity
- Development of townships and heat island generation
- Increase in carbon emission due to:
    - Rapid urbanisation of stations and planned townships

    - Real estate development
    - New road network needed for local bodies due to the disconnection of people and associated cultural activities because of track and embankments
    - Fragmentation of properties and habitat
    - Transportation of rail travelers to the stations
    - Transportation of trucks to RORO stations
- Off-site impacts, especially due to:
    - Extraction of natural resources including rocks and water
    - Sourcing energy requirements
    - Tourism-related developments

The DPR does not duly consider these issues.

Unlike a road development that increases demand for property in its vicinity, a rail track decreases the demand for property in its vicinity. Hence the criteria for determining the buffer zone on either side of the track has to be detailed for different scenarios of precautionary measures which are lacking in the DPR. The social impact due to being in the vicinity of the SilverLine project is not adequately addressed.

DPR says that the energy requirement will be met from solar energy (green energy) from its own sources, Kerala State Electricity Board Ltd. (KSEBL) and other sources. But locations and capacity of in-house generation, availability with other agencies, details of a purchase agreement with other agencies, etc. are not included in the DPR; There is only a brief discussion on the generation of 100 MW of solar energy from rooftops, etc.

Carbon emission is calculated in the DPR based on the number of passengers expected to travel per day and the number of vehicles on road expected to be replaced by semi high speed rail. The expected number of passengers is projected as 79,900/day which is highly unrealistic when compared to 40,000 passengers/day projected for the very busy route of Ahmedabad – Mumbai bullet train. Though the DPR mentions the removal of vegetation along the alignment route, no calculation has been carried out based on the area and number of trees and shrubs to be removed and the carbon sequestration potential of the area. Savings in carbon emission without considering the amount of carbon loss due to the removal of vegetation does not give a real picture for claiming SilverLine to be a green project.

There are glaring data gaps in the DPR which are detailed in Chapter 5 (Impact Assessment). These gaps include a lack of data on the quantum and source of fill materials required for embankments, land proposed to be filled and its details, quantum and specific source of construction materials, etc.

1.4. General Observations on the DPR

It seems the SilverLine project has been developed following the High-speed rail (HSR) models in big cities viz. Tokyo, New York, Paris, Bangkok, Denmark, etc in developed nations and which are in no way comparable to Kerala in socio-economic, environmental, climatological, geographic and demographic characteristics. Such models are directly fitted into the DPR for SilverLine project without considering the unique and specific characteristics of Kerala such as the extended monsoon climate and the increasing intensity of extreme events of storms, rains and floods due to climate change.

The national policy emphasis on shifting to electric vehicles and the possibility of achieving an increase in speed and comfort in road transport with improvements in National Highway connectivity through 6-lane traffic with bypasses and flyovers in the very near future have not been considered in the DPR in computing reduction in carbon emission and accidents. The ridership computation is based on traffic diversion from existing transport systems to SilverLine which may not be realistic when most of the present SilverLine route is not connecting to traffic generating points. The DPR has not considered the option of generating traffic. It is also noted that the existing intrastate and inter-state transportation is not in the direction envisaged in the SilverLine (Kasargod- Thiruvananthapuram). The different pattern of its history, geography, connectivity, trade routes and socio-cultural identity of the population across Kerala is not considered in the DPR.

The DPR has not considered the alternative of an additional (third) line for the existing broad gauge line with a modified signaling system and curves appropriately redesigned. This is a major drawback of the DPR. Though the proposed SilverLine project is for semi-high-speed rail connectivity, discussions on semi-high-speed rail projects in the country or elsewhere and analysis of the present project on that basis is lacking. The possibility of the semi-high-speed rail system being introduced into the railway network of the State through Vande Bharat Express trains, of the Indian Railways, has not been considered in the DPR. The Indian Railways is now prioritizing the introduction of semi-high-speed rail and integrating it with the existing rail network system through appropriate technology. There is news about having floated tenders for 400 Vande Bharat trains, some of them equipped with tilting technology having the capability of negotiating existing rail line curves, with a maximum design speed of 200 km/hr.

The NITI Aayog has already pointed out many shortcomings in the DPR and expressed its reservations on the projected cost estimate and the ridership projections. They have estimated that the actual cost would be twice Rs. 63,940.67 crore, which the KRDCL estimates. This is estimated to be 50% of the State Government's total budget expenditure during 2019-20 (Kannan, 2022).

Details of the materials required and their availability are not provided in the DPR with sufficient data, except mentioning that they will be procured from certain locations within and outside the State. The estimated quantity of rocks required is possibly a gross underestimation. The traffic projections were made by a survey conducted only at Ernakulam and Thrissur alone, which makes them unreliable. The DPR assumes without proper projection studies that the associated development will increase and attract passengers to K-Rail.

It is not clear whether the DPR prepared by a private firm hired by the KRDCL has been vetted by an independent expert body or relevant bodies of the GoK, such as the Kerala State Planning Board. In any case, the KRDCL should not have proceeded with this incomplete and defective DPR to initiate the implementation process of such a major project.

Chapter II: Methodology

This is a preliminary assessment of the environmental and social impact of the proposed SilverLine semi-high-speed rail project using the methodology of Environmental Impact Assessment (EIA). This study has not adopted the complete steps and procedures of a comprehensive EIA but, as for a People's Participatory EIA, it systematically documented the ecological and social characteristics of the region, where the project is proposed. The methodology included a field survey, study of the proposed activities at each location using the DPR, and analysis of the location-specific impacts using geospatial techniques. The environmental and social status of the proposed project area was assessed through field data collection and analysis of geospatial data. The study is carried out through people's participation with the guidance and support of subject experts. Technological assistance such as a custom-made mobile Application and GIS has been used for data collection and analysis. The methodology was developed by an Expert Committee considering different aspects and methods of environmental impact assessment. As People's Participatory EIA, the attempt is to understand the possible environmental damages, hazard possibilities and social problems that could arise due to the implementation of the project from people's perspective. Environmental damages are calculated by documenting and measuring the landscape characteristics and socio-economic characteristics of the proposed SilverLine route.

2.1 Land Area of study

The SilverLine track passes through 11 districts and crosses almost all types of landscape units and demographic patterns in the state. The DPR recommends that the government may freeze all activities in a 30 m zone from the centre of the rail alignment. The rapid EIA report of K-Rail – SilverLine project says that 500 m on either side has been considered as the zone of influence. It also says that the K-Rail provided data on flora in and around 15 m on either side of the rail alignment for the EIA study. As mentioned in the rapid EIA report already prepared for this project, the impact will not be confined to this 30 m zone. The impacts on the ecosystems like paddy fields and wetlands will be extending to the entire landscape. Similarly, the impact on drainage systems and flood plains cannot be contained in the near vicinity of the rail track. The impact on people and their livelihoods will also extend further away from the 30 m zone. The impact will gradually diminish on moving away from the track. Considering the influence of vibration due to the movement of rolling stock, the Expert Committee recommended a zone of 200 m from the centre of the rail line for data collection (Hanson et al. 2006). The data analysis was carried out for 30 m, 50 m, 100 m and 200 m zones to understand varied impacts in different zones.

2.2. Environmental Impact Assessment

The aim of an Environmental Impact Assessment (EIA) is to understand the adverse effects of any project on the environment and society and to inform these findings to the decision-makers and the public. It is also expected to discuss alternatives to reduce the negative impacts and plans to manage the environment during the construction and operation stages.

The methodology of an EIA includes the steps mentioned below:

1. Description of the Project proposal, consideration of alternatives and selection of preferred approach
2. Screening: Determining whether an EIA is necessary
3. Scoping: Deciding what issues needs to be addressed
4. Baseline data collection: Collecting relevant data on the status of environment
5. Impact assessment: Assess the possible impacts due to various project activities
6. Impact prediction: Predict the possible impacts in the future
7. Mitigation: Propose plans to mitigate the impacts due to implementation of the project
8. Environmental Impact statement: Detailing the impacts specific to each project activity
9. Environmental Impact statement to be reviewed by competent authority and others including the public and NGOS
10. EIA follow up, monitoring and auditing of impacts and environmental management plan

2.3 Methodology adopted for the present study

The present study is planned in a slightly different perspective and does not include all the above-mentioned components of an EIA. The primary aim of this study is to understand the impact of the proposed SilverLine project on the environment and landscape of Kerala. It also aims to study the social impact of the proposed SilverLine project on Kerala. The study has the following stages.

1. Understanding the proposed project activities in the SilverLine semi high-speed rail project
2. Understanding the ecological, geomorphological and social characteristics of the region through which the proposed rail track alignment passes and associated activities are located
3. Assessing the impact of the specific project activities on the ecology, geomorphology, hydrology and social setting of the region
4. Need analysis based on available reports and discussions with experts

The present study adopted the method of matrix analysis supported by baseline data collected through extensive field study through people’s participation and geospatial data analysis. Data collection and analysis were aimed at understanding the landscape and land use characteristics, built-up environment and socio-cultural characteristics in and around the rail track alignment. Data on previous disaster events along the proposed rail track has also been collected. The information, especially on project activities, from the DPR was also extracted wherever required. A list of project activities has been derived from the DPR with all other available details on the activities.

The objectives are;

1. To study the landscape characteristics of the proposed Silverline track
2. To study the land use characteristics of the proposed Silverline track
3. To study the characteristics of the built-up environment of the proposed Silverline track
4. To study the previous disaster incidents along the proposed Silverline track
5. To study the socio-cultural characteristics of the region where the Silverline track is proposed, and
6. To assess the environmental and social impact of the proposed project activities.

2.3.1. Methods and tools

The methods used for this study are participatory mapping and geospatial analysis of land cover land use, geological characteristics and social characteristics. The types of data collected for this study are related to landscape/landform characteristics, geological characteristics, drainage systems, biodiversity, land use characteristics (built-up, agriculture, mining), disaster incidents, social characteristics and cultural characteristics of the proposed project area. The spatial unit for data collection has been fixed as 5 km long segments of 200 m width (100 m on either side from the centre of the track). In the 200 m width, 30 m in the centre is the land used for the proposed track. The remaining 85 m on either side of the rail line has been considered as the immediate impact zone to be studied. The methods used in this study are GIS-assisted survey using a customised mobile application, geospatial analysis assisted with ground truth data and secondary data and analysis with geospatial techniques and simple statistical tools.

The impact statement is made based on the preliminary analysis of large primary data gathered by the local people using scientific formats and geo-tagging techniques in the mobile phone platform. Further, these have been transferred to GIS format for spatial analysis. The attribute data have been compiled in the tabular form to facilitate quantitative assessments. Using these spatial and attribute data and field level inferences, environmental impacts have been identified, assessed and evaluated. The rail track zone of 30 m and a buffer of 85 m either side have been considered as impact zones for the analysis. However, methods like modelling studies for impact prediction could not be done due to paucity of time and resources. But it has to be highlighted that an impact evaluation using primary data collected by local people all along the stretch of over 530 km may be for the first time in the impact assessment studies.

This study has the following components:

1. Participatory GIS assisted field data collection
2. Secondary data collation and analysis
3. Geospatial data generation and analysis
4. Analysis of available reports and experts' opinion
5. Impact evaluation and Impact statement preparation
6. Evaluation of the benefits and environmental and social damages using matrix analysis

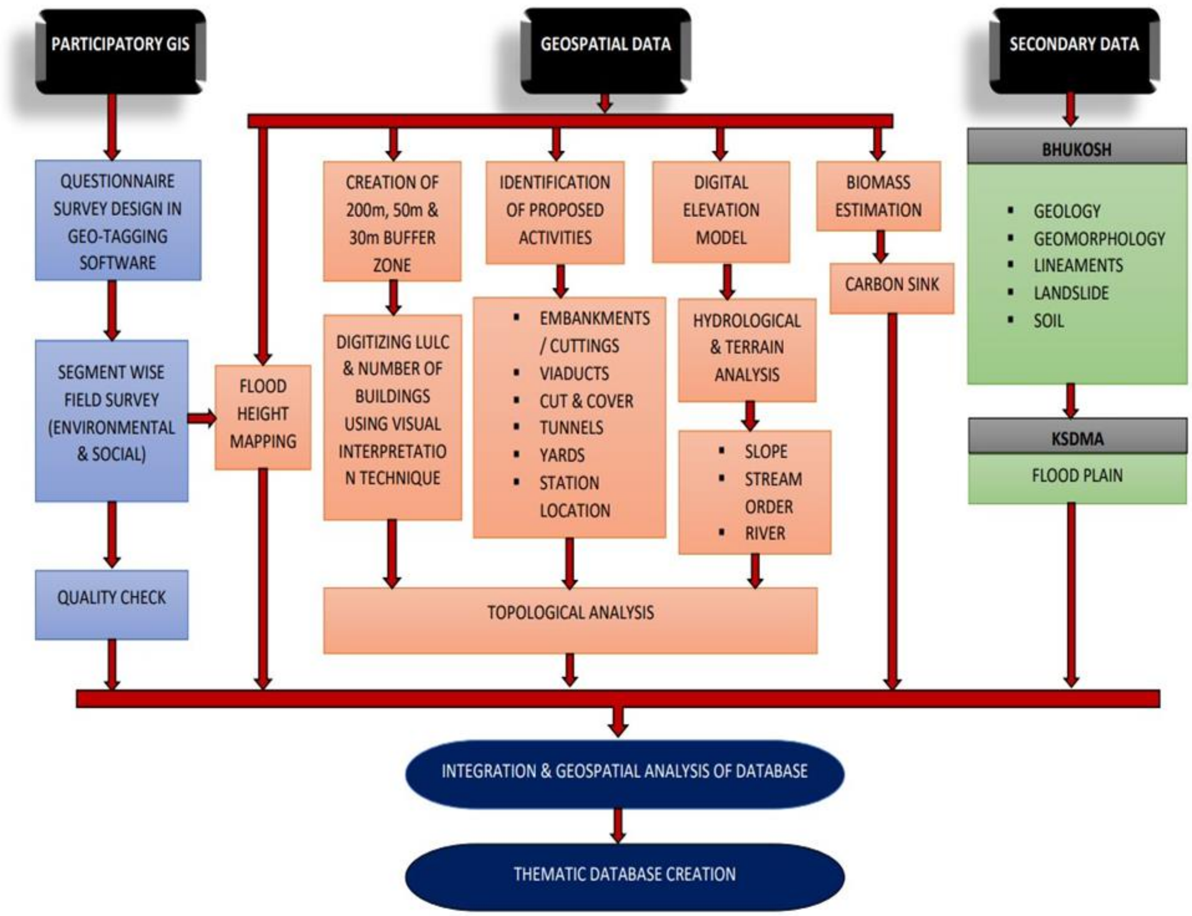


Fig. 2.1: Methodology used for SilverLine PEIA

The first phase of the study consisted of developing a questionnaire and organizing participatory GIS. Experts from various fields of social, environmental, geological science, and disaster management designed the questionnaire. The data collection for understanding the environmental impact was conducted for a defined 200 m buffer zone (100 meters each to either side of the proposed alignment) around the 529.45 km length (≅10,679 ha) of the SilverLine track. The entire zone was split into 5 km segments for detailed study. There were 107 segments in the 529.45 km long stretch. The study was organized in such a way that trained KSSP volunteers from each Mekhala (Regional) Committee of KSSP was given charge, by the respective District Committees, to conduct the geotagging survey of one 5 km segment each coming under that district.

Simultaneously collection of the secondary geospatial data from various State and central departments was initiated. For this analysis, the layers of Geology, Geomorphology, Lineaments, Landslide prone area and soil were collected from Bhukosh (https://bhukosh.gsi.gov.in/Bhukosh/) and floodplain data from Kerala State Disaster Management Authority (https://sdma.kerala.gov.in/maps/).

The next phase was extracting information from Geospatial data (Remote sensing data) using Geospatial techniques. In this phase, a GIS database was developed from satellite imagery and Digital Elevation Models (SRTM data models) for the detailed impact measurement. The GIS database consisted of 107 segments 5 km in length and 200 m in width along the rail line. Then two buffer zones of 30 m and 200 m were created. Digitization of Land use land cover, Landscape units and identification of the number of buildings falling in both the identified buffer zones were done.

The next step was the identification of proposed activities in the K-Rail – SilverLine project such as embankments/cuttings, viaducts, cut and cover, tunnels, yards and station locations using visual interpretation technique. SRTM Digital Elevation models are used for the identification of slope and stream orders that are interpreted by the K-Rail – SilverLine in each identified segment. The approximate vegetation biomass of both the buffer zones is estimated from earth observation data (Sentinel-2 mission) with the reference from vegetation biomass of the different secondary studies. From this biomass data the carbon sink was estimated district-wise using an allometric equation (Sergey et al., 2016, Chave et al., 201, Gudeta, 2019). Flood zonation map of the buffer zone was created using flood height data from fields and geospatial tools. Area and kilometre wise final output was created integrating a geotagged database, developed thematic layers and secondary data layers. Advanced geospatial analyses such as buffer, overlay and intersection were utilised in this process.

2.3.2. Impact assessment

This study adopted the matrix method (Leopold et.al. 1971) for evaluating the impact potential of the proposed project on the environment and social setting of Kerala. For this, specific project activities which are expected to cause an impact on the environment, and social settings of the State were identified from the DPR. About 18 possible impacts have been listed. These impacts for each activity have been categorised as beneficial or adverse, reversible or irreversible and long-term or short term. The possible impact of these listed project activities has been ranked according to the impact category in a matrix that assesses the activity-based impact and calculated the total impact using that.

2.4. Study process

The study was conducted by a committee of experts constituted by the Nirvahaka Samithi (Executive Committee) of the KSSP and monitored by its Parisara Vishaya Samithi (Environment Subject Committee). The study process was fully participatory in nature, involving people from different disciplines. Data collection was organised through more than 1000 volunteers under the supervision of the respective District and Megahala committees and the district IT cell of the KSSP.

The study also required facilitated analysis of data with the help of experts and facilities from KSSP organisations. The study necessitated careful planning, coordination and monitoring for its completion. Considering this, a committee called K-Rail cell was constituted within KSSP to coordinate the activities related to the study. The study ensured the support and participation of experts in different fields. An Expert Committee with members having expertise in various fields like EIA, ecology, biodiversity, agriculture, fisheries, disaster management, geoscience, hydrology, coastal management, engineering, socio-economics, and community dynamics was constituted which provided the required academic support. It also deliberated and decided on the methodology to be adopted and monitored and reviewed the study process including data collection and GPS (GIS) analysis at regular intervals. The committee guided in the preparation of the report.

Technical committees at the state level (IT Core Committee) and district levels (IT support team) were formed to ensure technological support at all levels and all stages. Once the methodology was finalised followed by a data collection format by the Expert Committee, the IT Core Committee developed a mobile app for data collection. A trial run of the mobile app was held at Thikkody in Kozhikkode, based on which changes were made to the mobile app. Printed and video training manuals (Fig. 2) were developed to guide the field level data collection and overall methodology.

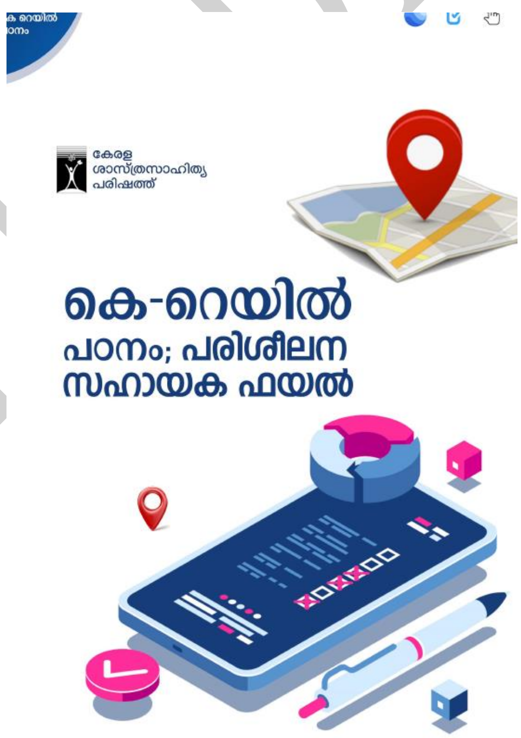


Fig. 2.2 Cover Page of the Training Manuel

Training for data collection was imparted by the Technical Committee for the State level, District level and Mekhala level resource persons consisting of KSSP volunteers. Field data collection teams were constituted at the Mekhala level. Adequate hands-on training was provided to the teams for baseline data collection. Each study team had a Leader (*Chumathalakkar*). The volunteers were given sufficient exposure to various tools for field data collection during the training. These trained study teams at Mekhala levels collected data from the field with the support and monitoring of technical support committees. While collecting field data the teams communicated with the local community and ensured their participation in gathering the local level information. The District and Mekhala Parisara Vishaya Samithi, Vikasana Upasamithi (Development Subcommittee) and Yuvasamithi (Committee of Youth) were actively involved in the study process.

Data collected were uploaded and verified by the State Level Technical Committee for its correctness. Every night, the Core Committee interacted with field teams through Google Meet for assessing the work, getting feedback, clearing doubts, and giving fresh instructions based on feedback analysis. Data gaps were also identified. Wherever required, secondary data were collected by the Technical Committee from reports, maps and other documents from the Land Use Board, Disaster Management Authority and Biodiversity Board.

Reports available from the websites of the IUCN and IPCC were also referred to. Analysis of the data collected was done by a group of GIS experts and statisticians constituted for the purpose under the guidance of the Technical Committee. The GIS team filled the gaps in data collection from satellite imageries, wherever possible. The whole process was completed voluntarily utilising the expertise and human resource of more than 1000 KSSP activists.

The Expert Committee met at different stages of data collection, analysed, monitored, and assessed the progress of the work. Once the data collection and analysis were completed, the Expert Committee held meetings both online and offline to prepare the report in consultation with the Technical Committee. The interim reports and final draft were regularly presented to the Nirvahaka Samithi of the KSSP for review. The draft report was also reviewed by a multidisciplinary group of experts before it was finalized. The final draft was placed before the Nirvahaka Samithi of the KSSP for review and formal approval. A brief content of the Executive Summary was presented at the 60th Annual State Conference of the KSSP held at Thrissur. The report thus prepared summarises the quantitative and qualitative impacts of the SilverLine project on the biological, physical, and social environment of Kerala as elicited from the study.

2.5. The Report

This report has an introductory chapter that illustrates the scope and objectives, and a detailed analysis of the DPR of the K-Rail – SilverLine project. The second chapter discusses the methodology, processes of the study, and the report format. The third chapter provides the baseline environmental status. The fourth chapter is about the state of social conditions of the region where the project is proposed. The fifth chapter is on the possible impact of the project on various ecosystems, the built-up environment, and people's lives in the region. The sixth chapter presents the final analysis of the cost and benefits of the project from a landscape, environmental, and social perspective. It illustrates the impact of the project on the total ecological and economic productivity of the biocultural landscape of Kerala against the benefit of the project and evaluation of the cost of ecosystem services. This report does not deal with the environmental management plan or alternatives for the project at this stage. This report will be presented back to the people who collected the data, and they will discuss it at the local self-government level.

2.6. Limitations of the study

This study is conducted entirely through people's participation and is based on the data collected thereof and also that is provided in the DPR about the project. The study and its analysis have this limitation. The study and its analysis have this limitation. In the districts of Alappuzha, Kottayam, and Pathanamthitta, a few segments have not been manually surveyed completely (though the data gaps have been filled up using GIS).

Chapter III Baseline Environmental Status

The baseline environmental status of the regions through which the SilverLine rail track passes provides an insight into the characteristics of the landscape/landform units, ecosystems, land use land cover, disaster incidents, and socio-cultural settings of the proposed project location of the SilverLine project. The current status of the land, environment, and social settings of the region is explained using the primary data collected and the secondary data from other sources to support it. The details are presented under different sections, namely:

- Geology and geomorphology
- Land cover
- Ecosystems and biodiversity
- Drainage systems
- Previous disaster incidents
- Climate change impacts

The State of Kerala lies between the Western Coast of India and the highest regions of the Western Ghats mountains in the east, which extend from the Thiruvananthapuram-Kanyakumari juncture at the southern tip of the Indian subcontinent up to the Kasaragod-Nilgiri region in the south-north direction. The State has a mountainous landscape in the monsoonal tropics.

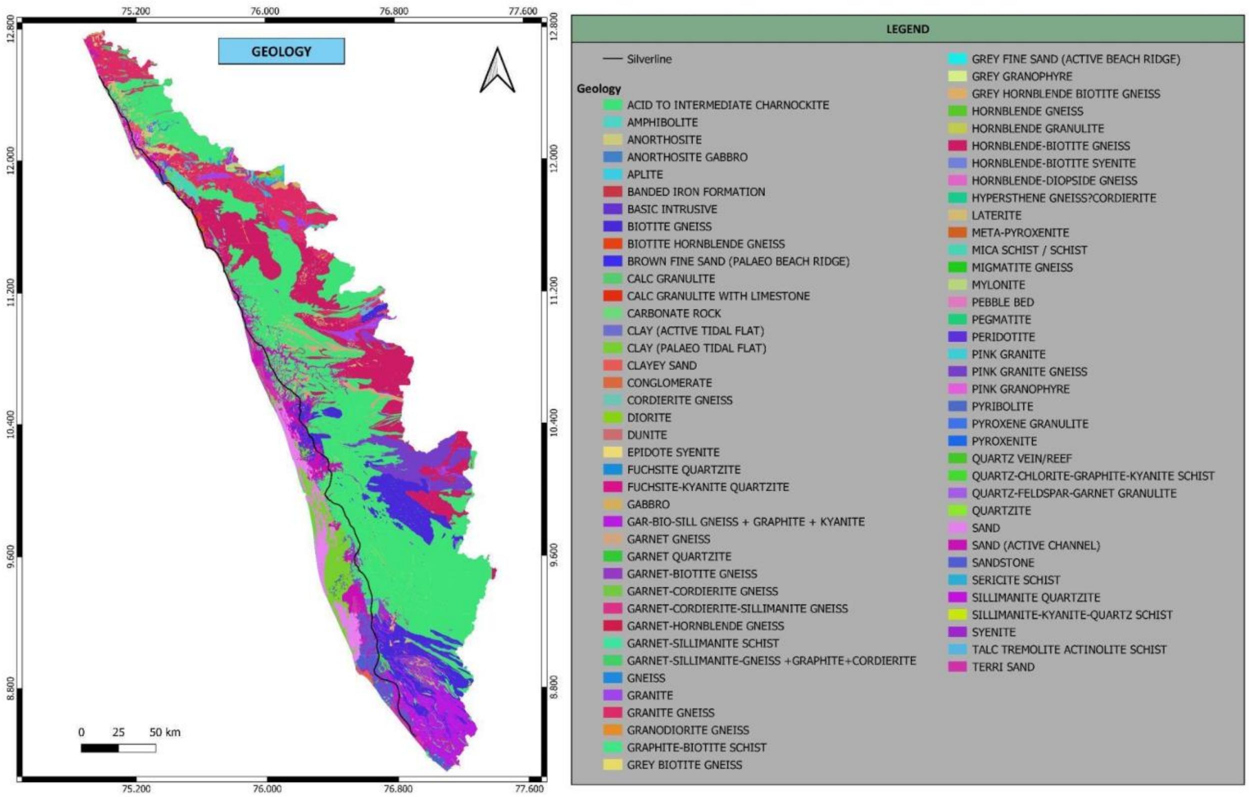
This larger landscape consists of watersheds of 41 west-flowing rivers originating from the Western Ghats. The catchments of these rivers are spread from the highland, valleys in the midland, floodplains in the midland, and to the Western coast with luxurious backwaters and estuaries.

The proposed SilverLine project cuts across the lowland-midland region, which is rich in population, wetlands, and floodplains; very unique Spur hills and laterite hillocks; and coastal wetlands including mangroves. The proposed railway track passes through almost all the unique ecosystems of Kerala except the mountain regions. It crosses all the complex geological formations other than the Western Ghats region and passes through the urban, semi-urban, and rural settings of Kerala, including the cropping area of almost all principal crops of the State. The proposed rail track, in many places, is along the well-developed regions of Kerala and disrupts the built social amenities and infrastructures along its track. The details are discussed here with the data gathered on these aspects during this study.

3.1. Geology and Geomorphology

Lateral connection among ecosystems is facilitated by the hydrology, geology, and geomorphology of the landscape. Spatial patterns and processes in landscapes influence the functioning of ecosystems. Biotic components depend on abiotic components, such as soil, rock, wetlands, etc., for their survival. Fragmentation and destruction of landscape components have a significant impact on biodiversity and environmental quality. It leads to an overall reduction in habitat and loss of hydrological and biotic connectivity.

Geologically, the Kerala region is part of the South Indian Precambrian terrain. The bulk of the rocks of Kerala, especially the granulites and associated gneisses, belong to the Precambrian. The onland sedimentary formations are confined to the Neogene period only. They include pebble beds, sandstone, grit, clay with shells, marl, and limestone. All the rock types are lateritised at variable depths. Duricrust formations are marked in places. The Recent and sub-recent sediments cover low-lying areas, the coastal plain, and river valleys (Soman, 2002; Chattopadhayay, 2021).



Map No 3.1. Map of Kerala geology and the proposed rail alignment on that

Kerala is a narrow stretch of land sandwiched between the Western Ghats in the east and the Arabian Sea in the west. It has a width ranging from 30 to 120 km, with an average of about 67 km. Forty-four rivers traverse the land, of which 41 flow towards the Arabian Sea. The other three rivers flow east, originating in the Western Ghats and flowing west until they drain into either the backwaters or the Arabian Sea. The rivers are mainly monsoon-fed, and most of them are perennial. Kerala has unique landforms, including the coastal plains and the mid-highlands, which lie between the Western Ghats mountain range in the east and the Arabian Sea in the west. The State can be classified into five physiographic zones: mountain peaks above 1800 m, highlands at altitudes of 600 to 1800 m, midlands at altitudes of 300 to 600 m, lowlands at altitudes of 10 to 300 m, and coastal plains and lagoons below 10 m. The area falling under low land where the rail line passes constitutes 54.17% of the total area of the State. This area is characterized by dissected peneplains, numerous flood plains, alluvial terraces, valley fills, colluvium, and sedimentary formations.

3.1.1. Land environment

The State of Kerala comprises a narrow strip of land between the Lakshadweep Sea to the west and the Western Ghats to the east. It is distinct from the adjoining States of Karnataka and Tamil Nadu by its topography and human settlement patterns. The coastline of Kerala is 590 km long, nearly straight trending north, northwest, south, and southeast directions, indicating structural control. The width of the State ranges from 30 to 120 km. The land environment plays a significant role in shaping Kerala's ecological, social, and economic systems.

Large-scale modifications to the land environment have already occurred, and further modifications could deteriorate environmental health, natural resources, and development processes. This could accelerate hazards related to climate change.

3.1.1.1. Landscape units

The approach to nature conservation for conserving biodiversity and ecosystem services has evolved from the protection of specific species to the conservation of large landscape areas consisting of a network of habitats. The landscape of the State falls under three broad categories based on altitude: Highland, Midland, and Lowland. The Western Ghats are the most prominent feature of the Highland. Undulated Laterite Terrain forms are the major feature of the Midland. Coastal plains, backwaters/lagoons/estuaries/kayals, beaches, barrier islands, spits, and offshore mud banks are distinct peculiarities of the lowlands.

These landscape units are very rich in biodiversity and support the livelihoods of a major section of the population. The Midland and lowland are major settlement areas with a high population density. The SilverLine track mostly passes through Midland and Lowland areas. The landscapes of all these have been drastically and irreversibly modified and fragmented due to human intervention over the last few decades. Fragmentation of the landscape units has significant impacts on biodiversity and ecosystem services, which in turn affects the livelihoods of local communities.

The study considered natural vegetation, laterite or sparse vegetation, mangrove forests, paddy fields, marshy areas, backwaters, ponds, chira, and sacred groves as categories of landscape units. The paddy fields are further divided into cultivated and cultivable fallow, while marshy areas are defined as any wetland other than cropped or cultivable. The data collected from the field level is within zones of 200 m width and 30 m width. The 30 m width is the area that will be converted fully to the project activity, and the 200 m zone is the immediate impact zone of 85 m on either side of the track.

The landscape units in the 200 m zone through which the rail track passes are presented in Table 3.1, based on land cover inferences. Most of the laterite hills are characterized by sparse vegetation. Laterite hills cover about 663 acres (268.46 ha) along the area through which the rail track passes. The dense vegetation (natural vegetation) cover is about 31 ha, while mangroves cover an area of 136.5 acres (54.91 ha). Kannur has the maximum mangrove areas that could be affected. The area coverage of marshy land is about 590 acres (238.54 ha). Kasaragod, Kannur, and Kozhikode have large areas of marshy land that may be affected. Sacred groves are very important ecosystems, and they cover an area of 60.76 acres (24.59 ha). Backwaters through which the rail track passes cover an area of 45 acres (18.40 ha). Ponds and chira occupy an area of 2,892 acres (1,172.39 ha). Cultivated paddy fields extend for 517 acres (208.84 ha), while cultivable fallow lands extend for 615 acres (248.83 ha). These land cover units have also been extracted from satellite imagery and are given in Table 3.2.

Information in the 30 m zone is also extracted from satellite imagery. Some variations from field mapping are observed in the values, which could be due to the differences in the methods adopted. Sacred groves are not discernible in the satellite imagery. Certain mangrove associates are also considered as mangroves in field mapping, which might have caused the observed difference in the two sets of data. Data from field mapping, as given in Table 3.1, has been used for analysis in this study. The information derived from satellite imagery has been used to gain more insight into land use.

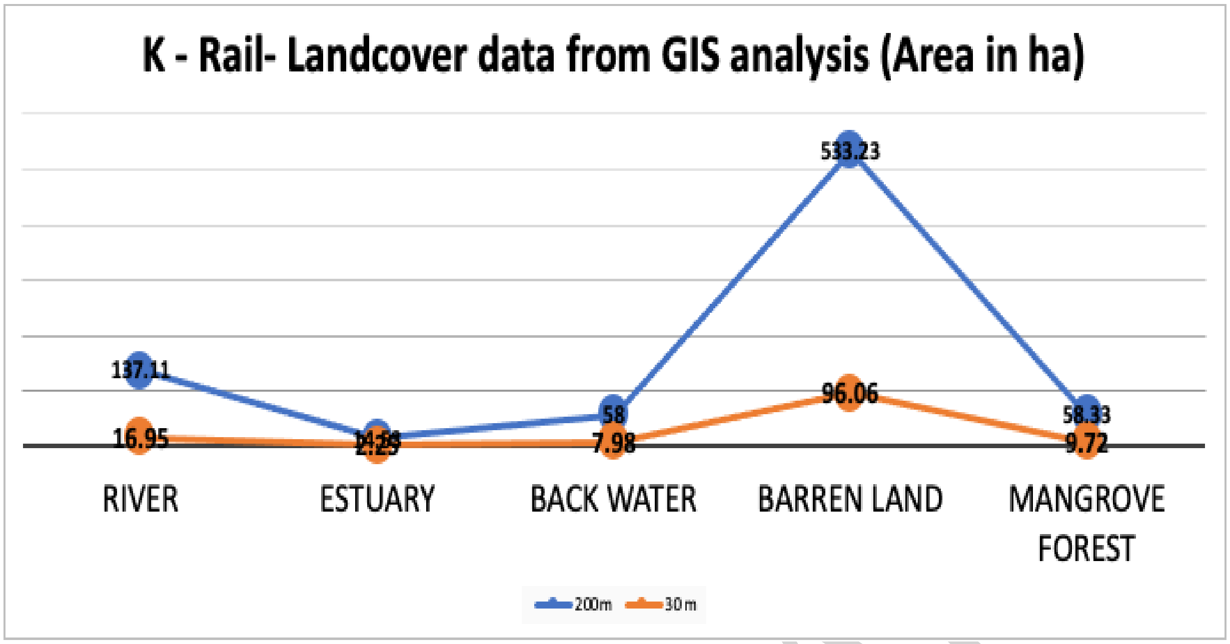
Table 3.1. Land Cover in 200 m zone area in acres (Ha in parenthesis); (*from field mapping*)

District	Natural Vegetation	Sparse vegetation (Laterite)	Mangrove forest	Paddy land		Marshy Areas	Backwater	Ponds and chira	Sacred grove
				Cultivated	Cultivable fallow				
Thiruvananthapuram	3.25 (1.32)	45.95 (18.60)	0.85 (0.34)	10.91 (4.42)	51.39 (20.80)	68.60 (27.76)	33.18 (13.43)	2.73 (1.10)	33.00 (13.35)
Kollam	1.65 (0.67)	15.00 (6.07)	22.26 (9.01)	67.76 (27.42)	58.93 (23.85)	41.57 (16.82)	0.15 (0.60)	14.68 (5.94)	1.55 (0.63)
Pathanamthitta	0.00	116.98 (47.34)	0.00	28.00 (11.33)	32.68 (13.22)	16.01 (6.48)	0.00	1.31 (0.54)	0.20 (0.08)
Alappuzha	0.00	3.24 (1.31)	1.21 (0.49)	0.00 (1.32)	5.46 (2.21)	2.02 (0.82)	0.06 (0.02)	0.67 (0.27)	0.02 (0.01)
Kottayam	0.40 (0.16)	97.41 (39.42)	0.00	40.73 (16.48)	11.58 (4.69)	19.24 (7.79)	0.00	2.62 (1.06)	0.10 (0.04)
Ernakulam	0.81 (0.33)	130.18 (52.68)	4.49 (1.82)	28.81 (11.66)	103.59 (41.92)	70.46 (28.51)	0.00	1.84 (0.74)	4.05 (1.64)
Thrissur	0.03 (0.12)	19.46 (7.88)	0.37 (0.15)	152.65 (51.77)	113.64 (45.99)	17.48 (7.07)	0.61 (0.25)	1.73 (0.7)	0.91 (0.37)
Malappuram	0.00	14.29	2.02	78.03	18.23	11.05	0.12	1.40	0.93

		(5.78)	(0.82)	(31.58)	(7.38)	(4.47)	(0.05)	(0.57)	(0.38)
Kozhikode	2.63 (1.06)	75.50 (30.55)	1.38 (0.56)	36.05 (14.59)	98.37 (39.81)	119.11 (48.20)	3.64 (1.47)	25.20 (10.20)	14.61 (5.91)
Kannur	9.94 (4.02)	31.08 (12.58)	83.81 (33.92)	30.37 (12.29)	49.80 (20.15)	96.98 (39.25)	1.21 (0.49)	3.04 (1.23)	2.63 (1.06)
Kasaragod	12.38 (5.01)	114.27 (46.24)	19.28 (7.80)	42.74 (17.30)	71.21 (28.82)	126.91 (51.36)	6.48 (2.62)	2.17 (0.88)	2.75 (1.11)
Total	**31.09** (12.58)	**663.37** (268.46)	**135.69** (54.91)	**516.05** (208.84)	**614.87** (248.83)	**589.44** (238.54)	**45.46** (18.40)	**57.39** **(**23.23)	**60.76** (24.59)

Table 3.2. Land cover data from GIS analysis (Area in ha)

Landscape units	**River**		**Estuary**		**Backwater**		**Barren land**		**Mangrove forest**	
District	**30 m**	**200 m**	**30 m**	**200 m**	**30 m**	**200 m**	**30 m**	**200 m**	**30 m**	**200 m**
Thiruvananthapuram	0.52	4.75	0.00	0.00	0.40	3.70	2.94	20.22	0.00	0.00
Kollam	0.52	5.37	0.00	0.00	0.00	0.00	5.36	36.75	0.00	0.00
Pathanamthitta	0.54	3.75	0.00	0.00	0.00	0.00	1.50	7.26	0.00	0.00
Alappuzha	0.14	1.01	0.00	0.00	0.00	0.00	1.66	11.22	0.00	0.00
Kottayam	1.43	11.61	0.00	0.00	0.00	0.00	5.00	31.90	0.00	0.00
Ernakulam	4.72	41.04	0.00	0.00	0.00	0.00	9.55	50.90	0.00	0.00
Thrissur	0.71	6.95	0.00	0.00	0.00	0.00	8.66	62.48	0.00	0.00
Malappuram	2.81	18.87	0.49	3.22	0.00	0.00	15.12	61.95	0.07	0.19
Kozhikode	1.63	8.02	1.76	11.31	1.68	11.29	16.24	68.59	1.98	7.84
Mahe	0.00	2.24	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00
Kannur	0.57	8.58	0.00	0.00	4.24	32.43	10.52	70.88	5.67	36.66
Kasaragod	3.35	24.93	0.00	0.00	1.66	10.58	19.51	110.62	2.00	13.64
Total	**16.95**	**137.1**	**2.25**	**14.53**	**7.98**	**58.00**	**96.06**	**533.23**	**9.72**	**58.33**



3.1.2. Wetland

Wetlands include waterlogged lowlands, cultivable fallow lands, paddy fields, and marshy areas. The Ramsar Treaty on wetlands defines wetlands as:

> "… areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres." (Ramsar Convention, 1971, Article 1.1)

The Kerala Conservation of Paddy Land and Wetlands Act, 2008 defines wetlands as 'land lying between terrestrial and aquatic systems, where the water table is usually at or near the surface or which is covered by shallow water or characterised by the presence of sluggishly moving or standing water, saturating the soil with water and includes backwaters, estuary, fens, lagoon, mangroves, marshes, salt marsh and swamp forests but does not include paddy lands and rivers'.

This is at variance with the Ramsar definition, as paddy and cultivable fallow land are not included in the definition of wetlands in the Kerala Act. Hence, these are separately considered for this study and shown in Table 3.1 and Table 3.2.

Wetlands perform significant environmental, social, and economic functions, ranging from being a source of drinking water, recharging groundwater, and acting as sponges to control flooding, supporting biodiversity, and providing livelihoods. The wetlands of the State are sites of exceptional biodiversity and are characterized by several endemic species. However, they have become the biggest casualty of development and urbanization today. Infrastructure development in the form of roads and railways has fragmented the contiguity of the wetlands and destroyed extensive tracts of wetlands, thereby upsetting the entire complex ecology. The regeneration possibilities of wetlands are diminishing since many of the changes are irreversible.

The area of wetland (mangrove, marshy area, backwater, ponds, and chira) that is affected by the proposed project in each district, as obtained from field data, is presented in Table 3.2. The area of wetland within the 200 m zone that will be affected is 335.08 ha. This includes mangroves in 54.91 ha. Rivers and some of the paddy fields which have a wetland nature are excluded from wetland as per Govt. of Kerala rule. (The data on wetlands computed through GIS analysis of satellite image is also given for reference (Table 3.3)). The total loss of wetland considering a 30 m width of 107 segments is 19.92 ha, and that of 200 m width is 130.86 ha. Thrissur district has the highest loss in wetland area with 15.75 ha in the 30 m width segment, and Kollam district has the highest losses with 116.94 ha in the 200 m width segment.

Wetlands are unique ecosystems characterized by their water holding capacity, which determines the region's surface and groundwater table. The impact of the fragmentation of large tracts of wetlands through this linear infrastructure introduction will be much more than the figure of actual loss. Fragmentation and filling in any wetland will alter its ecological characteristics and functions.

Table 3.3. Type of Wetlands and area in 30 m and 200 m zones in (ha)

District	Waterlogged lowlands		Cultivable fallow		Paddy		Marshy areas		Total	
	30m	200m	30m	200m	30m	200m	30m	200m	30 m	200 m
Thiruvanantha-puram	2.27	12.51	0.61	2.68	1.97	17.05	0.61	2.68	**5.21**	**38.46**
Kollam	20.23	118.06	1.90	13.12	0.23	0.41	1.90	13.12	**23.67**	**139.47**
Pathanamthitta	10.70	74.57	0.36	1.61	0.67	4.54	0.36	1.61	**14.68**	**100.81**
Alappuzha	12.72	81.74	0.62	3.12	0.00	0.00	0.62	3.12	**15.04**	**94.01**
Kottayam	13.63	89.35	6.26	34.27	4.96	30.04	6.26	34.27	**25.90**	**160.45**
Ernakulam	0.13	0.46	20.04	132.25	13.49	85.41	20.04	132.25	**45.55**	**291.72**
Thrissur	21.92	143.65	8.53	53.88	20.21	125.73	8.53	53.88	**64.54**	**410.67**
Malappuram	9.78	60.51	0.00	0.00	12.93	93.36	0.00	0.00	**23.23**	**163.40**
Kozhikode	0.00	0.00	0.20	3.10	0.99	6.54	0.20	3.10	**1.73**	**15.21**
Mahe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**
Kannur	1.06	5.84	1.63	16.04	2.10	13.51	1.63	16.04	**14.25**	**88.40**
Kasaragod	0.00	0.00	1.34	12.89	12.61	64.48	1.34	12.89	**18.35**	**129.07**
Total	**92.45**	**586.71**	**41.49**	**272.99**	**70.19**	**441.10**	**41.48**	**272.97**	**252.15**	**1631.67**

3.1.3. Rock Types

The proposed rail line passes through different geologic formations of varying ages, including alkali complex (1.76 km), Charnockite gneissic complex (335.3 km), coastal sediments (5.66 km), fluvial/aeolian/coastal sediments (143.11 km), Vengad formation (5.61 km), Warkalli formation (29.12 km), and rocks of uncertain age (13.35 km). The total length of the rail line falling in sedimentary terrain is about 177.89 km, and this terrain requires geotechnical treatment that is different from that of hard rock areas. Table 3.4 lists the geologic formations along the proposed rail line, and Table 3.5 provides detailed lithologic characteristics.

Table 3.4. Geologic formations along the proposed rail line

Geologic Formation	Age	Length (km)
Alkali Complex	Neoproterozoic	1.76
Charnockite - gneissic complex	Archean	331
Coastal Sediments	Quaternary	5.66
Fluvial/Aeolian/Coastal/Glacial sediments	Quaternary	143.11
Vengad Formation	Archean Proterozoic	5.61
Warkalli Formation	Mio-Pliocene	29.12
Rocks of unknown age	Not clearly known	13.35

(See Tables in Annexure for detailed lithological characteristics of the project area)

Various engineering structures, such as embankments, viaducts, bridges, tunnels, and cut-and-cover structures, must be constructed as part of the mega project. The geological formations through which these structures will be erected are provided in Table 3.5. The rail line passes through 268.63 km of unconsolidated sediments (sand, clay, pebble bed, and Terri sand), 40.82 km of sandstone formation, and 3.90 km of laterite. The remaining 222.735 km stretch passes through hard rocks. Detailed geotechnical investigation is required in areas of unconsolidated sediments through which the proposed line passes.

Table 3.5. Geological formations associated with different project Activities (Area in Ha, length in km)

No	Lithology	Length	30 m	200 m	Embankment	Viaduct	Bridge	Tunnel	Cut-and-Cover
1	Grey Fine Sand			3.11					

	(Active Beach Ridge)								
2	Sand (Active Channel)	151.51	459.97	3056.95	353.00	80.62	21.66	0.35	4.34
3	Clay (Palaeo Tidal Flat)	11.38	34.00	221.28	17.84	12.58	3.58	5.55	
4	Clayey Sand	45.36	136.02	909.37	113.95	14.40	0.84		1.29
5	Pebble Bed	1.17	3.52	23.03	3.17				0.36
6	Terri Sand	45.58	136.69	904.16	109.54	5.61	1.52	15.65	4.38
7	Sand	13.63	40.71	265.04	39.72	0.15	0.94		
8	Sandstone	40.82	122.57	824.29	92.37	17.95	1.11		11.13
9	Laterite	3.90	11.66	76.02	8.82	1.00			1.85
10	Hornblende-Biotite Syenite	2.57	7.70	51.35	7.31		0.39		
11	Hornblende Gneiss	0.99	2.98	19.83	2.98				
12	Hornblende-Biotite Gneiss	15.70	47.25	313.16	37.99		1.09		1.22
13	Garnet-Biotite Gneiss	6.30	18.91	129.54	9.57	6.94	0.51		1.60
14	Biotite Hornblende Gneiss	16.63	49.90	326.18	37.27	11.67	0.36		0.60
15	Biotite Gneiss	25.35	76.38	515.91	45.26	30.92			0.20
16	Garnet Gneiss	1.33	4.00	26.23	1.42	0.63		0.90	1.06
17	Cordierite Gneiss	0.30	0.90	5.50	0.36				0.54
18	Acid To Intermediate Charnockite	124.24	372.50	2491.40	272.12	55.78	2.44	10.04	32.13
19	Pyroxene Granulite	0.63	1.86	10.82	0.62	0.10		0.91	0.23
20	Gar-Bio-Sill Gneiss + Graphite + Kyanite	16.35	49.13	335.35	28.94	9.82	0.48	1.19	8.70

21	Garnet-Sillimanite-Gneiss +Graphite+Cordierite	3.76	11.27	74.05	2.82	6.10			2.35
22	Quartzite	0.17	0.49	1.55					0.49
23	Granite Gneiss	2.58	7.73	51.14	5.21	0.99			
24	Grey Hornblende Biotite Gneiss	0.87	2.64	14.68	2.27				
25	Banded Iron Formation	0.27	0.81	4.59	0.81				
26	Sillimanite-Kyanite-Quartz Schist	0.79	2.38	23.39	0.88	1.50			

3.1.4. Soil

Three types of soil encountered along the proposed track are coastal alluvial soil, lateritic soil, and peaty/saline peaty soils (Table 3.6). Coastal alluvial soils are of marine origin and are identified along the coastal plains and basin lands as a narrow strip. They include beach sands, marshes, paleo sand ridges, and very gently to gently sloping sandy plains. These areas generally have a high water table, which in some areas reaches above the surface during the rainy season. Of the total 530 km length of the Silverline, 470.671 km passes through this type of soil, which has a high thickness and a sandy texture. Lateritic soils mainly occur in the midlands and part of the lowlands. The texture of lateritic soil varies widely, with the proportion of gravel, sand, and clay particles varying from place to place. Peaty/saline peaty soils occur in isolated patches along the coastal plains adjoining the backwaters. Such areas are generally subjected to frequent flooding and water stagnation. These soils have a relatively high proportion of organic residues and are poorly aerated and ill-drained.

Map No 3.2. Soil map of Kerala and the Proposed Project Activities

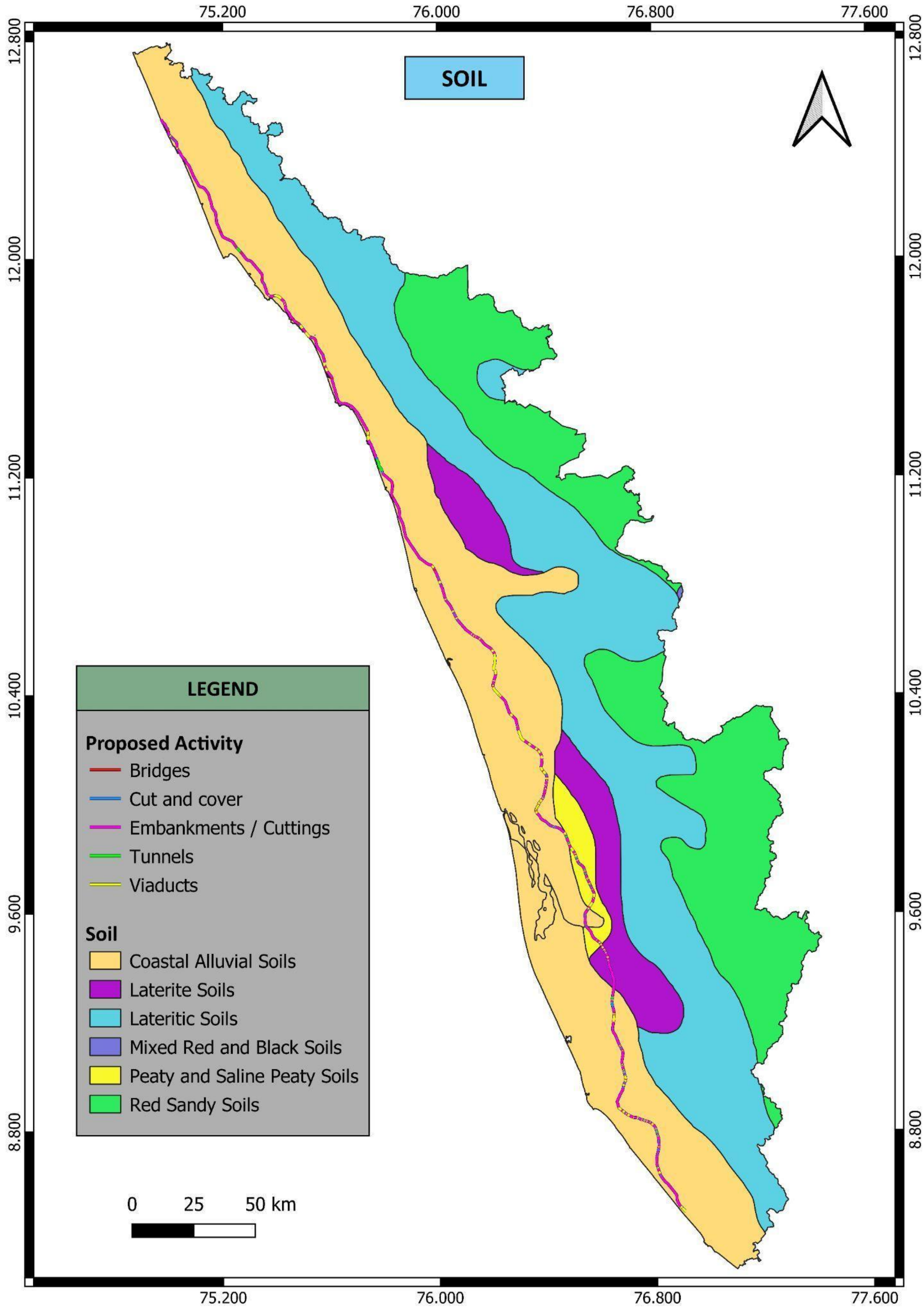


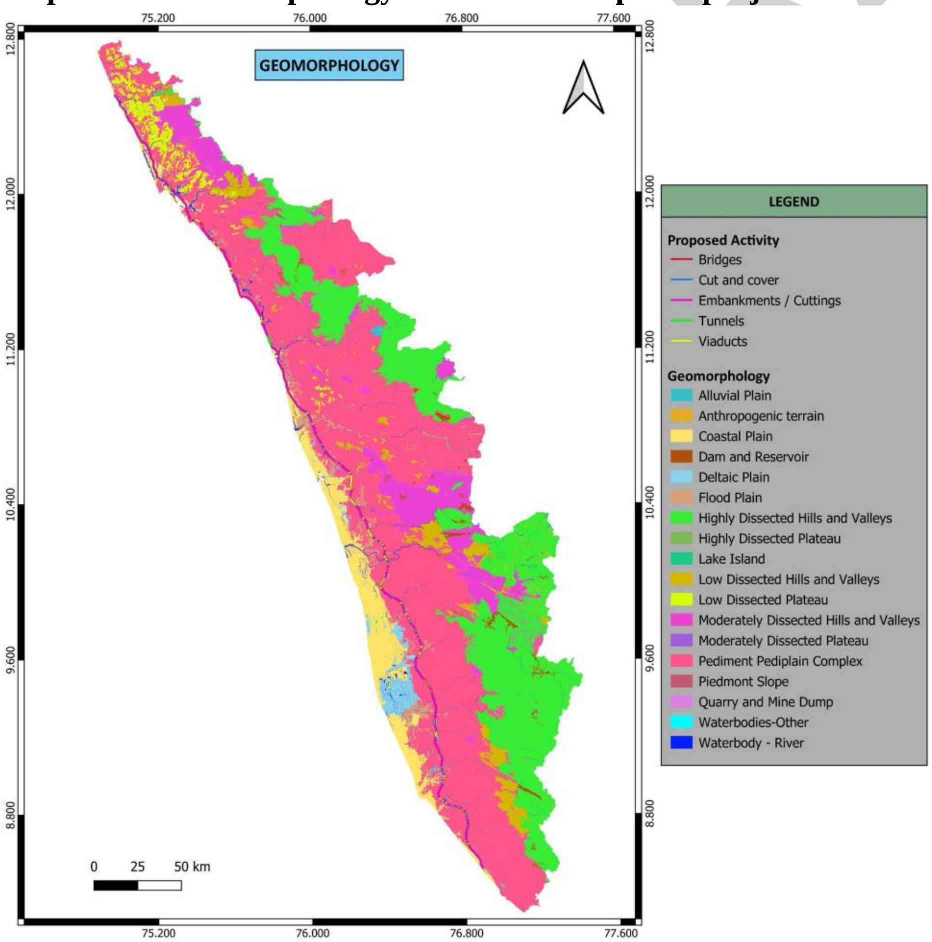
Table 3.6. Soil characteristics along the proposed rail line

Soil Type	Length (KM)
Coastal Alluvial Soils	470.67
Lateritic Soil	18.59
Peaty/Saline Peaty Soil	40.00

3.1.5. Geomorphology

The proposed Silver Line passes through a stretch of 119.37 km of coastal plain, 1.70 km of water bodies other than the river, 13.68 km of river, 49.48 km of floodplain, and the remaining part through a low dissected plateau and pediment pediplain complex (Table 3.8). Among the districts, Kasaragod has the longest stretch of line through the coastal plain (40.88 km). Ernakulam has the longest river stretch (4.02 km), and Thrissur has the most floodplain (16.54 km).

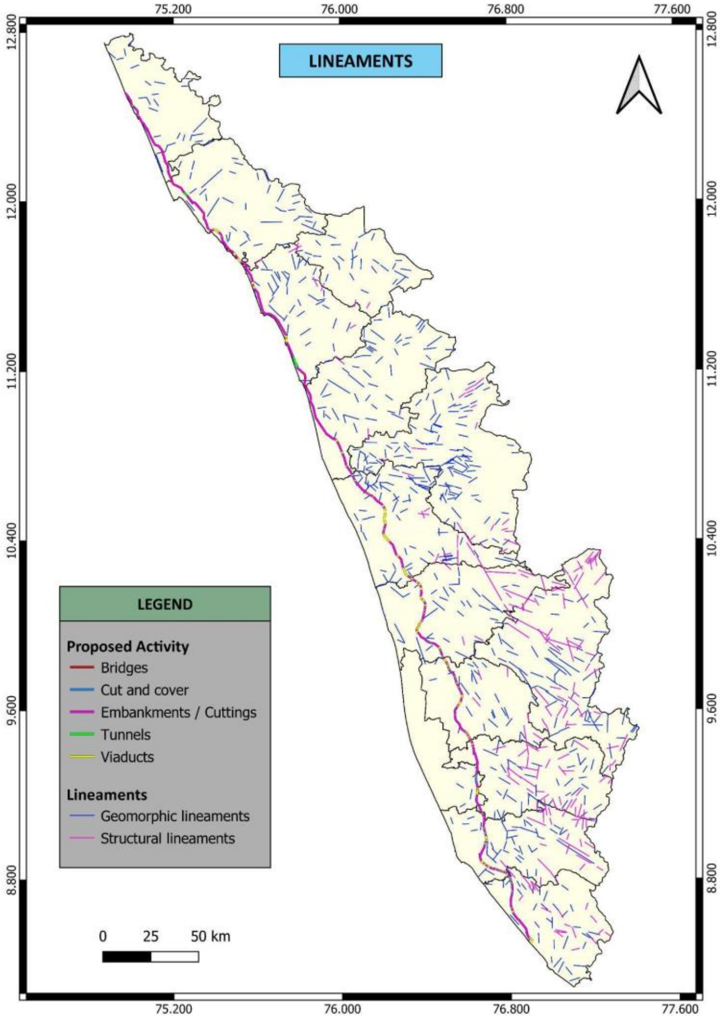
Map No 3.3. Geomorphology Kerala and Proposed project activities



(See annexure II for detailed segment wise maps)

3.1.6. Lineaments

Map No. 3.4. Proposed Project Activities on lineaments map of Kerala



The proposed rail line passes through geomorphic lineaments in all districts except Kozhikode (Table 3.7). The line crosses the structural lineament only in Kozhikode. In the 30 m wide zone, the line passes through 25 geomorphic lineaments and one structural lineament. In the 100 m wide zone, the proposed line is in direct contact with 31 geomorphic lineaments and one structural lineament. Lineaments are very important from a soil stability perspective because they control groundwater movement and storage. The proposed line cuts across only one structural lineament. Water can percolate through these weak zones, further weakening the strength of the in situ rocks and overburden.

Table 3.7. Lineaments through which the rail line passes

District/UT	Buffer type	Lineament Type	Description	Count
Thiruvananthapuram	30 m	Geomorphic Lineaments	Drainage parallel	1
	100 m	Geomorphic Lineaments	Drainage parallel	2
Kollam	30 m	Geomorphic Lineaments	Drainage parallel	0
	100 m	Geomorphic Lineaments	Drainage parallel	1
Pathanamthitta	30 m	Geomorphic Lineaments	Drainage parallel	3
	100 m	Geomorphic Lineaments	Drainage parallel	4
Alappuzha	30 m	Geomorphic Lineaments	Drainage parallel	1
	100 m	Geomorphic Lineaments	Drainage parallel	1
Kottayam	30 m	Geomorphic Lineaments	Drainage parallel	2
	100 m	Geomorphic Lineaments	Drainage parallel	2
Ernakulam	30 m	Geomorphic Lineaments	Drainage parallel	4
	100 m	Geomorphic Lineaments	Drainage parallel	5
Thrissur	30 m	Geomorphic Lineaments	Drainage parallel	6
	100 m	Geomorphic Lineaments	Drainage parallel	8
Malappuram	30 m	Geomorphic Lineaments	Drainage parallel	3
	100 m	Geomorphic Lineaments	Drainage parallel	3
Kozhikode	30 m	Geomorphic Lineaments	Drainage parallel	1
		Structural Lineaments	Joint/Fracture	1
	100 m	Geomorphic Lineaments	Drainage parallel	1
		Structural Lineaments	Joint/Fracture	1
Kannur	30 m	Geomorphic Lineaments	Drainage parallel	2
	100 m	Geomorphic Lineaments	Drainage parallel	2
Kasaragod	30 m	Geomorphic Lineaments	Drainage parallel	2
	100 m	Geomorphic Lineaments	Drainage parallel	2

(The project corridor of 30m buffer cut across 26 lineaments out of which one lineament is structural. The project corridor with 100m buffer cut across 32 lineaments out of which one is structural.)

3.1.7. Slope

The slope of the terrain through which the rail line passes is an important factor to consider when erecting engineering structures. A major part of the rail line, 514.58 km, passes through areas of gentle slope with a gradient of 0-10 degrees (Table 3.8). While 17.33 km passes through terrain with a gradient of 10-20 degrees, only a short segment (0.27 km) passes through terrain with a gradient of 20-30 degrees.

Map No. 3.5. Slope map of Kerala and the Proposed Project Activities

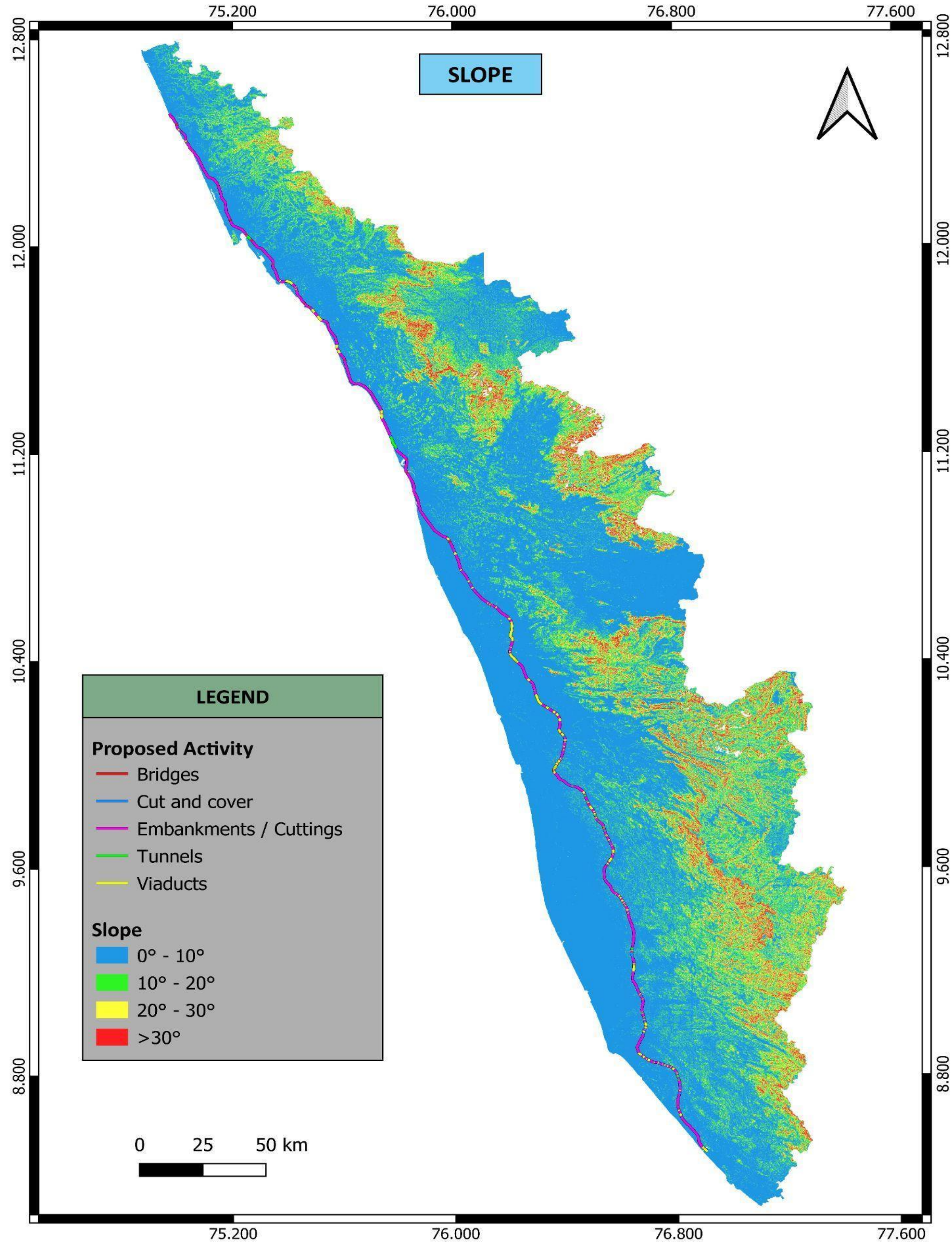


Table 3.8. Slope features

Slope in degrees - Length (km)			
District/UT	**0-10**	**10-20**	**20-30**
Thiruvananthapuram	36.39	2.45	0.00
Kollam	40.27	2.66	0.13
Pathanamthitta	20.14	0.67	0.00
Kottayam	43.96	4.90	0.11
Alappuzha	17.65	1.57	0.03
Ernakulam	49.70	2.48	0.003
Thrissur	67.40	0.21	0.00
Malappuram	53.61	0.07	0.00
Kozhikode	73.54	0.29	0.00
Kannur	59.32	1.30	0.00
Kasaragod	52.01	0.58	0.00
UT – Mahe	0.59	0.14	0.00
TOTAL	**514.58**	**17.33**	**0.27**

3.2. Climate and climate variability

The climate of the State is tropical monsoon, with most parts of the State experiencing large amounts of rainfall during the monsoon season and hot summers, except over some southern parts, where the climate is seasonally dry with hot summers. The State experiences four seasons: winter (January-February), humid climate during the pre-monsoon season (March-May), and the two principal rainy seasons (southwest monsoon, June-September, and northeast monsoon, October-December). Most parts of the State receive 75-85% of the annual rainfall during the southwest monsoon season.

3.2.1. Temperature

Climate, including temperature, is monsoon-controlled. Temperature is moderate in the coastal region and low towards the highlands. Temperature is high (>32°C) during the summer months (March-May). With the onset of the monsoon, heavy rains bring down the temperature from June. Coastal upwelling during the southwest monsoon also helps to lower the temperature. Increasing trends are noted in October, but the temperature falls below 27°C again in December-January. The temperature of coastal waters varies from 24 to 33°C. The zones of the highest temperature fall in the midland region. Coastal upwelling that occurs during the southwest monsoon lowers the temperature of coastal waters. Sea surface temperature (SST) substantially affects dynamic processes and ecosystems in the coastal region.

Due to climate change and global warming, the temperature has started showing an increasing trend both on land and in the sea. Heat islands that form as part of urbanization are becoming another concern with the increasing development and construction activities.

3.2.2. Rainfall

Rainfall in Kerala is mostly spread across a period of six months with a maximum during June–July. The average rainfall is about 300 cm (Guhathakurta et al., 2020). In general, southwest monsoon rainfall during 1901–2018 in Kerala exhibited a decreasing trend over the northern half and along the coastal areas of the State. The rainfall over the southern region of the State also showed a decreasing (but non-significant) trend. However, the data pertaining to the recent years (1971–2018) showed an increasing trend over most parts of the southern half and some interior areas of central parts of the State with isolated areas showing significant trends. A significant decreasing trend was observed over the northernmost areas of the State.

Kerala received the highest annual rainfall of 394 cm in the year 1924, followed by 391 cm and 352 cm in the years 1961 and 2018, respectively. Extreme Rainfall Events (EREs) have been repeating almost every year, especially since the 2018 mega floods. The State experienced some of the most severe EREs in the consecutive years 2018, 2019, 2020, and 2021. The EREs caused extensive flooding and inundation across the low-lying coastal plains, flood plains, and broad, flat-bottom valleys, as well as landslides on the hill slopes of the Western Ghats. The study indicates that 14.52% of the total geographic area is prone to floods. Similarly, 4.71% of the geographic area of Kerala is prone to landslides.

The main reason for the occurrence of large excess rainfall was the development of a deep depression over the northwest Bay of Bengal and nearby areas, coupled with the influence of the local orographic gradient on the atmospheric conditions. This may leave a vast area of the State vulnerable to flash floods and landslides at any time during the monsoon season.

The distribution and pattern of rainfall shows a wide variability in the last few years in the State. The increase in temperature over the Arabian Sea by 1.2– 1.4 °C in the past two decades has increased the frequency of cyclonic events along the Indian west coast. This has greatly affected the rainfall distribution in Kerala. Although July and June were the months receiving the highest rains, frequent and heavy spells have been seen in August and September in the last four years.

The study by Vijayakumar et al., 2021 revealed the occurrence of mesoscale mini cloudbursts that pour enormous amounts of precipitation in a very short period in Kerala, which does not have a history of mesoscale cloudbursts. A mesoscale mini cloudburst event occurred over Kerala on August 8, 2019, for the first time in the recorded history of rainfall events in Kerala (Vijayakumar et al., 2021).

The study suggests that a prolonged or intense spell of surplus rainfall during the months that follow a normal June monsoon has a huge potential to produce flooding near the river basins of

Kerala. Their analysis revealed that the 'west coast of India is prone to massive flooding from both a moderate to high-intensity rain spell that follows a prolonged wet period and events such as a cloudburst that pours enormous amounts of precipitation in a very short period'.

3.2.3. Drought

Meteorological droughts during monsoon and summer droughts are not uncommon across the State during recent years. Kerala has been impacted by droughts of varying intensities in the past. Severe dry spells and droughts were experienced by the State in 1983, 1986, 1987, 1992, 1997, and 1998 in the latter half of the last century, and also in 2002 and 2004 (Joseph et al., 2011). More recently, Kerala experienced one of the most distressing droughts in 2016, which severely impacted both agriculture and hydrology in the State.

Extreme rainfall events are also leading to increased drought and dry spells in the State, as evidenced in 2018 following the devastating floods. The days after the 2018 floods showed a drastic reduction in river flows and the drying up of streams and wells (Madhusoodhanan and Sreeja, 2019). Studies also indicate that once perennial river basins in the State, such as the Bharathapuzha, which is the largest basin in the State (based on drainage area), are experiencing persistent drought conditions owing to an increase in temperature conditions and a decrease in precipitation (Mathew et al., 2021).

It is noteworthy that climate change, in conjunction with changes in land-use patterns, is leading to extended periods of drought in the state, resulting in an increased frequency of water shortages for drinking, agriculture, and power generation. Since over 70% of agriculture in Kerala is rain-fed, extended meteorological drought severely impacts agriculture and associated activities.

3.3. Drainage systems, Floodplains, Flood height

The interdependence of economic production systems and biophysical systems is well established. Changes or modifications in biophysical systems influence production systems and thus economies too. The study of land use patterns has originally developed in close correspondence with landscape ecology. In the agrarian economies, the land use patterns were almost in alignment with the natural landscape features.

After globalisation and the boom of the consumer economy, the land use pattern of Kerala has changed in such a way that landscape considerations got the least priority. This led to large-scale conversion, isolation and fragmentation of ecosystems and loss of connectivity among the landscape units. That severely affects the productivity and resilience of all landscapes.

Kerala, as a populous and development-intensive region, already has a very high rate of ecosystem fragmentation and disconnectivity of landscape units. The lowlands and midlands of Kerala are characterized by dense drainage systems, floodplains, marshes, and backwaters. These natural systems are already saturated with development pressure.

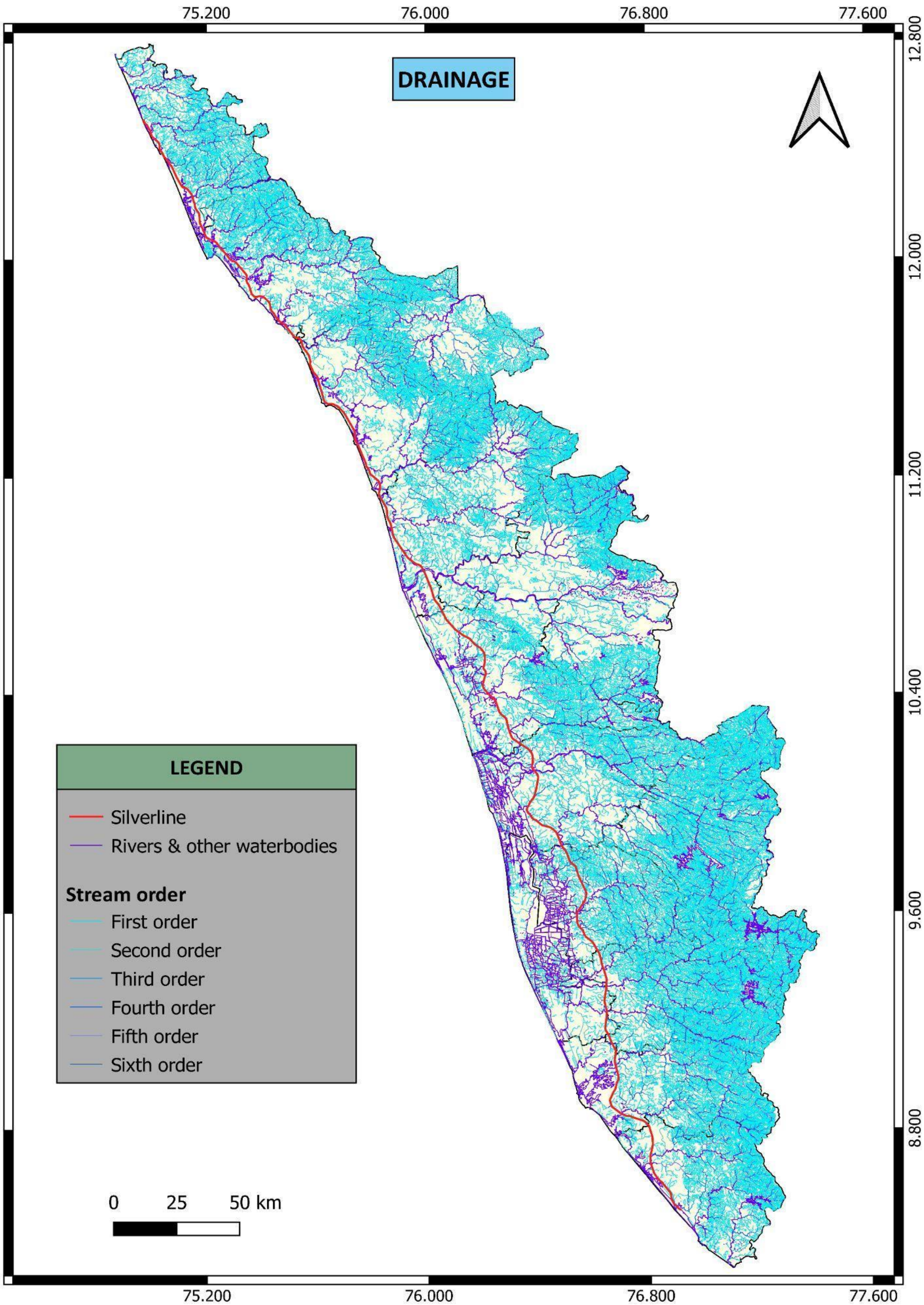
Over the last few decades, Kerala has lost hectares of its wetlands and paddy fields legally in the name of industry, infrastructure development, and housing (Chitra, 2016). Therefore, it is important to study the drainage systems through which this heavy linear infrastructure will pass.

Most of the proposed SilverLine track passes through water bodies, streams, and/or floodplains. Embankments and cut-and-cover structures are proposed for the rail line to cross streams and floodplains. The rail may bifurcate landscape units in many places, seriously affecting the biophysical systems. Details of drainage characteristics, floodplain status, and flood situations of the area through which the proposed rail line passes have been evaluated based on the field data gathered along all 107 segments. Information from the State Disaster Management Authority and satellite imagery have also been used in addition to field observations. The track has to cross first-order streams to sixth-order streams. The total number of streams that may be impacted due to the proposed rail is about 48, including multiple crossings. As per the analysis, the rail line has to cover flood hazard zones for a length of 202.96 km.

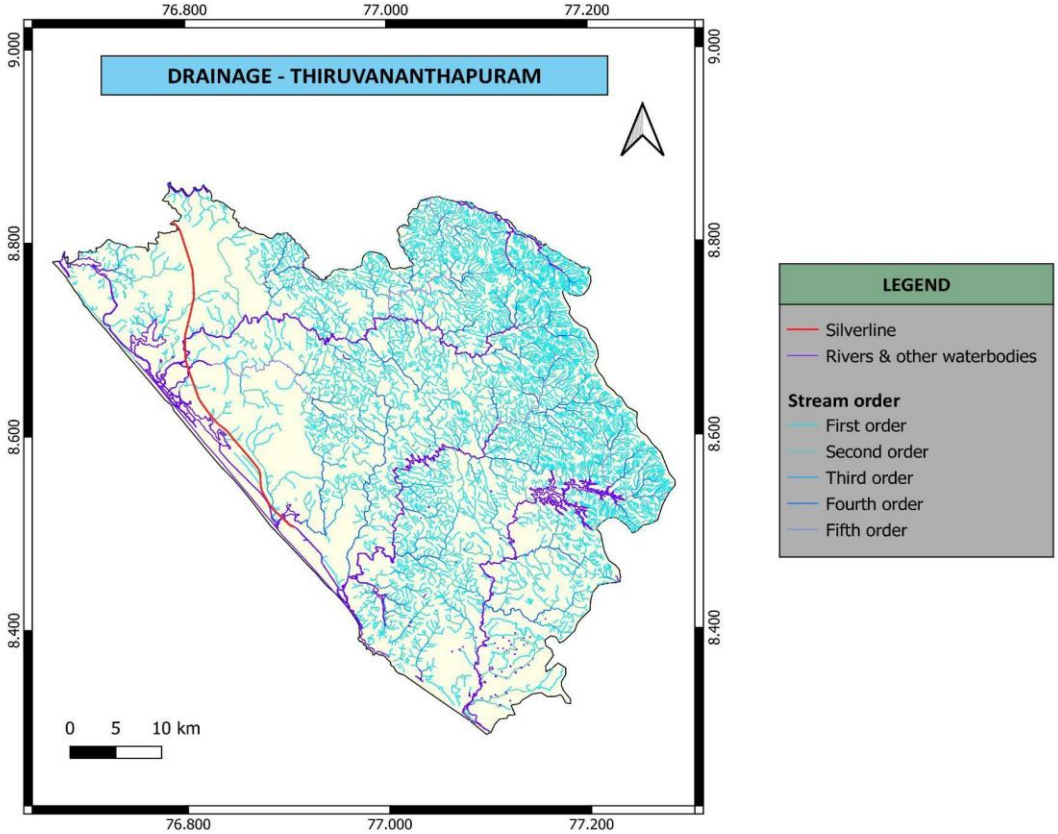
3.3.1. Drainage system

The proposed rail line crosses either a stream, waterbody, floodplain, or combination thereof in almost all segments. Flood levels in these segments reach up to 12 meters. The rail line in segment 21 in Alappuzha crosses 5 streams. Although the streams are perennial, no bridges are proposed in the DPR. The highest flood level in this segment is about 10 meters. Segment 22 (in Alappuzha and Pathanamthitta) is predominantly a floodplain with the highest flood level of 12 meters. The main structure proposed in this vast floodplain is an embankment. There are 12 streams from first to fourth order in Segment 33 (Kottayam) in the proposed passage of the rail track. Again, embankments are proposed as the main structure in this segment with 12 stream crossings. The proposed alignment of the rail line passes through the middle of a floodplain in Segment 49 (Thrissur). Tunnels are the major passage proposed in segment 72 (Kozhikode). It is proposed to be constructed below mean sea level and has to pass underneath a major river course. Supporting geological and geotechnical investigation reports are not available in the DPR to verify and evaluate the environmental and ecological stability/issues/consequences. Details of waterbody/stream crossings of the proposed rail track in each of the 107 segments are given in Annexure.

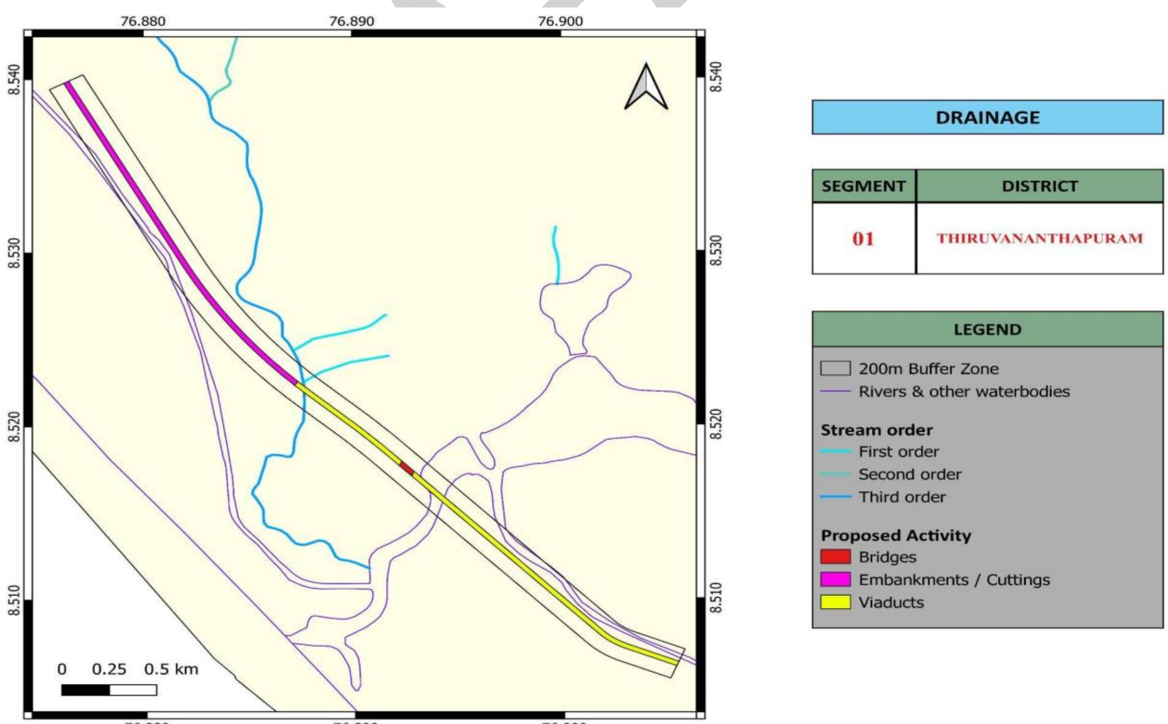
Map No. 3.6. Drainage system



Map No. 3.7. Drainage system and SilverLine alignment in Thiruvananthapuram Dist.



Map No. 3.8. Streams and proposed activities in segment 1.



(See Annexure I page… for details of all segments)

Table 3.9: Number of streams cut by the rail line in 30 metres buffer zone

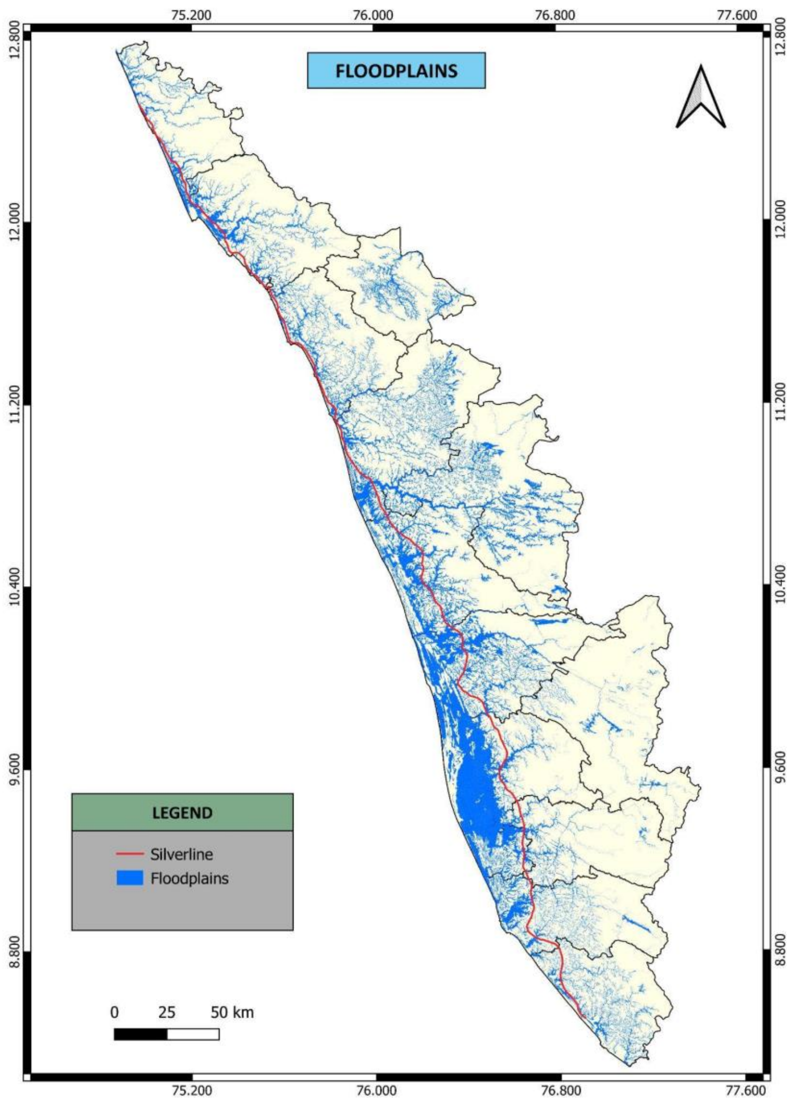
District/UT	Stream order				
	Zero	First	Second	Third	Rivers and other water bodies
Thiruvananthapuram	3	4	4	1	1
Kollam	2	9	5	2	3
Pathanamthitta	3	4	3	1	4
Alappuzha	1	2	4	0	2
Kottayam	6	24	17	12	2
Ernakulam	7	7	10	1	2
Thrissur	8	23	10	2	2
Malappuram	4	8	9	3	2
Kozhikode	7	4	2	0	3
Kannur	8	8	6	2	3
Kasaragod	8	3	2	1	4
UT-Mahe	0	0	0	0	1
Total	**57**	**96**	**72**	**25**	**29**

It is noted that the DPR does not mention inundation problems, and the management of groundwater and springs along the tunnels and cut-and-cover structures. High groundwater level conditions due to embankments and filling may adversely affect the terrain and structures erected unless great engineering and eco-restoration measures are taken throughout the line.

3.3.2. Flood plains

The State is drained by a network of 44 rivers, of which 41 flow west. These streams are short and swift-flowing, cascading down the slopes of the Western Ghats, displaying varied stages of gradation. Most of the river courses are structurally controlled, following lineaments of the earth's crust. Flood plains, the alluvial lands that border the rivers, provide a vital space for these waterways to spread their waters during periods of high flow. These ecologically productive areas are hydrologically significant and environmentally sensitive, performing many essential natural functions.

Map No. 3.9. Rivers and Flood Plain

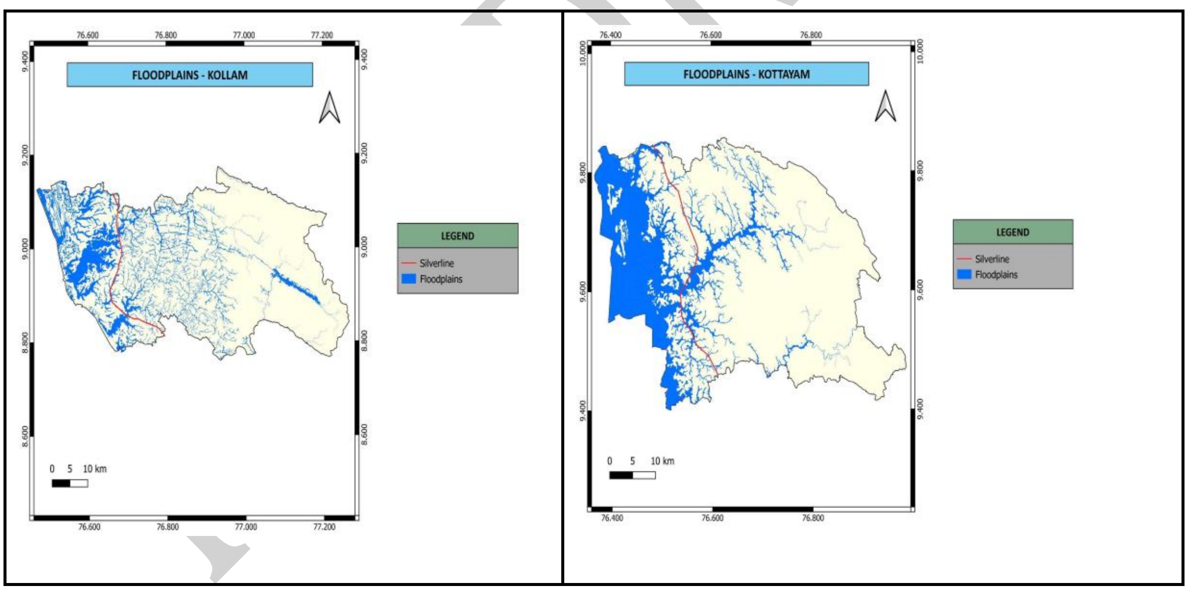


The physiographic profile of the State is classified into three distinct zones: the highlands (elevation >75 m above MSL and covering the steep and rugged part of Western Ghats), the lowlands (elevation <7.5 m above MSL, comprising the coastal plains) and the midlands (comprising the undulating hills and valleys in between). The altitude increases gradually from the coastal plain to the highland. The average rise of relief is 27 m for every kilometre from the seacoast to the Western Ghats crest. Some parts of the State around the Kuttanad area even lie at 1 to 2 m below mean sea level.

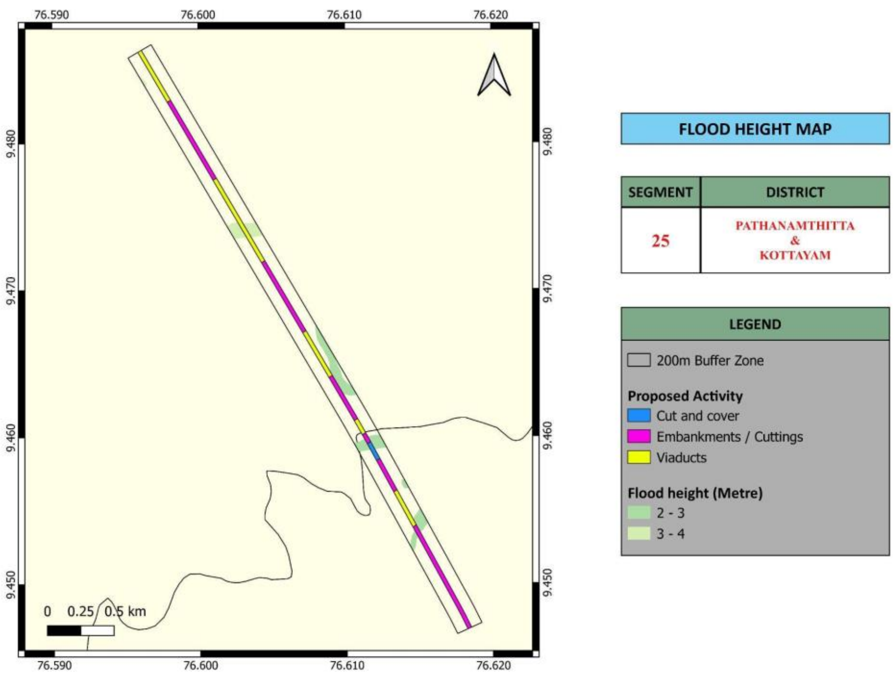
The proposed SilverLine rail line passes through the floodplain along 202.82 km (Table 3.10). The district-wise length in kilometers is as follows: Kasaragod (24.69), Kannur (24.72), Kozhikode (13.72), Malappuram (18.86), Thrissur (37.27), Ernakulam (27.97), Kottayam (16.98), Alappuzha (7.47), Pathanamthitta (8.15), Kollam (13.88), and Thiruvananthapuram (9.11). The table shows the length of the proposed SilverLine along the flood hazard zone.

The total area of the floodplain affected by the proposed alignment with a width of 30 meters is estimated as 607.67 ha, and that of a 200-meter width is 4033.70 ha. Thrissur district suffers the highest loss of flood plains (111.79 ha) considering the 30-meter width segment, and Ernakulam district loses the maximum flood plains with an area of 571.71 ha while considering a 200-meter width.

Map No 3.10. Floodplains of Kollam and Pathamthitta districts and SilverLine proposed activities



Map No 3.11. Flood height and SilverLine proposed activities in seg. 25



Map No 3.12. Flood plains and SilverLine proposed activities in seg. 25

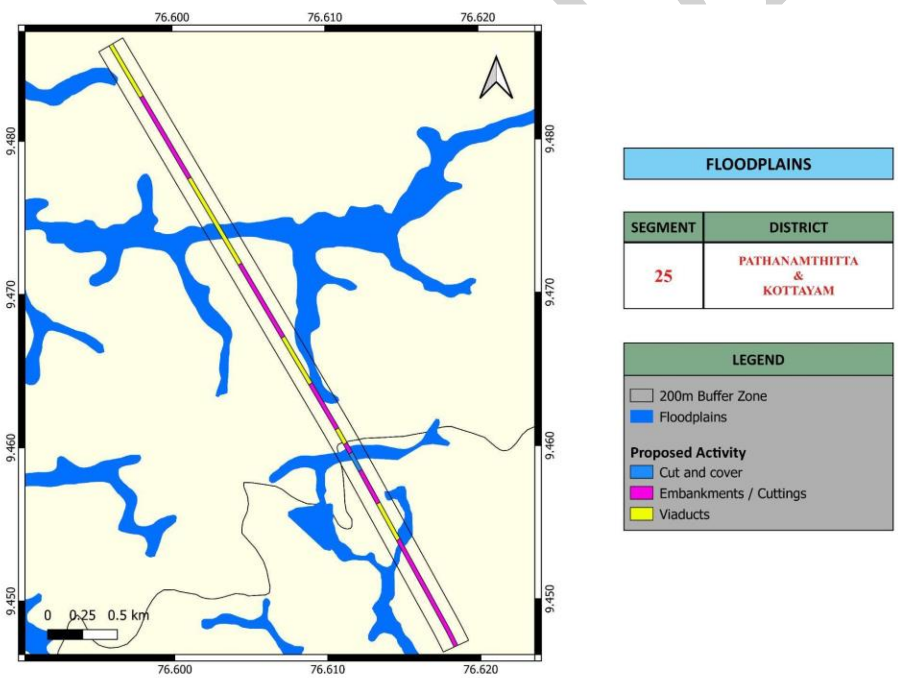


Table 3.10. Length of SilverLine that would pass through flood plains

District/UT	Length (km)	Area in Hectares	
		30 m Buffer	200 m Buffer
Thiruvananthapuram	9.11	27.44	191.44
Kollam	13.88	41.01	261.01
Pathanamthitta	8.15	24.54	169.16
Alappuzha	7.47	22.09	138.81
Kottayam	16.98	50.81	340.75
Ernakulam	27.97	83.92	571.71
Thrissur	37.27	111.79	744.86
Malappuram	18.86	56.63	395.35
Kozhikode	13.72	41.36	283.00
Kannur	24.72	74.20	485.84
Kasaragod	24.69	73.88	449.38
Mahe	0	0	2.46
Total	**202.82**	**607.67**	**4033.77**

3.4. Ecology

Ecological characteristics of the area through which the SilverLine project is proposed and the impact of the same on biodiversity, critical ecosystems, and carbon sequestration are elaborated in this section.

3.4.1. Threatened Species and their Habitat:

The Kerala State comes within the most important and bio-diverse ecoregions in the Peninsular India, the Southern Western Ghats, which is a globally significant conservation area for threatened species as per the International Union for Conservation of Nature and Natural Resources (IUCN). The Western Ghats region has 5,000 species of angiosperms, 140 species of mammals, 508 species of birds, 140 species of amphibians, 240 species of reptiles, and 290 species of freshwater fishes, of which amphibians (78%), reptiles (62%), fishes (53%), plants (34%), mammals (12%), and birds (4%) are endemic. Most of these are in the southern Western Ghats region, and those that are outside the protected areas (PA) are at high risk of endangerment.

The inland water bodies within the 41 rivers and associated wetlands are critical habitat for many freshwater biodiversity species including endemic and threatened species. The lateritic and other hillocks in the midland and the sandy areas near the coast are also habitats for unique species that lack proper protection. These habitats are under pressure from various developmental projects.

The proposed SilverLine route cuts across critical habitats in Kerala from south to north throughout the entire stretch of the State. This includes 292.73 km of embankment blocking the watercourse, wetlands, and critical habitats of species. The possible impact on various threatened species is assessed here, and a detailed list is provided based on assessments made for and by the IUCN.

The assessment indicates that the project is going through the habitat of 47 IUCN-threatened fishes, of which 37 shall face a serious threat and 10 a partial threat with this project (Table 3.16). This includes two Critically Endangered (CR) fishes, 27 Endangered (EN) fishes, and 18 Vulnerable (VU) species. The proposed project can also impact other groups, such as Odonates (10), freshwater molluscs (1), and plants (21) (Table 3.17 and Table 3.18). Among the Odonates, four are Vulnerable (VU) and six are Near Threatened (NT). Among the plants, 17 are associated with wetland and freshwater habitats in the midlands and the remaining are seen in the groves (Table 3.19). These include four Critically Endangered (CR) species, 10 Endangered (EN) species, and seven Vulnerable (VU) species.

Table 3.11. Threatened and Endemic Fishes

Sl. No.	Species	IUCN Status	High Impact	Moderate impact
1	*Horalabiosa arunachalami*	CR	Y	
2	*Hypselobarbus thomassi*	CR	Y	
3	*Barilius canarensis*	EN		Y
4	*Crossocheilus periyarensis*	EN		Y
5	*Devario neilgherriensis*	EN	Y	
6	*Garra hughi*	EN	Y	
7	*Garra surendranathanii*	EN	Y	
8	*Glyptothorax housei*	EN		
9	*Glyptothorax madraspatanus*	EN	Y	
10	*Hypselobarbus curmuca*	EN		Y
11	*Hypselobarbus dubius*	EN	Y	
12	*Hypselobarbus mussullah*	EN	Y	
13	*Hypselobarbus periyarensis*	EN	Y	
14	*Lepidopygopsis typus*	EN		Y
15	*Monopterus fossorius*	EN	Y	
16	*Osteochilus longidorsalis*	EN	Y	
17	*Parapsilorhynchus elongatus*	EN	N	
18	*Pseudeutropius mitchelli*	EN	Y	

19	*Pterocryptis wynaadensis*	EN		Y
20	*Puntius arulius*	EN	Y	
21	*Puntius cauveriensis*	EN	Y	
22	*Puntius chalakkudiensis*	EN	Y	
23	*Puntius denisonii*	EN	Y	
24	*Dawkinsia exclamatio*	EN		Y
25	*Puntius fraseri*	EN		Y
26	*Puntius ophiocephalus*	EN		Y
27	*Puntius sharmai*	EN		Y
28	*Tor malabaricus*	EN	Y	
29	*Travancoria elongata*	EN	Y	
30	*Travancoria jonesi*	EN	Y	
31	*Balitora mysorensis*	VU	Y	
32	*Batasio travancoria*	VU	Y	
33	*Carinotetraodon travancoricus*	VU	Y	
34	*Channa diplogramma*	VU	Y	
35	*Cirrhinus cirrhosus*	VU	Y	
36	*Garra menoni*	VU		Y
37	*Garra periyarensis*	VU	Y	
38	*Horabagrus brachysoma*	VU	Y	
39	*Hyporhamphus xanthopterus*	VU	Y	
40	*Hypselobarbus kolus*	VU	Y	
41	*Laubuca fasciata*	VU	Y	
42	*Nemacheilus keralensis*	VU	Y	
43	*Nemacheilus menoni*	VU	Y	
44	*Nemacheilus periyarensis*	VU	Y	
45	*Pseudosphromenus dayi*	VU	Y	
46	*Puntius arenatus*	VU	Y	
47	*Puntius assimilis*	VU	Y	

Table 3.12. Threatened freshwater molluscs in the impact region.

Class	Family	Binomial	RL Cat
Bivalvia	Etheriidae	*Pseudo mulleriadalyi* (Smith, 1898)	EN

Table 3.13. Threatened and Near Threatened Odonate Species in the impact area

	Binomial	IUCN Category
1	*Heliogomphus promelas* (Selys, 1873)	NT
2	*Idionyx galeata* Fraser, 1924	NT
3	*Megalogomphus hannyngtoni* (Fraser, 1923)	NT
4	*Melanoneura bilineata*Fraser, 1922	NT
5	*Phylloneura westermanni* (Selys, 1860)	NT
6	*Indothemis carnatica*(Fabricius, 1798)	NT
7	*Chlorogomphus xanthoptera*(Fraser, 1919)	VU
8	*Disparoneura apicalis*(Fraser, 1924)	VU
9	*Platysticta deccanensis*Laidlaw, 1915	VU
10	*Protostictas anguinostigma* Fraser, 1922	VU

Table 3.15. Threatened plant species in the impact area

	Binomial	Status
1	*Murdannia lanceolata*	VU
2	*Fimbristylis dauciformis*	EN
3	*Fimbristylis hirsutifolia*	CR
4	*Dimeria hohenackeri*	EN
5	*Ischaemum jayachandranii*	CR
6	*Ischaemum vembanadense*	EN
7	*Limnopoa meeboldii*	EN
8	*Eriocaulon richardianum*	EN
9	*Eriocaulon sivarajanii*	CR
10	*Rotala cookii*	EN

11	*Rotala floribunda*	VU
12	*Rotala malabarica*	CR
13	*Farmeria indica*	EN
14	*Farmeria metzgerioides*	VU
15	*Polypleurum filifolium*	VU
16	*Utricularia cecilii*	EN
17	*Lindernia manilaliana*	EN
18	*Ochna gamblei*	EN
19	*Hydnocarpu salpinus*	VU
20	*Hydnocarpu spentandrus*	VU
21	*Vateria indica*	VU
22	*Hopea ponga*	VU

EN- Endangered- CR- Critically endangered- VU- Vulnerable

3.4.2. Key Biodiversity Areas (KBA)

Key Biodiversity Areas or KBAs arose through the need to identify sites of global significance for biodiversity. The criteria used to identify KBAs are based on vulnerability of a site (which is the probability that the site will be lost in the future), and irreplaceability of the site (that is the spatial option available – in other words if it is lost from the place in reference, where else could it be preserved). The most extreme example of these in sites such as those that qualify as an Alliance for Zero Extinction (AZE) site, these are single sites which contain an Endangered or Critically Endangered species that occur nowhere else on Earth. Freshwater KBAs of Kerala are shown in Map. 3.12A.

The alignment of the K-rail – SilverLine passes through several KBAs of Kerala, with critically endangered species of fish, especially in the watersheds of river basins and the laterite regions of Kerala, which harbour unique and endemic subterranean fishes, especially in Pathanamthitta (Thiruvalla), Alappuzha (Chengannur), Kottayam, Thrissur, Malappuram, Kozhikode, and Kannur districts. Further, there is also overlap with some areas of Muriyad and Ponnani Kole, part of the Vembanad-Kole Ramsar Site.

Map 3.12A. Freshwater KBAs in Kerala

(Freshwater KBAs in Kerala and Tamil Nadu (Source: IUCN, 2014))

The wetlands along the path of the **SilverLine** also serve as feeding and breeding ground for waterbirds, in the designated Key Bird Areas of Kerala, especially in the Vembanad-Kole wetland system (the third largest of its kind in entire India, with about 241 species of birds, of which 30% are migrants) and Kattampally of Kannur district. The Kattampally wetland area in the Kannur district, known for its migratory bird sanctuary, is likely to be included in the Ramsar List of Wetlands of International Importance, with about 259 species recorded from the area. The district panchayat has proposed the area to the State government for designation under the Ramsar Convention. The 3,000 acres of wetland in Kattampally, spread over eight panchayats, has already been recognised as an Important Bird Area (IBA) by the BirdLife International (BLI). The entire wetland area is known for its brackish water rice and prawn cultivation system ('kaipad' farming).

Similarly, Madayipara, a lateritic hillock in Kannur district, is also a hotspot of biodiversity, with several endemic flora and fauna, including rich birdlife, and is located next to Kattampally in Kannur district (https://ebird.org/region/IN-KL-KN/hotspots?yr=all&m=). The Madayipara is a proposed Biodiversity Heritage Site in the Kannur district surrounded by Kuppam, Ramapuram, and Peruvamba rivers and the ecologically fragile Kavvayi backwaters. This region is home to 657 species of plants, 24 species of reptiles, 19 species of amphibians, 142 species of butterflies, 186 species of birds, and 60 species of odonates. Even though this region is less than 0.01% of the Kannur district, it harbours about 59% of the district's flora.

3.4.3 Ecosystems and Biodiversity

The infrastructural development associated with K-Rail – SilverLine can have many indirect effects on biodiversity and its habitat. The impacts can be categorised into five main classes:

i. Direct or resource destruction from the construction of roads and associated infrastructure;
ii. Raw material extraction for building roads or supplying resources, including power;
iii. Increased anthropogenic stresses (e.g., development of buffer zones, exposing key biodiversity areas for exploitation of resources);
iv. Habitat loss and fragmentation due to rail/road construction, and changes in animal behaviour, including migratory routes of fishes;
v. Promotion of over-exploitation of resources as key biodiversity areas become more accessible along the route.

Another major impact would be the colossal amounts of resources required for the infrastructure development of the proposed SilverLine, including the amount of non-mineral earth and granite from the soil and granite from the eco-sensitive zones of the Western Ghats. Further, as the alignment of the rail is along the key wetland areas of the State, and along the flood plains of the rivers, it may also impact the wetland flora and fauna unique to Kerala, besides impacting lateral migration of fish to the floodplains for breeding. This would jeopardise the sustainability of commercially valuable freshwater fishery resources of the State.

The project, could lead to a large-scale conversion of lateritic areas, endangered mangrove forests, wetlands and paddy fields, marshy areas, ponds and sacred groves, as it passes through some eco-sensitive areas along the route. This would also jeopardise the livelihoods of thousands of people who use the resources from these ecosystems for their survival. The ecosystem fragmentation would result in loss or decline in ecosystem services offered by the systems, which is essential for the sustainable development of the State by ensuring natural capital.

The villages with the most extreme impacts on biodiversity richness and uniqueness would be Madayipara, Kadalundi, Ponnani, and Thirunavaya. Kadalundi Wetlands are the only community reserve in Kerala. The Thirunavaya village is rich in ponds, which sustain the livelihoods of hundreds of people involved in lotus farming.

Increased transport infrastructure, which facilitates human movement and later human settlement, would promote land use changes in the area, further impacting biodiversity. Furthermore, sustained construction activities along the K-Rail – SilverLine path and its embankments may also restrict the movements of animals, and lead to increased emergence and intensification of human-wildlife conflicts (HWC) as animals move away from railways and roads to surrounding communities, thereby reducing the buffer between wildlife areas and human communities.

As the State is prone to the vagaries of climate change, the construction of embankments and infrastructure along the rail will further worsen the management of flood plains, therefore increasing the vulnerability. The embankments in the midland would further impact downstream irrigation, environmental flows through the streams in the watershed, changes in landslide probability, downstream saline incursion, and so on. The possible hydrological alterations in the watersheds can be revealed only through long-term monitoring.

3.4.3.1. Critical Ecosystems

3.4.3.1.1 Sacred Groves

The sacred groves of Kerala are remnants of wet evergreen forest patches, protected and conserved based on religious beliefs. They are also a great repository of many endemic, endangered, and economically important plant species. Floristic diversity indices of the sacred groves of Kerala are equal or nearly equal to the wet evergreen forests of the Western Ghats (Induchoodan N.C. and Pascal J.P. (1996) & Bachan A. K. H. and Devika M.A. (2023)). These isolated patches are self-sustainable ecosystems that function as a bioresource centre and closed system for the nutrient and water cycles for the nearby areas. Sacred groves represent the major effort to recognize and conserve biodiversity and ethnic diversity traditionally. The age-old system of villages having a temple, a tank and associated sacred grove explains the ancient method of water harvesting and sharing.

The vegetation in the undisturbed groves is luxuriant and with multi-layered trees mixed with shrubs, lianas and herbs. The ground is humus laden and abundant with fungus and ferns. The floristic composition is highly influenced by exposure to anthropogenic pressures, cattle grazing, edaphic and climatic variations. The common tree species found in the sacred grove are *Artocarpus hirsutus, Mesua ferrea, Vateria indica, Hopea parviflora, H. ponga, Alstonia scholaris Mimusops elengi, Hydnocarpus pentandra, Holigarna arnottiana etc.* The lianas include *Strychnos colubrina, Anamirta cocculus, Tetracera akara, and Acacia intsia.* Shrubs are represented by *Ixora nigricans, I. bracteata, Chassalia curviflora* etc. The seasonal plants, such as *Geophila reniformis, Borreria sp, Naregamia alata, Centella asiatica, Aerva lanata, Adrographis paniculata, Biophytum sensitivum,* form the ground vegetation. In the southern region of the State, members of the mangroves swamps like *Myristica fatua var.magnifica, M.malabarica, Hydnocarpus spp and Eugenia spp* are found in the poorly drained sacred groves. These species are known to develop high-profile humidity in the surroundings that promote the luxurious undergrowth.

The animals found in the sacred grove are of two types, those which inhabit the groves like snakes, frogs, lizards and other lower groups of organisms and higher groups of fauna that nest and den there and those who visit the grove temporarily for food, shelter, etc. Sacred groves act as an abode for many rare, endemic, and endangered species and economically important plants with fruit-bearing and medicinal properties.

K-Rail – SilverLine alignment (200 m) indicated that it passes through 8 different landscapes in which sacred groves constitute altogether 24.59 ha (Table 3.1). This means 24.59 ha of sacred groves are in the impacted zone (200 m) of K-Rail – SilverLine which would face various forms of degradation during different phases of construction. The maximum extent of the sacred grove is reported in Thiruvananthapuram district (13.35 ha) followed by Kozhikode (5.91 ha) and Ernakulam district (1.64 ha). Once there were 12,000 sacred grooves reported from Kerala, now it has been reduced to nearly 1,500, that too under various stages of degradation and conversion mostly for residential purposes. Conservation of these local biodiversity centres deserves paramount importance as it harbours many endangered species and ensures nutrient and water availability in nearby agro-ecosystems.

3.4.3.1.2. Mangroves

Mangrove forests, also called mangrove swamps, mangrove thickets or mangals, are productive wetlands that occur in coastal intertidal zones. Mangrove forests grow mainly at tropical and subtropical latitudes because mangrove trees cannot withstand freezing temperatures. Kerala State has 44 rivers and a wide network of estuaries and backwaters with tidal action. Kerala has a relatively small area under mangroves – just 25 sq km at present, down from 700 sq km in 1957. The mangrove patches that still survive are distributed across many coastal districts (https://indiaclimatedialogue.net/2016/12/05/coastal-barriers-can-buffer-rising-seas/).

Mangroves play an important role in mitigating climate change. These evergreen close-canopy shrubs copiously produce biomass and green leaves throughout their lives. In the process, they absorb atmospheric carbon in large quantities and help with carbon sequestration. They also shed their leaves copiously, strengthening the nutrient cycle. Strands of mangrove plants also protect the coast from the rising sea, both from storm surges and sea level rise. The roots of the plants trap the silt in the estuarine water and the falling leaves, building a living platform that grows faster than the rising sea, thereby protecting the coast. Mangroves establish a strong link between terrestrial and coastal environments. These are fragile ecosystems that support traditional fishing, maintain the fresh and salt-water interface in the coastal areas, and strengthen groundwater supply. (https://indiaclimatedialogue.net/2016/12/05/coastal-barriers-can-buffer-rising-seas/)

Mangroves are also effective bio-shields, protecting the coasts from erosion. The roots of the mangrove plants trap silt in the water and falling leaves from the plants get added to this. Thus a living and rising platform is created, which offers protection against an increase in sea level. The floristic diversity of mangroves in Kerala was represented by 18 species of true mangroves of which, *Sonneratia alba*, *Avicennia alba*, and *Ceriops tagal* were found to be rare in the State (Table 3.20).

Kerala State, situated on the west coast of India, has lost 95% of its mangroves in the past three decades. Of the 22.42 sq km of mangroves remaining in Kerala, Kannur district has the largest area (80%) and the most species (12 out of 18). The current environmental impact assessment of the SilverLine project revealed that the proposed rail will pass through 54.91 hectares of mangrove habitat, of which 33.92 hectares will be destroyed in Kannur district, followed by Kollam district (9.01 ha) and Kasaragod district (7.80 ha). The huge loss of this mangrove forest will further affect the various functions of this critical ecosystem and significantly reduce the livelihood opportunities of fishing communities. Felling and conversion of mangroves is not permitted under CRZ rules.

Table 3.16. Distribution of true Mangrove in Kerala

(Source: Kerala State Biodiversity Board)

No.	Name of the Species	TVM	KLM	ALP	KTM	EKM	TCR	MPM	KKD	KNR	KSD
1	Rhizophora mucronata	4	3	2	4	1	2	3	2	1	2
2	Rhizophora apiculata	4	1	3	4	3	4	4	3	1	3
3	Avicennia officinalis	4	1	2	3	1	3	2	1	1	1
4	Avicennia marina	2	1	2	5	1	4	3	1	1	3
5	Bruguiera cylindrica	4	2	2	4	2	3	3	3	1	5
6	Bruguiera gymnorrhiza	4	3	3	4	1	4	4	4	4	4
7	Kandelia candal	4	4	5	4	4	4	4	2	2	5
8	Bruguiera sexangula	4	4	5	2	5	4	2	4	4	3
9	Sonneratia alba	4	3	3	4	2	4	4	4	1	4
10	SonneratiaCaseolaris	3	3	2	3	1	4	2	2	1	2
11	Excoecariaagallocha	1	1	1	3	2	2	2	1	1	2
12	Excoecariaindica	5	4	4	4	4	4	4	4	4	4
13	Aegicerascorniculatum	4	2	3	4	4	3	3	2	1	2
14	Lumnitzeraracemosa	4	3	4	4	4	4	4	4	5	4
15	Ceriopstagal	4	5	4	4	4	4	4	4	4	4

(Reference: Profuse 2. Frequent 3. Rare 4. Not found 5. Threatened (Courtesy Vidyasagaran, K and Madhsoodanan, V.K, 2019)

3.4.3.1.3. Lateritic ecosystem

Lateritic soil is formed by the decomposition of different types of rock under conditions of high temperature and heavy rainfall, with alternating wet and dry periods. This leaching process leaves behind only iron and aluminium oxides. Lateritic hills are often classified as wasteland because they are not suitable for agriculture, which can lead to their allocation to large-scale projects. This can destroy this unique ecosystem.

Rocky surfaces, grasslands and green patches of lateritic hills are rich and diverse habitats accommodating vast varieties of flora and fauna. Lateritic hillocks are home to biodiversity-rich areas and provide valuable ecosystem services. Studies revealed that these areas include 970 endemic species, 4 endangered species, 14 vulnerable species, and 1 critically endangered species of angiosperms belonging to 138 families (KFRI). With regard to fauna, 112 species of spiders, 28 species of grasshoppers, 42 species of odonates, 140 species of butterflies, 215 species of birds, 27 species of reptiles, 20 amphibians, 68 species of fishes, and 25 mammal species are also found in this region. The presence of rich biodiversity and its interaction with the landscape elements provide valuable ecosystem services to society.

The hillocks serve as water-holding units that recharge groundwater during rains. Hence, the lateritic hills and associated ecological subunits interact with each other and support society by providing various ecosystem services, such as recharging groundwater, increasing agricultural production, providing food, nutrient cycling, and carbon sequestration.

Presently, the hillocks are considerably damaged by monoculture plantations (cashew and rubber), infrastructure development, and mining. Different ecological units associated with these lateritic hills include ephemeral flush vegetation, exposed rock surfaces, rock crevices, small ephemeral pools, soil-filled depressions, soil-rich areas, core areas, boulders, and crust edges. All these subunits can be identified by their morphological characteristics and biodiversity systems (KFRI Report No. 555).

K-Rail – SilverLine alignment goes through the lateritic hills, affecting an extent of 662.24 ha of this unique ecosystem. The embankment and cut and cover heavily disrupt the ecological subunits of these hillocks and cause severe damage to their physical continuity and biodiversity systems. In the context of climate change leading to heavy rain during monsoons, chances of massive runoff followed by subsidence and landslides during the construction and post-construction phase. District wise data shows the highest impact is noticed in Ernakulam district (130.1 ha) followed by Pathanamthitta (116.98 ha) and Kasaragod (114.27 ha).

The K-Rail – SilverLine alignment goes through the lateritic hills, affecting an extent of 662.24 hectares of this unique ecosystem. The embankment and cut-and-cover construction will heavily disrupt the ecological subunits of these hillocks and cause severe damage to their physical continuity and biodiversity systems. In the context of climate change leading to heavy rain during monsoons, there are chances of massive runoff followed by subsidence and landslides during the construction and post-construction phase. District-wise data shows the highest impact in Ernakulam district (130.1 hectares), followed by Pathanamthitta (116.98 hectares) and Kasaragod (114.27 hectares).

3.4.3.1.4. Paddy based wetland ecosystem

Rice fields are temporary wetlands that harbor many of the same species that breed in natural temporary ponds. Therefore, the rice agro-ecosystem has the potential to help sustain the regional biodiversity of many invertebrates and vertebrates. Like natural wetlands, rice cultivation provides a mosaic of temporary and more permanent waters. Paddy cultivation plays a significant and vital role in rice production, while also performing other important functions for the local environment, including climate mitigation, flood control, groundwater recharge, biodiversity conservation, and ecosystem development.

Nationally, the annual monetary value of services offered by inland wetlands is ₹22 lakhs per hectare, and for coastal wetlands, it is ₹107 lakhs per hectare. It was estimated in 2011 that Kerala is receiving annual ecosystem services worth ₹1.23 lakh crores from wetlands. This emphasizes that the conservation of the remaining paddy fields and wetlands is crucial for the state's ecological and economic sustainability. The average water level in a paddy field is one foot, so one hectare will hold three million liters of water. This water percolates down and replenishes groundwater, so losing paddy fields and wetlands will threaten the state's water security.

Kerala has always been a food-deficit state. Another key factor that calls for continuing paddy cultivation is the production of the state's staple food. The gap between the state's demand and production of rice has increased from 50% in the 1960s to more than 85% today. Kerala needs 4 million tonnes of rice a year compared to the 0.56 million tonnes it produces.

The lush green of paddy fields is one of the most captivating features of Kerala's landscape. The area under paddy cultivation increased substantially during the first fifteen years after the State's formation – from 7,60,000 hectares in 1955–56 to 8,80,000 hectares in 1970–71. In 1965–66, rice accounted for the highest share of gross cropped area in Kerala (32% of the total). There was, however, a steady decline in the area under rice cultivation from the 1980s onwards – from 8,50,000 hectares in 1980–81 to 5,60,000 hectares in 1990–91, 3,20,000 hectares in 2001–02 and 2,05,000 hectares in 2020-21.

The impact of the K-Rail – SilverLine project on the agriculture area has been evaluated, revealing that 1,631.67 hectares of paddy and associated land will be severely affected by the project (Table 3.3). The maximum loss is expected in Thrissur district (410.67 Ha), followed by Ernakulam (291.72 Ha) and Malappuram (163.40 Ha).

As food security is a vital issue in Kerala, the K-Rail – SilverLine project may further deteriorate the existing crisis in food deficit. Paddy fields also play a crucial role in groundwater recharge and ensuring the availability of drinking water to neighbouring villages. Reclamation and connection underutilisation of surrounding areas of paddy wetland in connection with the K-Rail – SilverLine project is a major environmental issue that the Government of Kerala must address.

In addition to mangroves and paddy fields, the wetland area is also encompassed by marshy areas, backwaters, and ponds. The total area occupied by these wetlands is 3,705.95 hectares, of which ponds account for the majority (2,897.04 hectares), followed by marshy areas (589.44 hectares) and backwaters (45.46 hectares). Ponds are the major water source in Kerala villages during the summer and significantly enrich the water table around human habitats. Therefore, the loss of a large number of ponds due to construction during the implementation of the project is expected to severely affect the availability of drinking water for village communities.

3.4.5. Impact on vegetation, green biomass and carbon sink

In addition to biodiversity loss, clear felling followed by degradation of vegetation in and around acquired land leads to a great loss in biomass and carbon sink. As part of the biomass assessment, the entire area was divided into low-carbon, medium-carbon, dense-carbon, and very dense-carbon areas. The study revealed that the total biomass areas at a width of 30 meters were registered as 381.6 hectares (low-carbon area), 743.56 hectares (medium-carbon area), 690.37 hectares (dense-carbon area), and 13.78 hectares (very dense-carbon area). For a width of 200 meters, the values were 1077.35 acres (low-carbon area), 4,959.45 hectares (medium-carbon area), 4,548.96 hectares (dense-carbon area), and 94.42 hectares (very dense-carbon area). Among districts, Kannur occupied the maximum biomass areas (1,225.65 hectares), followed by Thrissur (941.03 hectares).

3.4.5.1. Biomass areas of K-Rail – SilverLine Alignment

3.4.5.1.1. Loss in Biomass production (t/ha or Mg/ha)

Details of biomass production in the study regions are given in Table 3.21, 3.22, 3.23 and 3.24. Biomass production studies on the 30 m alignment disclosed the production data in four different categories recognized under various districts. The highest biomass production was reported in the dense-carbon category (1641.70 ton) followed by the medium-carbon area (110192.55 ton), very dense (3664.89 ton) and low-carbon area (1641.70 ton). The total biomass production in the 30 m alignment was assessed to be 1,94,585.32 M tons. The corresponding values for 200 m were 7,25,881.50 (dense-carbon area), 5,27,592.15 (medium-carbon area), 25,107.20 (very dense-carbon area) and 11,460.83 (low-carbon area). The total biomass production on the 200 m alignment was recorded to be 12,90,041.69 M. tons.

Table 3.17, 3.18, 3.19, and 3.20 show the biomass production in the study regions. Biomass production studies on the 30-meter alignment revealed the production data in four different categories recognized under various districts. The highest biomass production was reported in the dense-carbon category (1,641.70 tons), followed by the medium-carbon area (1,10,192.55

tons), very dense (3,664.89 tons), and low-carbon area (1,641.70 tons). The total biomass production in the 30-meter alignment was assessed to be 1,94,585.32 metric tons. The corresponding values for 200 meters were 7,25,881.50 tons (dense-carbon area), 5,27,592.15 tons (medium-carbon area), 25,107.20 tons (very dense-carbon area), and 11,460.83 tons (low-carbon area). The total biomass production on the 200-meter alignment was recorded to be 12,90,041.69 metric tons.

Map No. 3.13. Biomass calculated for seg no. 1.

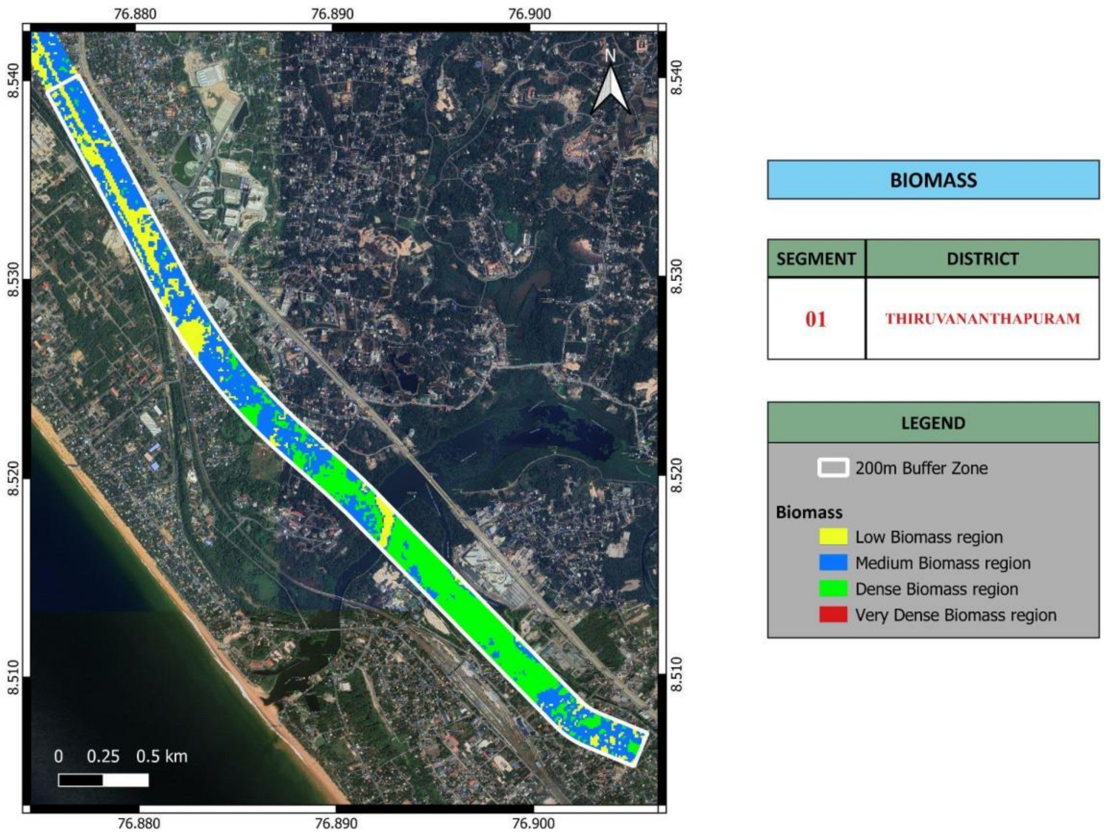


Table 3.17. Biomass in 30 metre buffer Zone

BIOMASS in 30 metre buffer Zone				
District / UT	**Biomass**	**Area of 30 m Buffer Zone (ha)**	**Biomass (Mg/ha)**	**Total Biomass in each district (Mg/ha)**
Thiruvananthapuram	Low biomass area	9.45	100.53	14871.81
	Medium biomass area	47.84	5089.36	
	Dense biomass area	57.99	9253.72	

	Very dense biomass area	1.61	428.19	
Kollam	Low biomass area	4.92	52.34	17866.70
	Medium biomass area	40.36	4293.62	
	Dense biomass area	81.08	12938.30	
	Very dense biomass area	2.19	582.45	
Pathanamthitta	Low biomass area	0.89	9.47	9127.02
	Medium biomass area	15.36	1634.04	
	Dense biomass area	44.48	7097.87	
	Very dense biomass area	1.45	385.64	
Kottayam	Low biomass area	4.81	51.17	20222.98
	Medium biomass area	48.89	5201.06	
	Dense biomass area	90.7	14473.40	
	Very dense biomass area	1.87	497.34	
Alappuzha	Low biomass area	4.09	43.51	7827.02
	Medium biomass area	17.61	1873.40	
	Dense biomass area	33.77	5388.83	
	Very dense biomass area	1.96	521.28	
Ernakulam	Low biomass area	9.28	98.72	20538.09
	Medium biomass area	60.39	6424.47	
	Dense biomass area	83.61	13342.02	
	Very dense biomass area	2.53	672.87	
Thrissur	Low biomass area	17.84	189.79	24390.85
	Medium biomass area	97.92	10417.02	
	Dense biomass area	85.63	13664.36	
	Very dense biomass area	0.45	119.68	
Malappuram	Low biomass area	17.68	188.09	18365.21
	Medium biomass area	90.33	9609.57	
	Dense biomass area	53.69	8567.55	
	Very dense biomass area		0.00	
Kozhikode	Low biomass area	22.97	244.36	26529.47
	Medium biomass area	114.23	12152.13	
	Dense biomass area	87.65	13986.70	
	Very dense biomass area	0.55	146.28	

Kannur	Low biomass area	27.47	292.23	19431.60
	Medium biomass area	109.73	11673.40	
	Dense biomass area	45.57	7271.81	
	Very dense biomass area	0.73	194.15	
Kasaragod	Low biomass area	34.82	370.43	15224.68
	Medium biomass area	99.47	10581.91	
	Dense biomass area	26.04	4155.32	
	Very dense biomass area	0.44	117.02	
UT – Mahe	Low biomass area	0.1	1.06	189.89
	Medium biomass area	1.28	136.17	
	Dense biomass area	0.33	52.66	
	Very dense biomass area		0.00	
Total	Low biomass area	154.34	1641.70	194585.32
	Medium biomass area	743.39	79086.17	
	Dense biomass area	690.54	110192.55	
	Very dense biomass area	13.78	3664.89	

Table 3.18. Biomass in 50 metre buffer

Biomass in 50 Metres buffer				
District / UT	**Biomass**	**Area of 50 m Buffer Zone (ha)**	**Biomass sink (Mg/ha)**	**Total Biomass in each district (Mg/ha)**
Thiruvananthapuram	Low biomass area	18.04	191.95	24555.47
	Medium biomass area	78.05	8302.88	
	Dense biomass area	95.9	15303.70	
	Very dense biomass area	2.85	756.95	
Kollam	Low biomass area	8.33	88.63	29775.55
	Medium biomass area	67.24	7153.49	
	Dense biomass area	134.95	21534.36	
	Very dense biomass area	3.76	999.07	
Pathanamthitta	Low biomass area	1.51	16.04	15206.12
	Medium biomass area	25.6	2723.00	
	Dense biomass area	74.28	11852.48	

	Very dense biomass area	2.31	614.61	
Kottayam	Low biomass area	8.41	89.48	33609.26
	Medium biomass area	82.09	8733.05	
	Dense biomass area	150.39	23998.38	
	Very dense biomass area	2.96	788.35	
Alappuzha	Low biomass area	6.8	72.31	13035.02
	Medium biomass area	29.3	3117.09	
	Dense biomass area	56.51	9017.63	
	Very dense biomass area	3.11	827.99	
Ernakulam	Low biomass area	16.99	180.80	34049.50
	Medium biomass area	99.7	10606.46	
	Dense biomass area	138.85	22156.49	
	Very dense biomass area	4.16	1105.76	
Thrissur	Low biomass area	29.88	317.90	40665.93
	Medium biomass area	163.01	17341.69	
	Dense biomass area	142.78	22784.17	
	Very dense biomass area	0.84	222.16	
Malappuram	Low biomass area	33.04	351.45	30027.73
	Medium biomass area	150.1	15967.85	
	Dense biomass area	85.91	13708.44	
	Very dense biomass area	0	0.00	
Kozhikode	Low biomass area	47.56	506.00	42775.92
	Medium biomass area	191.52	20374.71	
	Dense biomass area	135.71	21656.02	
	Very dense biomass area	0.9	239.19	
Kannur	Low biomass area	51.57	548.58	31712.26
	Medium biomass area	179.94	19143.05	
	Dense biomass area	73.25	11688.86	
	Very dense biomass area	1.25	331.78	
Kasaragod	Low biomass area	58.86	626.21	25280.02
	Medium biomass area	165.53	17609.35	
	Dense biomass area	42.8	6830.27	
	Very dense biomass area	0.81	214.18	

UT – Mahe	Low biomass area	0.2	2.16	306.81
	Medium biomass area	2.02	214.45	
	Dense biomass area	0.57	90.20	
	Very dense biomass area	0	0.00	
Total	Low biomass area	281.2	2991.50	320999.60
	Medium biomass area	1234.1	131287.06	
	Dense biomass area	1131.89	180621.00	
	Very dense biomass area	22.94	6100.03	

Table 3.19. Biomass in 200 metre buffer

District / UT	Biomass	Area of 200 m buffer (ha)	Biomass sink (Mg/ha)	Total Biomass in each district (Mg/ha)
Thiruvananthapuram	Low biomass area	62.16	661.23	99643.42
	Medium biomass area	322.95	34356.82	
	Dense biomass area	380.36	60696.19	
	Very dense biomass area	14.77	3929.18	
Kollam	Low biomass area	34.04	362.17	118833.95
	Medium biomass area	276.62	29428.16	
	Dense biomass area	528.25	84294.99	
	Very dense biomass area	17.85	4748.63	
Pathanamthitta	Low biomass area	8.40	89.37	60162.92
	Medium biomass area	111.36	11847.29	
	Dense biomass area	285.41	45543.64	
	Very dense biomass area	10.09	2682.62	
Kottayam	Low biomass area	35.87	381.60	133714.66
	Medium biomass area	337.65	35919.93	
	Dense biomass area	593.43	94695.81	
	Very dense biomass area	10.22	2717.32	
Alappuzha	Low biomass area	29.04	308.89	51732.71
	Medium biomass area	113.15	12037.29	
	Dense biomass area	230.95	36853.40	
	Very dense biomass area	9.52	2533.13	

Ernakulam	Low biomass area	82.48	877.44	132698.64
	Medium biomass area	414.93	44141.31	
	Dense biomass area	526.09	83950.91	
	Very dense biomass area	14.02	3728.98	
Thrissur	Low biomass area	134.58	1431.70	160449.09
	Medium biomass area	650.67	69219.93	
	Dense biomass area	556.93	88871.22	
	Very dense biomass area	3.48	926.24	
Malappuram	Low biomass area	110.36	1174.06	123779.86
	Medium biomass area	589.08	62668.51	
	Dense biomass area	375.61	59937.29	
	Very dense biomass area	0.00	0.00	
Kozhikode	Low biomass area	191.59	2038.15	171472.78
	Medium biomass area	753.49	80158.45	
	Dense biomass area	552.29	88131.05	
	Very dense biomass area	4.31	1145.12	
Kannur	Low biomass area	218.66	2326.12	126611.37
	Medium biomass area	694.93	73928.60	
	Dense biomass area	306.74	48947.26	
	Very dense biomass area	5.30	1409.38	
Kasaragod	Low biomass area	167.21	1778.81	109875.34
	Medium biomass area	687.92	73183.32	
	Dense biomass area	210.73	33626.61	
	Very dense biomass area	4.84	1286.60	
UT – Mahe	Low biomass area	2.94	31.28	1066.96
	Medium biomass area	6.60	702.55	
	Dense biomass area	2.09	333.12	
	Very dense biomass area	0.00	0.00	
Total	Low biomass area	1077.32	11460.83	1290041.69
	Medium biomass area	4959.37	527592.15	
	Dense biomass area	4548.86	725881.50	
	Very dense biomass area	94.40	25107.20	

Table 3.20. Biomass Consolidated

BIOMASS				
Area	**Biomass**	**Buffer Zone (ha)**	**Biomass (Mg/ha)**	**Total Biomass (Mg/ha)**
30 m	Low biomass area	154.34	1641.70	**194585.32**
	Medium biomass area	743.39	79086.17	
	Dense biomass area	690.54	110192.55	
	Very dense biomass area	13.78	3664.89	
50 m	Low biomass area	281.20	2991.50	**320999.60**
	Medium biomass area	1234.10	131287.06	
	Dense biomass area	1131.89	180621.00	
	Very dense biomass area	22.94	6100.03	
200 m	Low biomass area	1077.32	11460.83	**1290041.69**
	Medium biomass area	4959.37	527592.15	
	Dense biomass area	4548.86	725881.50	
	Very dense biomass area	94.40	25107.20	

3.4.5.1.2. Loss in Carbon Sink

Carbon sequestration in both 30 m and 200 m alignment areas was estimated for four different category areas, as identified in biomass studies. Average carbon sequestration in each category was estimated from the corresponding biomass values. The total carbon sequestration in each district was also calculated and added together to assess the total carbon sink by the terrestrial biomass.

In the 30 m alignment width, carbon sequestered in different categories was reported as 771.7 tons (low-carbon area), 37,769 tons (medium-carbon area), 51,790.5 tons (dense-carbon area), and 1,722.5 tons (very dense-carbon area), respectively. Hence, the total carbon sequestration in different carbon areas along the entire alignment was estimated to be 91,454.5 tons. Among the districts, Kozhikode registered the highest carbon sink (12,468.85 tons), followed by Thrissur (11,463.65 tons) and Ernakulam (9,652.90 tons).

The carbon sequestration potential of vegetation in the 200 m alignment showed relatively higher values because the area was much larger. However, during the construction phase, tree felling may not be restricted to the 30 m width, and large trees will not be allowed to remain close to the railway line. Therefore, there is a chance that more trees and shrubby vegetation will be felled outside the proposed line (30 m width). Additionally, the transportation of raw materials may also destroy more vegetation outside the proposed line. A study of the carbon sequestration potential of vegetation in a 200 m width indicated that the carbon sequestration of 5,386.59 tons (low-carbon area) was followed by 2,47,968.59 tons (medium-carbon area), 3,41,164.30 tons (dense-carbon area), and 11,800.38 tons (very dense-carbon area). The entire K-Rail – SilverLine alignment for a 200 m width revealed a total carbon sequestration of 6,06,320 tons.

The total affected area for the 30 m K-Rail – SilverLine alignment was found to be 1,602 hectares (16.02 sq. km) and for 200 m width, it was 10,670 ha (106.7 sq. km).

3.4.5.1.3. Impact of clear felling on carbon sink

The complex web of life within an ecosystem comprises plants, animals, bacteria, and fungi, and many species cannot survive when that network of relationships breaks down. Undisturbed vegetated areas are crucial for a healthy climate, continuously taking carbon dioxide (CO_2) from the atmosphere and storing it in trees, shrubs, and soil. However, logging can transform a swath of forest from a carbon "sink" into a carbon source, not only destroying CO_2-absorbing trees but also emitting tons of new greenhouse gases in the process.

Clear felling, the most CO_2-spewing logging method, is devastating to wildlife, habitat, and water quality. It may also lead to increased streamflow during storms, loss of habitat and species diversity, opportunities for invasive and weedy species, negative impacts on scenery, and a decrease in property values. It can also undermine the future ability of habitats to soak up greenhouse gases from the atmosphere. In other words, a balanced ecosystem becomes far less effective at being a carbon sink, one of our best tools in the fight against climate change.

Clear felling of vegetation all along the K-Rail – SilverLine alignment removes 194,585 metric tons of green biomass at 30 m width, whereas at 200 m width, the value increases to 12,90,041 metric tons. When biomass value is converted to carbon sequestration capacity of the above area, the value changes to 91,454.20 metric tons of carbon at 30 m width and 6,06,320.0 metric tons at 200 m width. This indicates that the removal of green biomass has a detrimental impact on carbon sequestration and consequently affects the ability of the local ecosystem to absorb and trap atmospheric **CO_2** through photosynthesis.

Clear felling, in addition to the loss of biomass and carbon sink, also impacts species diversity, stream flow, infiltration potential, and nutrient retention capacity of the soil. In the current context of climate change, it is noteworthy that the construction and post-construction phases of K-Rail – SilverLine will have a significant chance of disrupting the ecosystem services and livelihood opportunities of the local community.

Table 3.21. Carbon sequestration in 30 m-width K-Rail – SilverLine Alignment

CARBON SINK					
District / UT	**Carbon sink**	**Area of 30 m Buffer Zone (Ha)**	**Average Carbon stored (tC/ha)**	**Total carbon sink (tC/ha)**	**Total in each district (tC/ha)**
Thiruvananthapuram	Low carbon area	9.45	5	47.25	6989.75
	Medium carbon area	47.84	50	2392.00	
	Dense carbon area	57.99	75	4349.25	
	Very dense carbon area	1.61	125	201.25	
Kollam	Low carbon area	4.92	5	24.60	8397.35
	Medium carbon area	40.36	50	2018.00	
	Dense carbon area	81.08	75	6081.00	
	Very dense carbon area	2.19	125	273.75	
Pathanamthitta	Low carbon area	0.89	5	4.45	4289.70
	Medium carbon area	15.36	50	768.00	
	Dense carbon area	44.48	75	3336.00	
	Very dense carbon area	1.45	125	181.25	
Kottayam	Low carbon area	4.81	5	24.05	9504.80
	Medium carbon area	48.89	50	2444.50	
	Dense carbon area	90.70	75	6802.50	
	Very dense carbon area	1.87	125	233.75	
Alappuzha	Low carbon area	4.09	5	20.45	3678.70
	Medium carbon area	17.61	50	880.50	
	Dense carbon area	33.77	75	2532.75	
	Very dense carbon area	1.96	125	245.00	
Ernakulam	Low carbon area	9.28	5	46.40	9652.90
	Medium carbon area	60.39	50	3019.50	
	Dense carbon area	83.61	75	6270.75	
	Very dense carbon area	2.53	125	316.25	
Thrissur	Low carbon area	17.84	5	89.20	11463.70
	Medium carbon area	97.92	50	4896.00	
	Dense carbon area	85.63	75	6422.25	
	Very dense carbon area	0.45	125	56.25	

Malappuram	Low carbon area	17.68	5	88.40	8631.65
	Medium carbon area	90.33	50	4516.50	
	Dense carbon area	53.69	75	4026.75	
	Very dense carbon area		125		
Kozhikode	Low carbon area	22.97	5	114.85	12468.85
	Medium carbon area	114.23	50	5711.50	
	Dense carbon area	87.65	75	6573.75	
	Very dense carbon area	0.55	125	68.75	
Kannur	Low carbon area	27.47	5	137.35	9132.85
	Medium carbon area	109.73	50	5486.50	
	Dense carbon area	45.57	75	3417.75	
	Very dense carbon area	0.73	125	91.25	
Kasaragod	Low carbon area	34.82	5	174.10	7155.60
	Medium carbon area	99.47	50	4973.50	
	Dense carbon area	26.04	75	1953.00	
	Very dense carbon area	0.44	125	55.00	
UT – Mahe	Low carbon area	0.10	5	0.50	89.25
	Medium carbon area	1.28	50	64.00	
	Dense carbon area	0.33	75	24.75	
	Very dense carbon area		125		
Total	Low carbon area	154.34	5	771.60	91455.10
	Medium carbon area	743.39	50	37170.50	
	Dense carbon area	690.54	75	51790.50	
	Very dense carbon area	13.78	125	1722.50	

Table 3.22. Carbon Sequestration in 50 m-width K-Rail – SilverLine Alignment

CARBON SINK					
District/UT	**Carbon sink**	**Area of 50 m Buffer Zone (Ha)**	**Average Carbon stored (tC/ha)**	**Total carbon sink (tC/ha)**	**Total in each district (tC/ha)**
Thiruvananthapuram	Low carbon area	18.04	5	90.2159	11541.07
	Medium carbon area	78.05	50	3902.353	

	Dense carbon area	95.90	75	7192.737	
	Very dense carbon area	2.85	125	355.7666	
Kollam	Low carbon area	8.33	5	41.65658	13994.51
	Medium carbon area	67.24	50	3362.138	
	Dense carbon area	134.95	75	10121.15	
	Very dense carbon area	3.76	125	469.5619	
Pathanamthitta	Low carbon area	1.51	5	7.537999	7146.88
	Medium carbon area	25.60	50	1279.809	
	Dense carbon area	74.28	75	5570.666	
	Very dense carbon area	2.31	125	288.8649	
Kottayam	Low carbon area	8.41	5	42.05674	15796.35
	Medium carbon area	82.09	50	4104.533	
	Dense carbon area	150.39	75	11279.24	
	Very dense carbon area	2.96	125	370.5224	
Alappuzha	Low carbon area	6.80	5	33.98353	6126.46
	Medium carbon area	29.30	50	1465.033	
	Dense carbon area	56.51	75	4238.287	
	Very dense carbon area	3.11	125	389.1549	
Ernakulam	Low carbon area	16.99	5	84.97383	16003.26
	Medium carbon area	99.70	50	4985.035	
	Dense carbon area	138.85	75	10413.55	
	Very dense carbon area	4.16	125	519.7069	
Thrissur	Low carbon area	29.88	5	149.4145	19112.99
	Medium carbon area	163.01	50	8150.595	
	Dense carbon area	142.78	75	10708.56	
	Very dense carbon area	0.84	125	104.4166	
Malappuram	Low carbon area	33.04	5	165.1808	14113.03
	Medium carbon area	150.10	50	7504.888	
	Dense carbon area	85.91	75	6442.965	
	Very dense carbon area	0.00	125		
Kozhikode	Low carbon area	47.56	5	237.8197	20104.68
	Medium carbon area	191.52	50	9576.114	
	Dense carbon area	135.71	75	10178.33	

	Very dense carbon area	0.90	125	112.4198	
Kannur	Low carbon area	51.57	5	257.8326	14904.76
	Medium carbon area	179.94	50	8997.232	
	Dense carbon area	73.25	75	5493.762	
	Very dense carbon area	1.25	125	155.9371	
Kasaragod	Low carbon area	58.86	5	294.3172	11881.61
	Medium carbon area	165.53	50	8276.396	
	Dense carbon area	42.80	75	3210.229	
	Very dense carbon area	0.81	125	100.6651	
UT-Mahe	Low carbon area	0.20	5	1.015413	144.20
	Medium carbon area	2.02	50	100.791	
	Dense carbon area	0.57	75	42.39226	
	Very dense carbon area	0.00	125		
TOTAL	Low carbon area	281.20	5	1406.005	150869.81
	Medium carbon area	1234.10	50	61704.92	
	Dense carbon area	1131.89	75	84891.87	
	Very dense carbon area	22.94	125	2867.016	

Table 3.23. Carbon sequestration in 200 m-width K-Rail – SilverLine Alignment

CARBON SINK					
District / UT	**Carbon sink**	**Area of 200 m Buffer Zone (Ha)**	**Average Carbon stored (tC/ha)**	**Total carbon sink (tC/ha)**	**Total in each district (tC/ha)**
Thiruvanant hapuram	Low carbon area	62.16	5	310.78	46832.41
	Medium carbon area	322.95	50	16147.70	
	Dense carbon area	380.36	75	28527.21	
	Very dense carbon area	14.77	125	1846.71	
Kollam	Low carbon area	34.04	5	170.22	55851.96
	Medium carbon area	276.62	50	13831.24	
	Dense carbon area	528.25	75	39618.65	
	Very dense carbon area	17.85	125	2231.86	

Pathanamthitta	Low carbon area	8.40	5	42.00	28276.57
	Medium carbon area	111.36	50	5568.23	
	Dense carbon area	285.41	75	21405.51	
	Very dense carbon area	10.09	125	1260.83	
Kottayam	Low carbon area	35.87	5	179.35	62845.89
	Medium carbon area	337.65	50	16882.37	
	Dense carbon area	593.43	75	44507.03	
	Very dense carbon area	10.22	125	1277.14	
Alappuzha	Low carbon area	29.04	5	145.18	24314.37
	Medium carbon area	113.15	50	5657.53	
	Dense carbon area	230.95	75	17321.10	
	Very dense carbon area	9.52	125	1190.57	
Ernakulam	Low carbon area	82.48	5	412.40	62368.36
	Medium carbon area	414.93	50	20746.41	
	Dense carbon area	526.09	75	39456.93	
	Very dense carbon area	14.02	125	1752.62	
Thrissur	Low carbon area	134.58	5	672.90	75411.07
	Medium carbon area	650.67	50	32533.37	
	Dense carbon area	556.93	75	41769.47	
	Very dense carbon area	3.48	125	435.33	
Malappuram	Low carbon area	110.36	5	551.81	58176.53
	Medium carbon area	589.08	50	29454.20	
	Dense carbon area	375.61	75	28170.53	
	Very dense carbon area	0.00	125		
Kozhikode	Low carbon area	191.59	5	957.93	80592.21
	Medium carbon area	753.49	50	37674.47	
	Dense carbon area	552.29	75	41421.59	
	Very dense carbon area	4.31	125	538.21	
Kannur	Low carbon area	218.66	5	1093.28	59507.34
	Medium carbon area	694.93	50	34746.44	
	Dense carbon area	306.74	75	23005.21	
	Very dense carbon area	5.30	125	662.41	

Kasaragod	Low carbon area	167.21	5	836.04	51641.41
	Medium carbon area	687.92	50	34396.16	
	Dense carbon area	210.73	75	15804.51	
	Very dense carbon area	4.84	125	604.70	
UT – Mahe	Low carbon area	2.94	5	14.70	501.46
	Medium carbon area	6.60	50	330.20	
	Dense carbon area	2.09	75	156.57	
	Very dense carbon area	0.00	125		
Total	Low carbon area	1077.32	5	5386.59	606319.59
	Medium carbon area	4959.37	50	247968.31	
	Dense carbon area	4548.86	75	341164.31	
	Very dense carbon area	94.40	125	11800.38	

Table 3.24. Carbon sink Consolidated

Area	**Carbon sink**	**Buffer Zone (Ha)**	**Average Carbon stored (tC/ha)**	**Total carbon sink (tC/ha)**	**Total (tC/ha)**
30 m	Low carbon area	154.34	5	771.6	91455.10
	Medium carbon area	743.39	50	37170.5	
	Dense carbon area	690.54	75	51790.5	
	Very dense carbon area	13.78	125	1722.5	
50 m	Low carbon area	281.20	5	1406.005	150869.81
	Medium carbon area	1234.10	50	61704.92	
	Dense carbon area	1131.89	75	84891.87	
	Very dense carbon area	22.94	125	2867.016	
200 m	Low carbon area	1077.32	5	5386.59	606319.6
	Medium carbon area	4959.37	50	247968.31	
	Dense carbon area	4548.86	75	341164.31	
	Very dense carbon area	94.40	125	11800.38	

Detailed investigations of the K-Rail – SilverLine project's impact on aquatic and terrestrial biodiversity revealed that the project will have short- and long-term impacts on the biodiversity of critical ecosystems. The project claims that the reduction of energy consumption and greenhouse gas (GHG) emissions is one of the main drivers of the project. However, carbon sequestration studies have revealed that clear felling and subsequent degradation of vegetative areas have detrimental impacts on carbon sequestration potential and carbon sinks, increasing the project's carbon footprint. The removal of large quantities of green biomass during the construction phase shows that the project will not reduce carbon emissions as projected.

3.5. Atmospheric Characteristics

3.5.1. Rainfall

Rainfall events in the State have been discussed in detail in Section 3.2.1. The long-term annual rainfall in Kerala is 282 cm (Chattopadhyay, 2021). Recent trends show an average annual rainfall of 300 cm (Guhathakurta et al., 2020). Rainfall varies widely over the years. The State received the highest annual rainfall of 394 cm in 1924, followed by 391 cm in 1961. Both these years witnessed devastating floods. The year 2018 also recorded a very high annual rainfall of 352 cm. Unprecedented extreme rain events in 2018 caused unprecedented flood havoc. During the period from 2009 to 2018, the monsoon rainfall varied from 131 cm to 252 cm, pointing to the vagaries of monsoon rainfall.

The 1.2–1.4 °C increase in temperature over the Arabian Sea in the past two decades has increased the frequency of cyclonic events along the Indian west coast, greatly affecting the rainfall distribution in Kerala. Though July and June were the months that received the highest rains, frequent and heavy spells have been seen in August and September in the last four years. The pattern of heavy-intensity rainfall repeated in August 2019, August 2020, and October 2021, causing floods and landslides that led to the loss of life and property in various parts of the State.

3.5.2. Air pollution

Air pollution has become a health hazard in many major cities in India, but it has not yet reached a critical level in Kerala. As a conglomeration of towns and cities, Kerala is rapidly developing infrastructure and urbanization, resulting in increased vehicular traffic, construction activities, settlement development, and reduced vegetative cover. These factors could change the situation in the near future.

The critical air pollutants in Kerala, especially, are suspended particulate matter (SPM), Sulfur dioxide (SO_2), Nitrogen oxide (NO_2), and aerosols. Among the SPM, respirable particulate matter (RSPM), $PM_{2.5}$, and PM_{10} are more critical. Other pollutants of concern are Carbon monoxide (CO), Ozone, and volatile organic compounds (VOCs). Regular exposure to these pollutants can have negative impacts on the cardiovascular and respiratory systems, such as decreased lung and heart function and aggravation of asthma (CPCB, 2015). The impacts are more severe on people with heart and respiratory diseases. Aerosols and fine particulate matter can cause fog and reduce visibility during some seasons. They can also be carried to water bodies like backwaters, estuaries, and coastal waters, which can cause increased acidification. This can also affect the nutrients in the soil and the terrestrial ecosystem. Air pollutants also contribute to climate change.

Vehicular traffic, including non-road mobiles (like marine vessels and locomotives), construction and demolition of waste, real estate development, urbanisation, clearing of vegetation, and other land use changes, as well as e-waste processing, etc. are the major reasons for the increase in air pollutants (Manoj et al., 2018). All these causative factors are on an increasing trend with rapid urbanization and associated activities.

Some recent studies (Jyothi et al., 2019; Neethu and Sindhu, 2017; Amogh et al., 2018) have shown that the Air Pollution Index (API) values in Kerala have gone up to 70.89. Overall, the air pollution level in the State could be considered moderate. SPM values have been reported to be up to 76.17 μg/m3 in certain years.

The rapid urbanization of the state and associated increase in travel, including short-distance travel; infrastructure developments in the transport sector, including road, rail, and navigation; tourism and the IT industry; and township development have the potential to further deteriorate the air quality. Conservation of wetlands, vegetation, and geomorphology is needed for controlling air pollution.

As the K-Rail – SilverLine project will severely impact the wetlands of Kerala (wetlands constitute 3,705.87 hectares in the K-Rail – SilverLine alignment) and contribute to a major reduction in biomass (removing 1,94,585 metric tons of green biomass at 30 meters wide, while the value increases to 12,90,041 metric tons at 200 meters wide), it will have a multiplier effect as less area will be available for the absorption of polluted air. Therefore, the overall impact would be an increase in air pollution.

3.5.3. Heat islands

The growth of urban population concentration in India is one of the highest in the world. This rapid urbanisation and associated development and activities affect radiative, thermal, and moisture emissions. Open land and vegetation are replaced by built-up areas. Surfaces that were once permeable become impermeable and dry. These changes in the natural environment lead to the formation of heat islands, which refer to changes in climatic conditions, including temperature, compared to nearby areas. Changes in urban geometry contribute to the formation of three-dimensional spaces bounded by streets and surrounding buildings, called "urban canyons." These canyons cause multiple reflections of radiation and restrict the free movement of air, trapping heat. The formation of heat islands is intensified by the complex heat exchange between buildings and their surroundings, such as the increased use of air conditioners.

Kochi, where the built-up area increased from 17% in 2002 to 23% in 2013, recorded an Urban Heat Island Intensity (UHII – temperature difference between urban and rural/neighbourhood areas) of 4.3 in the summer of 2019 (George et al., 2020). Development of new townships, stations, and depots as part of K-Rail–SilverLine will inevitably pave the way for more and more heat islands.

3.5.4. Noise and Vibration

Semi-high-speed rail traffic generates sound and vibration that can be harmful to both humans and animals. In addition to noise and vibration generated during the construction phase due to the operation of construction machinery and transport vehicles, some studies in Japan have shown that high-speed train noise is more annoying than conventional train noise and that vibration leads to greater noise annoyance (Lee and Griffin, 2013). The three main noise types due to semi-high-speed rail are traction noise (emitted from traction motors, cooling fans, gears, and auxiliary equipment), rolling noise (through wheel-rail contact interaction), and aerodynamic noise (due to vortex shedding from wheels and pantographs, flow separations at train nose and tail, and flow disturbances at edges and cavities).

The direct and psychological effects of semi-high-speed rail noise and vibration can be significant, especially if they are intense or persistent. These effects can include sleep disturbance, stress, irritation and annoyance, and interference with normal conversations. Prolonged exposure to semi-high-speed rail noise and vibration may also increase the risk of hearing problems and cardiovascular diseases (Hao et al., 2022).

Vibration from semi-high-speed rail can also lead to structure-borne noise in the surrounding built environment. In more severe cases, such vibration can lead to safety implications for buildings.

Factors that influence the impact of semi-high-speed rail noise and vibration include the distance between the rail and the listener, ambient noise levels, the presence of buildings and sound barriers, the type of semi-high-speed rail technology employed, and the speed and length of the train.

The maximum permissible noise level depends on the nature of the surrounding zone, such as residential areas, educational institutions, hospitals, industrial areas, and protected areas. Datson et al. (2018) reported that noise measured for German high-speed rail at 200 km/hr was over 80 dB(A) at 25 m from the track. While there have been many studies on the impact of semi-high-speed rail noise on humans, the impact on animals is still uncertain.

Both transit and construction vibration can generate ground waves that interact with nearby structures in a manner similar to seismic waves. If the frequency of the vibration coincides with the natural frequency of a floor or wall, it can resonate with the structure, amplifying the sound level within the building.

Another major problem caused by vibration is bridge resonance when the train travels at a certain critical speed. This issue has been observed in studies conducted by Taiwan High-Speed Rail (THSR), which also reported damage to buildings, such as cracks in walls, and failure of embankments due to increased water seepage (Chen, 2008). This type of problem is more likely to occur in areas with wet and soft soil, such as in the center of agricultural regions.

Indian rules and regulations are silent on noise and ground-borne vibration limits during the construction and operation of railways. Although the Central Pollution Control Board (CPCB) framed the Noise Pollution (Regulation and Control) Rules, 2000, specifying ambient air quality in respect of all noise events in the atmosphere (Table 3.25), it has yet to release standards and regulations for railway noise and vibration. The noise above the specified Noise Regulations and Rules (2000) will adversely affect the comfort of people living near the semi-high-speed rail track. One can file a complaint if the noise level exceeds the ambient noise standards by 10 dB(A) or more given in the corresponding columns against any area/zone (http://www.elaw.in/noise/veerate.htm). Standards and regulations for railway noise and vibration must be established, and the impact must be assessed and mitigation measures implemented before proceeding with the K-Rail–SilverLine project.

Table 3.25. Ambient Air Quality Standards in respect of Noise (Noise pollution: Regulation and control) rules, 2000)

Category of Area/Zone	Limits in dB(A) Leq*	
	Day time	Night time
Industrial area	75	70
Commercial area	65	55
Residential area	55	45
Silence Zone	50	40

(Daytime is between 6 am and 10 pm & Night time is between 10 pm and 6 am)

3.5.5. Climate change

3.5.5.1. Climate Change and Floods

The new report by the Intergovernmental Panel on Climate Change (IPCC, 2021) unequivocally clarifies the warming of the Arabian Sea, which triggers marine heat waves, low-pressure zones, cyclones, and cloud bursts, as well as rising sea levels and the possibility of extreme climatic events such as heavy rainfall in the region.

The issue of climate change needs much more serious attention in all realms of development in the State, as the manifestations of increasing temperature are much more evident in the forms of variations in monsoon patterns, extreme climate events such as floods and cyclones, and changes in the distribution of biodiversity.

Additionally, climate change may also severely impact the livelihood and future economic sustainability paradigms of the State. There is increasing evidence of vagaries in monsoon rainfall and the incidence of high-intensity rainfall separated by longer dry periods. This impacts existing water management infrastructures and disrupts agricultural practices that have evolved with the region's monsoon cycles. While reduced rainfall affects water storage, high-intensity rainfall will cause increased storm runoff.

The extreme rain in Kerala impacted the urban areas due to water dispersion system issues in cities and the entry of floodwaters into rivers, as the rivers have lost most of their water-retaining wetlands and channels in the floodplains.

The State experienced three consecutive floods and landslides in 2018, 2019, and 2021. Kerala received the highest summer rain in 2021, the best summer rainfall in 60 years. The highest-ever summer rain in the State was 915.2 mm in 1933, followed by 750.9 mm so far this year. This increase in rainfall is primarily due to the changing climate in the region, and the cyclones Tauktae and Yaas which formed in the Arabian Sea and the Bay of Bengal, respectively, contributed towards increased rainfall. The heavy downpour in Kerala in August 2018 that caused massive floods and destruction was categorized as the heaviest in the last nine decades.

All these events were triggered by the extreme rainfalls in the state, a direct indication of the changing climate in the region. The Kerala State Planning Board appointed an expert committee to examine the causes of and appropriate policy responses to repeated extreme heavy rainfall events and subsequent floods and landslides. The committee recommended the need for increasing the capability and potential for accurate forecasting of such events with sufficient lead time; reviewing indicators and methods to locate areas prone to severe landslides during such extreme events and remedial measures to minimize such hazards and their consequences; studying current maps of areas prone to flood hazards and remedial measures to minimize such hazards; and paying particular attention to the role of changing land use in these hazards. The emerging issues related to climate change warrant better management of rivers and their floodplains, wetlands, and coastal zones to ensure the ecosystem services rendered by these systems.

According to the IPCC report, the rising sea level is expected to adversely affect the coastal regions of Kerala and islands worldwide. The impacts will vary depending on the topography of the land and its susceptibility to flooding. Some low-lying coastal regions of Kerala will experience more frequent flooding or even permanent inundation. Large areas of Kerala's coastal regions are slightly above sea level, making them more vulnerable to even a small increase in sea level. Higher sea levels will accelerate the erosion of beaches and other coastal terrain. Salty water will intrude further inland in estuaries and brackish marshes, altering ecosystems.

A probable increase in "compound" extreme events is foreseen, where one type of weather disaster feeds into and intensifies another. Tropical cyclones may form more frequently in places close to the Kerala coast where they had not before. The rise in sea surface temperature (SST) and ocean heat content makes the north Indian Ocean, especially the Arabian Sea, a potential breeding ground for frequent and intense cyclonic systems. The average system count over the Arabian Sea has increased from 2 to 3 during recent decades.

Evidently, the intensity of cyclonic systems has increased in recent decades, along with the number of cyclones. Latest studies suggest that the recent increase in the frequency of extremely severe cyclonic storms over the Arabian Sea during the post-monsoon season is due to anthropogenic influence rather than natural variability. It is also reported that dynamical and thermodynamic factors over the Arabian Sea are becoming favourable for producing more cyclones during the pre-monsoon season as well in recent epochs.

The onslaught of flash floods induced by mesoscale "mini cloudburst" events has proliferated in Kerala, as evidenced by the back-to-back events during 2019, 2020, and 2021. Extreme weather events are taking place around the world and will only become more common as a result of climate change. Flash floods and landslides are the manifestations of an accelerating pattern of extreme weather in Kerala in response to global warming. Wetlands are the "shock-absorbing" region of any river course.

The SilverLine rail passes through 202.82 km of floodplains, affecting 1,500 acres in the 30 m zone and 9,960 acres in the 200 m impact zone. About 500 underpasses and 500 bridges will block the natural free flow of floodwater in the western sides of Kerala if not properly designed. SilverLine embankments and cuttings pass through about 1,050 acres, viaducts pass through 354 acres, and bridges will come in 73 acres of wetlands. The cumulative impacts will be detrimental to flood water management in the future, especially in the context of extreme weather events.

The irreversible loss of 1,94,585 metric tons of green biomass in the 30 m impact zone will contribute to climate change impacts. Further loss of biomass will occur during the construction stage, including the construction of access roads, facilities for labourers, and storage space for construction materials and machinery. Clearing vegetation for earth and rocks will also contribute to biomass loss. The development of new townships invariably paves the way for more heat islands, which will also contribute to climate change. The removal of green biomass has a detrimental impact on carbon sinks and consecutively affects the ability of local ecosystems to absorb and trap atmospheric CO_2 through photosynthesis.

There will be significant emissions of gases like CO_2 and other CHGs during the construction stage due to the machinery in use, the running of vehicles to transport workers, materials, and pieces of machinery, and operations at the extraction sites of natural resources like granite and soil for construction purposes. The impact during the five-year construction period needs to be worked out with modelling studies when the detailed project report (DPR) is revised with projections for extensions in the completion target.

The generation of dust, smoke, and other aerosols will be significant during the 5-year construction period, as per the Detailed Project Report (DPR). This will add to the aerosol loading in the atmosphere. The cumulative impact may be further extended if the construction period is extended, which is expected. However, the impact will not be significant during the operational stage.

Energy conservation also paves the way to reduce the carbon footprint. Energy consumption for built-up structures like stations, depots, roll-on/roll-off (RORO) stations, maintenance depots, and ballast depots is not available in the DPR. Details of the energy consumption of each of these built-up structures must be worked out with the design details of these structures. Details of measures proposed to minimize energy consumption are also missing. Measures proposed to minimize energy consumption must be provided. There should be sufficient measures for using energy-efficient processes for the extraction of natural resources, including stones and other materials required for construction. No details are available on this in the DPR. Similarly, details on the use of recycled materials for construction, which could reduce the carbon footprint, should also be included in the DPR.

The recent Intergovernmental Panel on Climate Change's (IPCC's) Sixth Assessment Report (AR6) was released at a time when record-breaking extreme events are being reported from most parts of the globe. The planet's average surface temperature has increased by about 1.1 degrees Celsius compared to the pre-industrial baseline period of 1850–1900. Warmer temperatures allow the atmosphere to hold more water vapor. It is estimated that for every 1-degree increase in temperature, atmospheric water availability increases by 7%, leading to heavier rainfall and faster runoff. Extreme precipitation in humid regions increases with global warming (6.31%/K). Since extreme precipitation amplification can lead to an increase in the frequency and intensity of floods, reducing floodplain area through massive construction will increase flood impacts and recurrent economic losses to the state during heavy floods, as experienced since 2018. The number of weather-related disasters worldwide has increased by a factor of five over the past 50 years, and each disaster costs more, as economic losses have increased sevenfold between 1970 and 2010.

The impact of SilverLine construction activities and associated landscape fragmentation on the fragile land and water environment, compounded by climate change-induced effects such as amplified extreme precipitation and increased frequency and intensity of floods, must be accounted for in the DPR before proceeding with the project.

3.5.6. Hazard vulnerability

The State's geographical location, weather patterns, and high population density make it prone to severe natural and human-induced disasters. Kerala is more vulnerable to natural and anthropogenic hazards than other states in India due to its high population density and the higher value of property and assets in its households. Kerala is prone to natural hazards such as floods, droughts, lightning, landslides, earthquakes, and coastal erosion.

A mesoscale mini cloudburst event occurred over Kerala on August 8, 2019. The west coast of India is prone to massive flooding from both moderate to high intensity rain spells that follow a prolonged wet period and events such as cloudbursts, which pour enormous amounts of precipitation in a very short period. This suggests that a prolonged or intense spell of surplus rainfall during the months that follow a normal June monsoon has a high potential to produce flooding near the river basins of Kerala.

202 kilometers of the flood-prone area will be affected by construction, resulting in the loss of 607.68 hectares of fertile floodplain area due to the 30 m width of the rail segment and the impact on an additional 4,033.76 hectares within a 200 m impact zone. Only 101 kilometers of the stretch are covered by a viaduct and bridge to ensure uninterrupted flood flow, meaning that the remaining 101 kilometers will block storm waters and affect considerable areas in the upstream. A modelling study is required to estimate the height, temporal, and spatial coverage of floodwaters caused by the embankments. The extreme rainfall events predicted as part of climate change could further increase the risk in the adjacent areas.

Climate change and the increased frequency and intensity of extreme weather events add a new dimension to hazards like floods and landslides. Interruptions caused by numerous streams and other flow channels in the east-west direction modify the runoff and may enlarge the flooding area. Many lineaments are also interfered with by the rail and embankment system, which will also increase flood levels and area of spread. There are many areas with slopes from 10 to 20 degrees, which may increase the chance of landslides. There is a need for hazard mapping with respect to floods and landslides in and around the regions through which the SilverLine passes, giving due consideration to drainage blockages and extreme weather events expected with climate change. Based on this, a detailed management plan to manage flooding may be included in the DPR.

Table 3.26. Flood plain length and area, flood incidents, historical reasons for waterlogging, other flood-related vulnerabilities.

District/UT	Length (KM)	Area -Buffer type Hectares	
		30 m	200 m
Thiruvananthapuram	9.111	27.439	191.44
Kollam	13.888	41.01	261.01

Pathanamthitta	8.153	24.545	169.162
Alappuzha	7.467	22.09	138.807
Kottayam	16.981	50.808	340.747
Ernakulam	27.972	83.92	571.707
Thrissur	37.265	111.791	744.855
Malappuram	18.858	56.633	395.351
Kozhikode	13.718	41.364	283.002
Kannur	24.722	74.198	485.835
Kasaragod	24.693	73.881	449.384
Mahe			2.458
Total	**202.828**	**607.679**	**4033.758**

Table 3.27: the length and Area of flood plains under each project activity of SilverLine

Area of Proposed Activity in Floodplains (Hectares)				
Bridges	**Cut & Cover**	**Embankments / Cuttings**	**Tunnels**	**Viaducts**
73.892	**20.02**	**1050.600**	**4.062**	**354.098**

To conclude, the data collected from the field, secondary data, and GIS data sets show that the proposed semi-high-speed rail track will cut across all important geological features of Kerala, except the mountainous region of the Western Ghats. The rail will pass through all sensitive ecosystems and habitats of many threatened and native animal and plant species. It will cross rivers or streams 48 times, including multiple crossings, and pass through 202.82 km of floodplain areas with a history of flood levels up to 15 meters.

As a linear infrastructure, the area of direct impact in many ecosystems may seem small, but it is significant as it will fragment almost all kinds of ecosystems, including wetlands and other water bodies. Climate predictions show that the rail is proposed through a highly climate-vulnerable region with a high susceptibility to frequent floods and water logging.

The project will pass through the habitat of 47 IUCN-threatened fishes, of which 37 will face serious threats and 10 will be partially affected. It will also pass through several Key Biodiversity Areas.

The removal of a large quantity of green biomass during the construction phase suggests that the project will not reduce carbon emissions as projected.

A close look at the published DPR revealed its inadequacy in assessing the magnitude of the project's impact.

The social, economic, and cultural characteristics of the region through which the rail will pass, including land use patterns, are elaborated in the next chapter.

Chapter IV: Socio-Economic aspects

This chapter discusses the socio-economic characteristics of the region through which the proposed SilverLine passes and the possible impacts. It summarizes the data collected on land use, built-up structures, public amenities and services, public utility spaces, and social and cultural amenities that fall within the proposed SilverLine track. The data for each characteristic are presented under different sections: built-up environment, social amenities, services, economic conditions, and sociocultural characteristics.

Largely, the SilverLine project runs through the State of Kerala, cutting across all the coastal districts and the midlands of Kottayam and Pathanamthitta. The project directly affects people across these districts, representing a cross-section of the Kerala population, excluding the high-altitude mountains. 67% of the land area under the proposed project is under the jurisdiction of Gram Panchayats, 15% under municipalities, and 18% under various corporations. 33% of the project area is in urban conglomerates. This indicates that the project affects both rural and urban populations of the state. Land acquisition and relocation will displace these communities from their residences and livelihood options, disrupting all social and cultural networks that they are part of.

Demographically, the SilverLine project area is home to a diverse mix of urban, semi-urban, and rural communities. As a result, the livelihoods of people along the track vary widely, from farming to all other sectors of the economy. The land use pattern of the proposed track also varies, including multiple farming operations such as paddy cultivation, built-up areas such as human habitations, marketplaces, institutions, and various kinds of services, as well as small and cottage industries and small business enterprises that provide livelihoods for people.

The study considered the buildings and infrastructures that were developed by humans as the built environment. In that sense, this section explains the possible loss of different categories of buildings that fall on the proposed 30 m rail track (20 to 25 meters is the width of the rail line, and 2.5 meters on either side is included in the calculation considering the base of embankments). The section further details the number and category of buildings that fall beyond the 30-meter zone in the 85-meter zone on either side of the rail track.

As per the EIA report submitted by KRDCL, a 500 m zone on either side of the proposed SilverLine track has been considered as the zone of influence (*section 3.1, page 34 of the EIA report*). Buildings and other institutions situated within the 500 m buffer zone will experience direct and indirect impacts of noise pollution, jerking, water logging, and social disturbances. The construction of the rail and its approach roads will disrupt the connectivity and movement of people for different services and daily livelihood options.

4.1. Built-up structures

The present study considered the impact of built-up structures, both private and public buildings, along the track in the 200 m buffer zone (100 meters on either side of the track). The possible impacts to both groups are highlighted separately in Tables 4.1 and 4.2. Although the number of units (buildings) is given in the tables, the size, number of rooms, and number of floors were not calculated, as data on the size and number of floors of the buildings were not collected. However, these parameters are being calculated using the available secondary data.

Table 4.1 shows the number of houses, flats, commercial buildings, and other private and public buildings that fall along the rail alignment and within the 30 m (15 m on either side of the track), 50 m (25 m on either side of the track), and 200 m (100 m on either side of the track) impact zones. A total of 7,409 houses, 33 flats, 454 commercial buildings, and 173 other private and public buildings will be completely demolished for the construction of railway lines. The number of buildings that have to be demolished for dumping yards, stations, service roads, and labour short-stay services has not been calculated in this study.

Table 4.1. Total built-up private and public buildings in 30 m, 50 m and 200 zone

Category	**Houses (No.)**			**Flats (No.)**			**Other Private Buildings (No.)**			**Commercial Buildings (No.)**			**Other Public Buildings (No.)**		
Impact zone	**30 m**	**50 m**	**200 m**	**30 m**	**50 m**	**200 m**	**30 m**	**50 m**	**200 m**	**30 m**	**50 m**	**200 m**	**30 m**	**50 m**	**200 m**
Total number	**7409**	**10362**	**50926**	**33**	**51**	**286**	**110**	**169**	**424**	**454**	**621**	**3366**	**63**	**105**	**424**

The Table 4.2 shows district-wise data of buildings that are directly and indirectly affected by the project. This implies that the K-Rail – SilverLine project will displace around 8,000 families and disturb the residences of more than 50,000 families. The project will affect more than 4,000 commercial buildings in the state. These buildings, coming under different categories, have to be demolished and rebuilt, which will double the burden on the state and public finances. The DPR does not provide details of debris utilisation or management.

4.2. Built-up structures – financial impact

A study of apartments in Kerala conducted by the Kerala government in 2011 (https://townplanning.kerala.gov.in/wp-content/uploads/2018/12/apartments_survey-2011.pdf) found that the maximum number of apartments (40%) have 5-10 floors, and most apartments (34%) have a plinth area between 400 and 600 square meters. Of the 1,032 apartments reported in the State at the time, 30% have a built-up area in the range of 2000-4000 square meters. The state average of dwelling units (ie flats) in apartments is 35, according to the 2011 survey. Therefore, the 33 flats falling right in the SilverLine track will evict no fewer than 1,155 dwelling units or families and demolish built-up areas of flats no less than 99,000 square meters.

The Kerala Government's 2011 report on housing conditions in the State states that 68% of dwelling units in rural and 64% in urban areas have an average plinth area of 75 square meters. Therefore, the total built-up area of houses to be demolished will be 5,55,675 square meters. A total of no fewer than 6,54,675 square meters of built-up residential structures will be demolished. The current construction rate in Kerala ranges between INR 2,200 and INR 3,500 per square foot. Considering an average of INR 2,850 per square foot, the demolition loss of residential structures alone in monetary terms would be around INR 2,007 crores.

Apart from these, 564 private and commercial buildings along the rail will be demolished and 3,788 commercial buildings in the 200 m zone will be affected. According to data from the field, the average number of business units in a commercial building is 20. Therefore, at least 60,000 business units in the state will be affected by the project. The plinth area of these buildings and public buildings has also not been calculated.

The State Urbanisation Report of Kerala, published in 2012, reports a two-fold decadal increase in townships and a six-fold increase in urban centers in Kerala (Government of Kerala 2012). The report also predicts that this trend will continue in the future. The proposed SilverLine track connects almost all of the urban agglomerations and urbanization corridors identified in the report. Therefore, the damage caused by the construction of the SilverLine will be significant, considering the growth that has occurred in Kerala in the last decade.

The Table 4.3 shows the details of the affected built-up areas.

Table 4.2. Built-up private and public buildings affected/demolished (district-wise)

No	District	Houses (No.)			Flats (No.)			Other Private Buildings (No.)			Commercial Buildings (No.)			Other Public Buildings (No.)		
		30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m
1	Thiruvananthapuram	827	1083	4778	0	2	23	8	15	36	37	50	302	8	13	36

2	Kollam	944	1062	4353	1	1	2	0	0	7	46	44	168	2	2	7
3	Pathanamthitta	127	204	920	0	0	0	2	2	9	18	14	49	1	2	9
4	Alappuzha	165	252	966	0	0	0	4	5	5	6	11	39	2	2	5
5	Kottayam	434	697	3070	0	0	4	1	6	7	11	17	78	1	1	7
6	Ernakulam	371	567	2608	0	0	10	4	7	25	26	35	181	3	8	25
7	Thrissur	929	1403	6328	1	2	47	6	11	30	65	106	457	7	8	30
8	Malappuram	655	998	5638	2	4	23	10	12	26	24	34	406	7	12	26
9	Kozhikode	1240	1850	10742	16	24	102	35	55	123	95	145	803	19	30	123
10	Mahe	18	23	75	0	0	0	0	0	0	0	0	0	0	0	0
11	Kannur	1102	1416	6808	12	17	39	15	20	63	113	123	650	7	15	63
12	Kasargod	597	807	4640	1	1	36	25	36	93	29	42	233	6	12	93
	Total	**7409**	**10362**	**50926**	**33**	**51**	**286**	**110**	**169**	**424**	**470**	**621**	**3366**	**63**	**105**	**424**

Table 4.3 describes the total estimated plinth area of buildings to be demolished/affected as part of the rail construction in 30 m and 200 m buffer zones. The plinth area of the built-up area is estimated in acres by adding the plinth area of houses, institutions, the airport, schools, bus stands, townships, power stations, workshops, industries, housing colonies, flats, public and private buildings, churches, temples, mosques, stadiums, and other public/private buildings. Fifty percent of the settlement area of settlements is considered the built-up area of houses. Therefore, the total plinth area of residential units and other buildings to be demolished for the project is 1,486.77 acres or 64,763,701.20 square feet.

The current construction rate in Kerala ranges from INR 2,200 to INR 3,500 per square foot. Considering an average of INR 2,850 per square foot, the average monetary value of the total residential and other buildings to be demolished as part of this project will be around INR 18,000 crores at the current rate of construction.

The rate of construction of roads in Kerala varies from INR 1.8 crore per kilometer to INR 10 crore per kilometer. According to this, the average demolition loss of roads by this mega project will be INR 300 crores.

Table 4.4 gives district-wise area details of other built-up structures.

Table 4.3. Built-up Area Consolidated (in Acres)

No.	Category	30 m (Acres)	200 m (Acres)
1	Settlements	957.36	6943.45
2	Other built-ups	529.41	3929.81
Sub Total (Total Built-up area)		**1486.77**	**10873.26**
3	Linear infrastructure	236.21	1253.70
4	Canals	7.72	64.25
	Total	**1730.70**	**12191.21**

Table 4.4. Total Other built-up area estimate district-wise (in acres)

No.	District	30 m (Acres)	200 m (Acres)
1	Thiruvananthapuram	58.66	397.51

2	Kollam	43.46	310.29
3	Pathanamthitta	9.50	71.23
4	Alappuzha	11.74	75.98
5	Kottayam	37.79	266.93
6	Ernakulam	40.84	322.12
7	Thrissur	56.61	440.21
8	Malappuram	36.02	300.95
9	Kozhikode	115.15	848.56
10	Mahe	1.22	6.59
11	Kannur	62.37	492.70
12	Kasaragod	56.05	396.74
	Total	**529.41**	**3929.81**

Table 4.5 shows the total number of buildings that will be demolished to develop this project and fall within the immediate impact zone of the project. It shows that 2,954 houses will be 20 meters away from the rail track and 43,517 houses will be 85 meters away from the rail track after its construction. A total of 8,085 buildings fall in the 30 m buffer zone, and 55,426 buildings fall within the 200 m buffer zone. These buildings include houses, flats, facilities and services, institutions, and cultural amenities.

The impact of high-speed rail on a densely populated region like Kerala needs to be worked out, for which more details are required. The DPR does not specifically say about any relocation package for people in this region. There is high uncertainty regarding the future of people living here.

Table: 4.5. Built-up structures (in Numbers) - Consolidated

No.	Category	Buffer Zone		
		30 m (No.)	50 m (No.)	200 m (No.)
1	Houses	7409	10362	50926
2	Flats	33	51	286
4	Facilities and services	786	1131	62000
5	Institutions	74	134	592
6	Cultural	166	271	1148
	Total	**8468**	**11949**	**114952**

4.3. Social Amenities and Infrastructure

Social amenities and infrastructure categories include all built-up structures that are beneficial to people as social amenities and infrastructure. These assets, both private and public, are used for common and individual purposes. This section explains the amount and nature of common and private facilities that will be affected by the construction of the K-Rail – SilverLine project.

The data on social amenities and built structures are presented in both numbers and areas. Settlements and homesteads include both built-up houses and the vegetative homesteads around them. The area is calculated using geospatial tools by drawing polygons. The Table 4.6 shows the district-wise area of settlements and homesteads in acres. A total of 387.29 hectares (957 acres) of homesteads will be completely demolished within 30 meters of the railway line. 2,098.78 hectares (5,186.10 acres) of homesteads fall within 85 meters on either side of the rail. The project will also have indirect effects such as fragmentation, isolation, and loss of social amenities and connectivity, which are not considered in the compensation packages. The table illustrates district-wise data on settlements falling within the 30 m and 200 m buffer impact zones.

The Tables 4.4 and 4.5 show the total area of built up that will be demolished fully or partially during the construction of the project.

4.3.1 Transport

Public infrastructures are public utility buildings built with public funds. They include bus stops, bus stands, KSRTC garages, workshops, and other public utility buildings related to transportation. There are 50 bus stops, 7 bus stands, 2 KSRTC garages, 137 workshops, and 298 other buildings related to transportation within the 200 m buffer zone of the rail. The corresponding numbers in the 30 m buffer of the rail track are 5, 0, 0, 22, and 43, respectively. Table 4.6 shows the district-wise details of such infrastructure.

Table 4.6. Built up - Public infrastructures (in numbers)

No	District	Bus Stop (No.)			Buss Stand (No.)			KSRTC Garages (No.)			Workshops (No.)			Any other Built up (No.)		
		30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m
1	Th'ananthapuram	0	0	7	0	0	0	0	0	0	2	4	6	8	13	39
2	Kollam	0	0	0	0	0	1	0	0	0	4	4	12	3	4	20
3	Pathanamthitta	1	2	2	0	0	0	0	0	0	0	0	2	1	2	7
4	Alappuzha	2	3	4	0	0	0	0	0	0	2	2	4	1	2	3
5	Kottayam	0	0	2	0	0	0	0	0	0	0	1	3	4	7	14
6	Ernakulam	0	0	9	0	0	1	0	0	0	4	7	14	6	8	33
7	Thrissur	0	0	3	0	1	1	0	0	0	3	4	32	2	3	26
8	Malappuram	0	0	0	0	0	1	0	0	0	0	3	12	1	4	11
9	Kozhikode	0	1	13	0	0	0	0	0	1	6	9	27	14	21	96

11	Kannur	1	3	4	0	0	3	0	1	1	1	1	13	2	6	26
12	Kasaragod	1	1	6	0	0	0	0	0	0	0	1	12	1	2	23
	Total	**5**	**10**	**50**	**0**	**1**	**7**	**0**	**1**	**2**	**22**	**36**	**137**	**43**	**72**	**298**

4.3.2. Public Institutions

Public amenities such as post offices, village offices, panchayat offices, ration shops, and Akshaya centers are considered public institutions. Table 4.7 illustrates the number of such public institutions that are directly and indirectly affected by the project. Because the construction of the rail line and its approach roads will disrupt the entire road network in the area, and considering the operational impact of the rail in the vicinity, these institutions cannot continue to operate here.

Table. No: 4.7. Other Public Institutions (in numbers)

	Post office (No.)			Village office (No.)			Panchayath office (No.)			Ration shop (No.)			Akshaya Centre (No.)		
Impact Zone	**30 m**	**50 m**	**200 m**	**30 m**	**50 m**	**200 m**	**30 m**	**50 m**	**200 m**	**30 m**	**50 m**	**200 m**	**30 m**	**50 m**	**200 m**
Total	**2**	**4**	**13**	**1**	**3**	**15**	**2**	**2**	**7**	**4**	**5**	**13**	**7**	**10**	**51**

4.3.3. Financial Institutions

Banks, cooperative financial institutions, other cooperative institutions, and ATMs, etc. considered as financial institutions for the study. They are surveyed and marked along the proposed railway line during the study. There are 38 banks, 31 cooperative financial institutions, 24 other cooperative institutions, and 8 ATMs within the 200 m buffer zone of the proposed track. The corresponding numbers in the 30 m buffer zone are 4, 4, 1, and 0, respectively (Table 4.8).

Table: 4.8. Financial Institutions (in numbers)

No.	District	Banks (No.)	Cooperative finance institutions (No.)	Other co-operative institutions (No.)	ATMs (No.)

		30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m
1	Th'ananthapuram	0	1	11	1	1	7	0	1	5	0	0	0
2	Kollam	0	0	1	0	0	0	0	0	3	0	0	1
3	Pathanamthitta	0	0	2	0	0	1	0	0	0	0	0	0
4	Alappuzha	0	3	2	0	0	0	0	0	3	0	0	0
5	Kottayam	0	0	2	0	0	3	0	0	2	0	0	0
6	Ernakulam	0	0	0	0	2	3	0	0	1	0	0	0
7	Thrissur	0	0	2	0	0	1	0	0	1	0	0	0
8	Malappuram	0	0	1	1	1	1	1	1	2	0	0	2
9	Kozhikode	3	4	10	2	5	10	0	2	3	0	0	1
11	Kannur	1	2	3	0	0	2	0	0	2	0	0	2
12	Kasargod	0	0	4	0	0	3	0		2	0	0	2
	Total	**4**	**10**	**38**	**4**	**9**	**31**	**1**	**4**	**24**	**0**	**0**	**8**

4.3.4. Health Infrastructure and Facilities

The proposed railway project will impact approximately 105 health facilities both in the private sector and the public sector, including district hospitals, taluk hospitals, public health centers, speciality private hospitals, and non-speciality private hospitals. Within the 85-meter buffer zone on either side of the railway line, there are eight district hospitals, eight taluk hospitals, 17 public health centers, 25 specialty private hospitals, and 25 non-speciality private hospitals."

Table 4.9. Health Infrastructure and facilities

No.	District	District hospitals (No.)			Taluk Hospitals (No.)			Public health Centres (No.)			Private Speciality hospitals (No.)			Private non-speciality hospitals (No.)		
		30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m
1	Th’ananthapuram	0	0	0	0	0	2	0	0	2	0	0	2	0	1	3
2	Kollam	0	0	2	0	0	0	0	0	1	0	0	1	0	0	2
3	Pathanamthitta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Alappuzha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Kottayam	1	1	1	0	0	1	0	0	1	0	0	1	0	0	0
6	Ernakulam	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
7	Thrissur	0	0	2	0	0	1	0	0	2	3	3	3	0	0	1
8	Malappuram	0	0	0	0	0	0	0	0	2	2	2	4	0	0	2
9	Kozhikode	0	0	3	1	2	2	0	0	7	0	0	4	0	0	6
11	Kannur	0	0	0	0	0	1	0	0	0	1	1	5	0	1	3
12	Kasaragod	0	0	0	0	0	1	0	0	1	0	2	5	0	1	6

	Total	**1**	**1**	**8**	**1**	**2**	**8**	**0**	**0**	**17**	**6**	**8**	**25**	**0**	**3**	**25**

4.3.5. Education Institutions

The details of education institutions falling within the railway line and situated in the immediate and indirect impact zones are provided in Table 4.10. A total of 325 education institutions, including universities, colleges, government and aided schools, unaided schools, day-care centers, Anganwadis, and pre-primaries, are located within the 200 m buffer zone. Government and aided schools and Anganwadis are the most affected categories. While institutions beyond 30 meters are not eligible for compensation packages, it is difficult to envision how schools and anganwadis can function effectively within 100 meters of the semi-high-speed rail service.

Table 4.10. Education Institutions

	Education institutions	**30 m (No.)**	**50 m (No.)**	**200 m (No.)**
1	University Centres/ Colleges	1	2	23
2	Govt and aided schools	11	17	107
3	Unaided schools	9	18	54
4	Day-care centres	2	3	9
5	Anganwadis	18	31	116
6	Pre-primaries	1	2	15

The Table 4.11 shows district wise data about the education institutions that will be affected by the project.

Table 4.11. Education Institutions - District wise

	Education	University Centres and Colleges (No.)			Schools govt and aided (No.)			Schools unaided (No.)			Day care Centres (No.)			Anganwadis (No.)			Pre-Primaries (No.)		
	District	**30 m**	**50 m**	**200 m**	**30 m**	**50 m**	**200 m**	**30 m**	**50 m**	**200 m**	**30 m**	**50 m**	**200 m**	**30 m**	**50 m**	**200 m**	**30 m**	**50 m**	**200 m**
1	Thiruvananthapuram	0	0	0	0	0	26	1	4	9	0	1	3	2	2	9	1	2	5
2	Kollam	0	0	1	0	0	0	0	0	4	0	0	0	2	4	9	0	0	0
3	Pathanamthitta	0	0	0	0	0	0	0	0	1	0	0	0	0	1	3	0	0	0
4	Alappuzha	0	0	0	0	0	0	2	4	4	0	0	0	0	1	2	0	0	1
5	Kottayam	0	0	5	0	0	5	1	3	5	0	0	0	0	2	19	0	0	1
6	Ernakulam	0	0	0	0	0	6	0	0	3	1	1	1	2	3	6	0	0	0
7	Thrissur	0	1	4	1	1	9	2	2	6	0	0	1	3	4	12	0	0	5
8	Malappuram	0	1	9	0	1	6	0	0	3	0	0	0	1	2	7	0	0	1
9	Kozhikode	0	0	0	5	9	30	3	4	11	0	0	1	6	9	31	0	0	2
11	Kannur	0	0	2	4	5	9	0	1	5	1	1	1	2	2	6	0	0	0
12	Kasaragod	0	0	2	1	1	16	0	0	3	0	0	2	0	1	12	0	0	0

	Total	**0**	**2**	**23**	**11**	**17**	**107**	**9**	**18**	**54**	**2**	**3**	**9**	**18**	**31**	**116**	**1**	**2**	**15**

4.3.6. Cultural Institutions

Cultural institutions are categorised as temples, mosques, churches, stadiums, sports centers, cinema halls, community centers, libraries, and clubs. Table 4.12 provides an overview of the cultural amenities that will be impacted by the rail project. The total number of cultural infrastructures within the rail line and its immediate impact zones demonstrates that the rail project will affect the cultural lives of people from all walks of life. As these infrastructures are demolished or rendered unusable, they will have to be permanently written off.

Table 4.12. Cultural Institutions

No	Cultural institutions	30 m (No.)	50 m (No.)	200 m (No.)
1	Temple	54	92	381
2	Mosque	29	40	164
3	Church	9	20	91
4	Stadiums	3	6	31
5	Sports Centres	2	6	25
6	Cinema halls	0	0	5
7	Community centres	6	9	31
8	Libraries	11	14	60
9	Clubs	9	12	62

Table 4.13A & 4.13B show the district-wise data of different cultural infrastructures that will be affected by the rail project.

Table 4.13A. District-wise details of different cultural infrastructures

District	Temple (No.)			Mosques (No.)			Church (No.)			Stadiums (No.)		
	30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m
Thiruvananthapuram	8	11	51	2	3	34	0	0	5	0	0	4
Kollam	7	12	33	0	0	0	0	0	5	1	2	2
Pathanamthitta	1	2	6	0	0	0	0	1	5	0	0	0
Alappuzha	2	2	6	0	0	0	0	1	4	0	0	2
Kottayam	2	3	14	0	0	0	3	9	24	0	0	7
Ernakulam	4	7	19	0	0	1	2	3	17	0	0	0
Thrissur	8	13	64	4	5	12	2	3	18	0	0	2
Malappuram	5	9	17	9	11	13	0	0	0	0	0	0
Kozhikode	11	17	71	9	11	56	0	0	6	1	1	6
Mahe	0	0	0	0	o	0	0	0	0	0	0	0
Kannur	1	9	43	3	4	24	0	1	3	1	1	4
Kasaragod	5	7	57	2	6	24	2	2	4	0	2	4
Total	**54**	**92**	**381**	**29**	**40**	**164**	**9**	**20**	**91**	**3**	**6**	**31**

Table 4.13B. District-wise details of different cultural infrastructures

District	Sports Centres (No.)			Community Centres (No.)			Libraries (No.)			Clubs (No.)		
	30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m	30 m	50 m	200 m
Thiruvananthapuram	0	1	3	1	1	3	2	2	9	2	2	6
Kollam	0	0	0	0	0	4	0	0	1	0	0	6
Pathanamthitta	0	0	1	1	1	2	0	0	2	0	0	0
Alappuzha	0	0	0	0	0	1	0	0	0			0
Kottayam	0	0	1		1	5	0	0	3	1	1	3
Ernakulam	0	0	2	1	1	1	0	0	1	1	1	4
Thrissur	0	0	0	1	1	3	1	1	1	0	0	6
Malappuram	0	0	0	0	0	1	3	5	4	1	1	5
Kozhikode	0	3	9	1	3	8	3	4	23	1	2	13
Mahe	0	0	0	0	0		0	0		0	0	0
Kannur	0	0	2	0	0	2	1	1	12	2	4	8
Kasaragod	2	2	7	1	1	1	1	1	4	1	1	11
Total	**2**	**6**	**25**	**6**	**9**	**31**	**11**	**14**	**60**	**9**	**12**	**62**

4.3.7. Linear Infrastructure or Transportation System.

The linear infrastructure includes roads and railway lines. The survey details show that 22 km of district roads, 49 km of panchayat roads, 3 km of state highways, 7 km of national highways, and parts of existing railway lines are located within the 30-meter buffer zone. In the 200-meter buffer zone, these numbers are 140 km, 316 km, 39 km, and 64 km respectively (Table 4.14). This will disrupt the entire existing transportation system in the region, requiring the reconstruction of roads and underpasses, along with approach roads. The cost and natural resources required for this restructuring are not included in the total project cost, which will be an additional financial burden for the state.

Based on existing construction rates for different types of roads in Kerala, the estimated demolition cost of roads alone in monetary terms is ₹236.89 crores. This is calculated only for the 30-meter stretch along the rail line. The actual demolition of roads and the cost of the project will be much higher, as it will disrupt the entire surface transportation system.

Table: 4.14. Linear infrastructure excluding existing railway assets (in km)

No	Linear infrastructure	30 m	200 m	Monetary loss in Crores for 30 m
1	District Road	22.30	140.67	54.63
2	Panchayat Road	49.19	316.28	94.73
3	State Highway	3.21	38.94	9.5
4	National Highway	7.30	64.48	78.03
	TOTAL			236.89

4.4. Social Impact

The social impact of the 530-kilometer high-speed railway line in densely populated Kerala is much greater than in any other part of the globe. According to field data, it will directly demolish 221 housing colonies, 21 small-scale industrial units, 67 small towns, 13 rural marketplaces, 18 townships, 32 industrial units, and 42 other institutions of local economic importance (Table 4.15). The project passes through 12 Scheduled Caste (SC) hamlets in different districts. Additionally, 1396 housing colonies and 64 SC hamlets are located within 85 meters on either side of the proposed railway track, along with more than 700 townships and marketplaces and around 500 industrial or small business units. The development model of large infrastructure projects like K-Rail – SilverLine aim for a new mode of economic development as an impact/benefit of the project's operation. Therefore, the future of these townships and business centers in the vicinity of the project is uncertain.

Table 4.15. Social Impact (in Numbers)

No	Category	30 m	50 m	200 m
1	Housing colonies	221	358	1616
2	Small Scale industrial units	21	32	147
3	Small Towns	67	123	509
4	S C Hamlets	12	21	76
5	Rural marketplaces	13	23	85
6	Town ships	18	31	140
7	Women-led industries	2	3	24
8	Handicraft Units	5	8	16
9	Industrial units	32	47	181
10	Other important institutions	42	74	137

The information gathered from people along the proposed rail line clearly reveals the expected losses from the project. This study attempts to quantify the loss of tangible assets, but the losses also include people's sense of belonging and feeling of home. The project's impact will be felt by the anxiety of people who are forced to relocate from their homes, amenities, and familiar social networks. This study has not attempted to systematically document people's feelings, but the data collectors have reported the anxiety that people are experiencing about the uncertainty of their lives in relation to the project.

4.5. Economic system

The DPR of the K-Rail – SilverLine project claims that this mega project will support the state's economic growth. However, the previous sections have explained the estimated damage to existing amenities, houses, and transportation systems. This section attempts to quantify the direct impacts of the project in monetary terms, but the cumulative impacts are not considered. This section also illustrates the economic systems of the state that will be affected by the project. On the basis of this information, the projected benefits of the project can be assessed.

4.5.1. Agriculture

Even though the SilverLine project is a linear infrastructure that uses 25-30 meters of land, it cuts across all categories of cropping areas in the state, including paddy wetlands, rubber, vegetables, fish farming, pepper, coconut, pineapple, and mixed agriculture (Table 4.16). In addition, the field-level study included a category of thick vegetation, which refers to areas not under current cultivation of any specific crop but covered with thick native vegetation. The data in the table below shows the results from the ground-level study of the area under each crop along the proposed rail line.

The study shows a loss of more than 2,500 acres of paddy, 2,500 acres of rubber, 4,700 acres of mixed agriculture, and 2,400 acres of coconut farms along the rail line. The loss of agricultural land was calculated for both a 30 m buffer zone and a 200 m buffer zone. The 200 m buffer zone was used to assess the impact on agricultural productivity, as it is not possible to maintain the productivity of agricultural land in the vicinity of large-scale construction and operation of the rail line.

The constructions will largely change the ecosystem characteristics of the landscape units, making it impossible to continue growing the current crops in the 200-meter zone, including the rail line. This applies to all principal crops, such as paddy, mixed cropping, vegetables, and coconut.

Table 4.16. Land use agriculture Area in 200 Metres area in acres

District	Paddy (in Acres)	Kaipp-ad / Pokkali (in Acres)	Rubber (in Acres)	Vegetables (in Acres)	Fish Farming (in Acres)	Pepper (in Acres)	Coconut (in Acres)	Mixed Agriculture (in Acres)	Thick Vegetation (in Acres)
Thiruvananthapuram	117.59		363.36	24.93	2.30	5.13	358.05	645.02	17.45

Kollam	113.18	23.00	379.42	8.09	2.80	0.10	78.02	115.11	24.98
Pathanamthitta	130.15		408.58	5.91		0.21	8.57	108.71	
Alappuzha	7.00		223.43	2.75		0.10	7.60	87.02	
Kottayam	184.05		566.90	38.25	0.20	3.40	30.90	301.01	3.70
Ernakulam	402.79	3.00	484.25	29.75	1.00	1.50	7.90	537.07	11.27
Thrissur	673.81		69.70	9.67	7.44	1.50	137.57	1174.80	14.09
Malappuram	490.42			3.33	0.10		308.98	638.37	2.50
Kozhikode	33.97	2.90	5.00	25.30	3.14	0.16	709.00	776.67	9.52
Kannur	123.31	13.00		3.75	3.50	0.20	203.66	126.80	10.20
Kasaragod	224.30	6.31	0.52	15.43	0.10	0.53	632.58	254.35	12.10
Total	**2500.57**	**48.21**	**2501.16**	**167.16**	**20.58**	**12.83**	**2482.84**	**4764.92**	**105.81**

The loss and fragmentation of farmlands along the SilverLine will considerably reduce agricultural productivity in the region and directly affect farmers and agricultural labourers who depend on farming. A calculated active crop area of 1,927 acres along the rail line and 12,498.27 acres in a 200 m buffer zone will be impacted by the project, based on the current cropping pattern. In addition, 235 acres of land that is not currently cultivated in a 30 m buffer and 1,307 acres in 200 m buffer are also reported to be affected. Additionally, 112 acres and 764 acres of cultivable fallow land under the category of wetlands are also coming under the 30 m and 200 m buffer zone, respectively.

The 2021 economic review of the State finds that, *“…. In recent years, the agriculture sector in Kerala has been facing challenges with respect to growth because of risks and uncertainties arising out of variability in climate, fluctuations in commodity prices and constraints in marketing the produce. The Gross State Value Added (GSVA) from agriculture declined from*

12.37 per cent in 2013-14 to 9.44 per cent in 2020-21".

The report also mentions the decline in the area of land used for agriculture due to conversions to non-agricultural purposes. It states that increasing productivity is a strategy to revive agriculture in the state. As a State with a dwindling agricultural sector, the land loss and decline of agro-ecosystems due to this mega infrastructure project will have a greater social and economic impact.

4.5.2. Land use

Demand for land is always increasing due to population growth, changes in lifestyle, and accelerated development activities. Economic concerns and political considerations often dictate how land use changes, with geomorphological sustainability and ecosystem services rarely being considered.

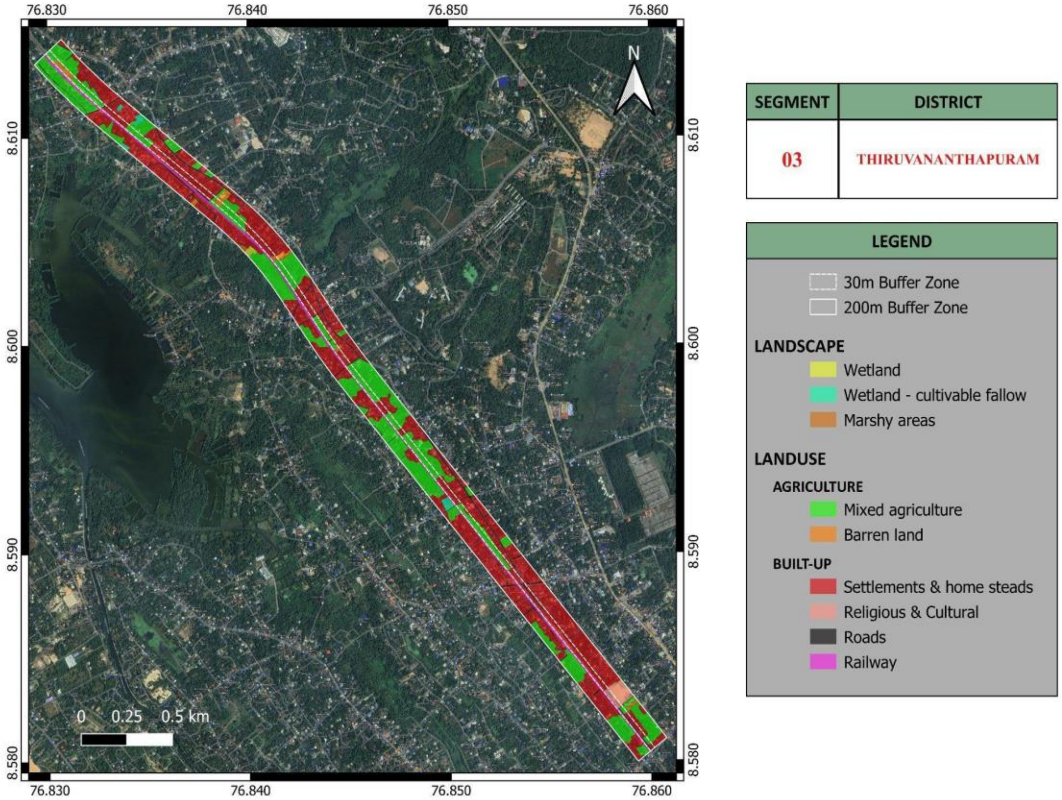
The State's land use has undergone large-scale changes in the past 20 years due to the reclamation of wetlands (including backwaters, ponds, and canals), conversion of paddy lands, rapid urbanisation, dredging/mining of hills, removal of topsoil, fragmentation of landforms, loss of beaches, quarrying, and destruction of mangroves. The impacts are already visible in the form of urban flooding, decreased land productivity, and increased pollution.

The construction activities planned under the SilverLine project, such as embankments, maintenance yards, townships, approach roads, and service roads, may cause substantial changes to the already highly modified geomorphology and ecosystem, and fragment land units.

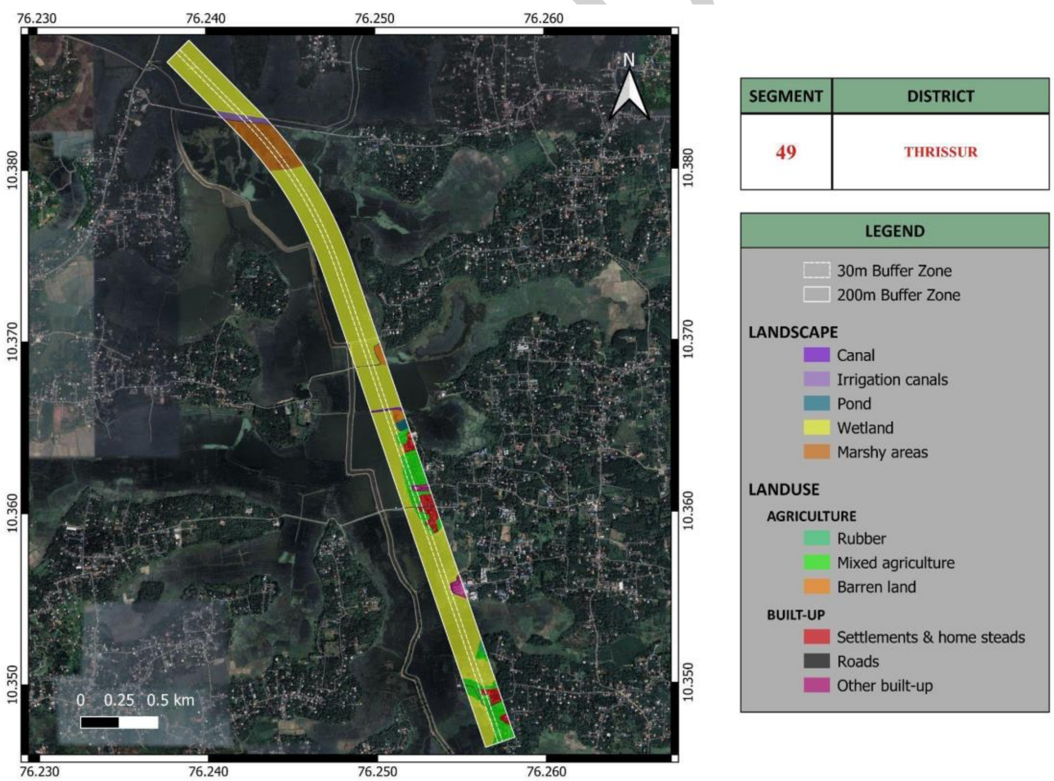
The estimated loss of mangrove forest in the 200 m width segment is 54.91 Ha, river and estuary 151.63 Ha, sacred grove 24.59 Ha, cultivated paddy field 208.84 Ha, cultivable fallow paddy field 248.83 Ha, marshy areas 238.54 Ha, backwater 58 Ha, canal 26 Ha and ponds and chira 23.23 Ha. The total agricultural area falling within the proposed path is 4,103 Ha and built-up area 3,001.25 Ha and for 200 m buffer values are 5057.87 Ha and 4,400.25 Ha receptively. The line passes through 533.23 Ha of barren land (Table 3.1, 3.2 & 4.3). The total agricultural area falling within the proposed path is 861.70 Ha and the built-up area is 601.67 Ha.

The survey reports 470 commercial buildings along the rail line and 3,366 commercial buildings within the 200 m buffer in various sizes. These buildings range from single-room buildings to multi-storied buildings with more than 50 business units. On average, this displaces no less than 60,000 business units in the region. All commercial buildings outside the proposed 30 m buffer will not be covered by the compensation packages.

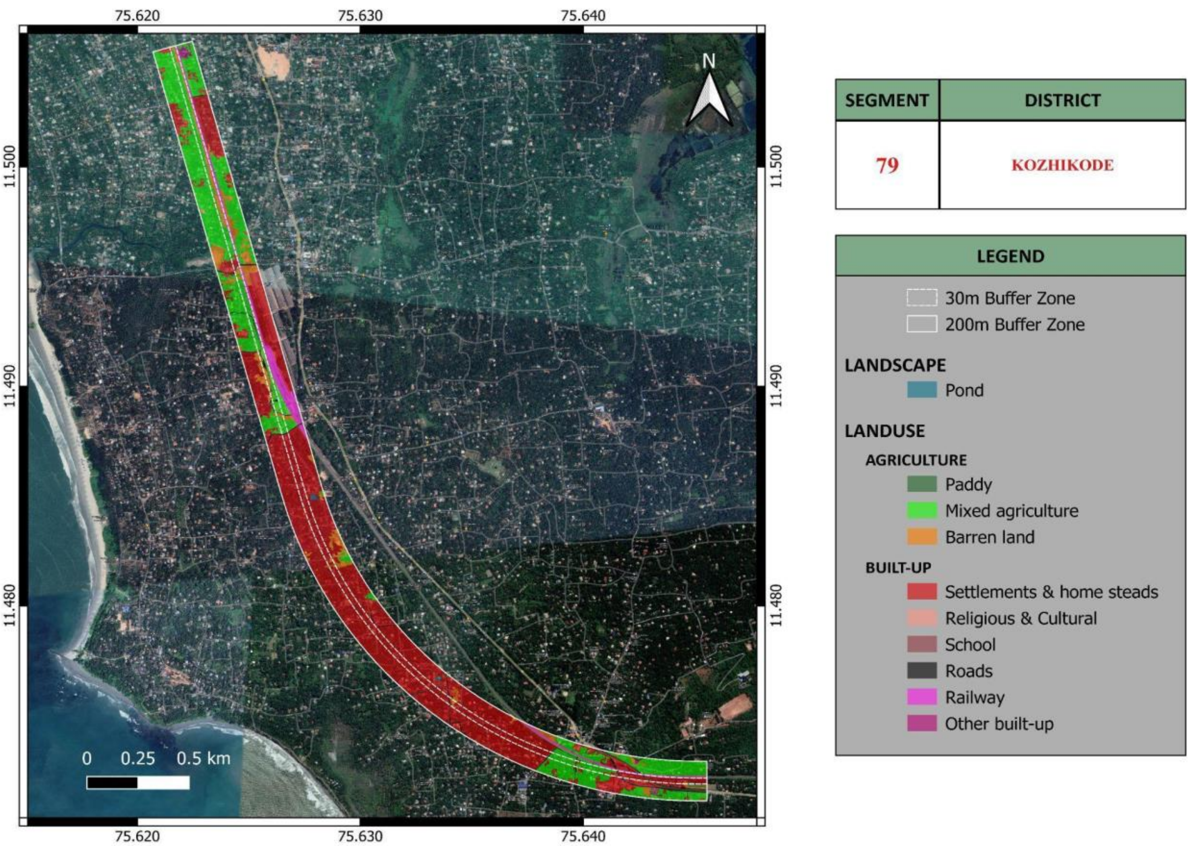
The maps below show examples of the land use and land cover characteristics of the regions through which the SilverLine is proposed to pass.



Map 2.6.1 – Land cover land use characteristics of seg. No.3 of Thiruvananthapuram district



Map 2.6.2 – Land cover land use characteristics of seg. No.49 of Thrissur district



Map 2.6.3 – Land cover land use characteristics of seg. No. 79 of Kozhikode district

As Chen and Vickerman (2019) state in their comparative study on high-speed rails in Europe and the People's Republic of China**;** *"In looking at evidence of the impacts of HSR on different cities, including impacts on the transformation, structural change, and location of new firms, clear differences emerge between Europe and the PRC (People's Republic of China). These suggest potentially important lessons for less developed or transitional economies. Above all, HSR investment needs to be seen as one element in a comprehensive policy of regeneration and transformation; HSR cannot create change on its own". (Chen and Vickerman, 2019)*

The discussions on the economic impact of HSRs in this study and several other studies of this kind say the total economic impact of the HSRs will be different for different economies and societies. So, it is important to understand the economic situation of Kerala and the possible future economic development that the State is planning to understand the impact of the Silverline project on Kerala's economy. As per the State urbanisation report of Kerala published in the year 2012, Kerala is a fast-urbanising state. While comparing the emerging urban conglomerations, the proposed SilverLine project connects almost all the emerging urban centres of Kerala. The same report points to the increasing rate of hierarchy among people living within the emerging urban centres.

The discussions on the economic impact of HSRs in this study and several other studies of this kind state that the total economic impact of HSRs will vary depending on the economy and society in question. Therefore, it is important to understand the economic situation of Kerala and the state's plans for future economic development in order to assess the impact of the SilverLine project on Kerala's economy.

And many other studies from China and Europe *(Chen, C. and R. Vickerman. 2019)* say that the objective or function of HSRS and semi-HSRS in many countries like China is to connect distant and populated urban centres and they pass through less populated rural landscapes. The existing metros and those under construction in India bring the stories of large-scale displacement of people against financial loss and increasing traffic jams in the cities. So the economic advantages that the silver line hemi high-speed rail project's DPR is claiming through increased labour movements and the development of urban centres are critical. It is necessary to assess the actual loss of productive assets and its cumulative impact on the economy to understand the real benefit that can be expected out of the project.

This section of the report details the direct loss of productive assets, production systems such as agriculture, small-scale industries and other present and future livelihood options of the people that can be affected by the project.

The above section gives data on the loss of industrial units 32 and181, small-scale industrial units 21 and 147, handicrafts units 5 and16, women-led industries 2 and 24, small townships 67 and 509, rural market places 13 and 85 and townships 18 and 140 in respective impact zones of 30 metres and 200 metres. It also indicates the number of livelihood opportunities that are going to be replaced or completely affected by the project. As the compensation is again restricted within the 30 m of the direct impact zone, the livelihood units falling in the 200 m immediate indirect impact zone will be unaddressed. The number of displacements and possible livelihood losses due to the project is much higher than the employment opportunity that the project can generate as per the DPR.

This study has not attempted any passenger survey to assess the business model that was given by K-Rail corporation on the SilverLine semi-high-speed rail project. But all existing studies and reviews of similar projects in the country and other countries give ample data to critically look into the DPR and the economic model that it put forward. Analysing the possible loss of productive assets such as agricultural land, livelihood units and public amenities that support the existing economic and social activity of the region it is obvious that the actual cost of the project is much more than the estimated one in the DPR.

Chapter V. The Impact Assessment

Any development project, regardless of its type or magnitude, will have implications for the environment, social, and economic sectors that can be beneficial or adverse. There is potential for enhancing the beneficial impacts and mitigating the adverse impacts. This is achieved by adjusting the project activities, if feasible, and managing the activities through the application of appropriate technologies, if available and applicable. It requires us to predict, understand, and analyze the impacts that are likely to emerge due to the implementation of the project. Predicting impacts involves identifying, evaluating, and assessing their potential. Impact assessment is essentially a cause-effect analysis in which the causative factors are the project activities and the effect is the impact on various environmental, social, and economic aspects of the site where the activities are undertaken and the surrounding impact zone. In this report, we focus on the impact on environmental aspects, including limited social and economic aspects.

The first phase of impact assessment involves identifying the activities planned for the project. The second phase involves identifying the environmental aspects of the site that will be affected by the project activities. The third phase identifies the impacts on various environmental aspects of the site due to the causative factors associated with the project activities. The impacts are categorized as beneficial or adverse, short-term or long-term, and reversible or irreversible. Subsequently, the identified effects or impacts are assessed based on the magnitude and intensity of the planned project activities and the importance of a particular environmental aspect to the overall environmental conditions of the site.

5.1 Project activities

The project activities that are intensive enough to cause environmental impacts are delineated from the project description and discussion with the project proponent. These activities pertain to the planning, construction and operational phases of the project and are listed accordingly. Based on normative evaluation of the detailed project report, the list of activities involved during the planning, construction and operational phases of the project are delineated and given in Table. 5.1.

During the delineation of the project activities, an effort is taken to assess the magnitude and intensity of various activities envisaged in the project. However, due to the data gaps in the detailed project report, it could not be done for many of the project activities. The following are the data gaps identified in the detailed project report.

1. Areas to be filled and width, height and fill materials required for embankments
2. Initial and final levels above MSL after filling flood plains and low-lying and water-logged areas
3. Source and type of fill materials and their storage places

4. Areas to be stripped and locations, volume and quantity of earth to be removed, type of soil and proposal for utilisation of removed topsoil with location of dump site
5. Areas to be cut, depth of cut, locations, soil type, volume and quantity of earth and other materials to be removed with its utilisation plan or location of dump site to be provided
6. Details of proposed alignment stretches passing through a hilly area
7. Details of proposed alignment stretches where there may be land stability issues
8. Details of tunnels and their locations along with geological structural characteristics. Alsoquantity and type of cut material and its utilisation plan or location of the dump
9. Details of micro drainage, flood passages and information on flood periodicity in the flood plains through which the alignment is proposed
10. Details of land proposed to be reclaimed and the locations and quantity of material required for filling
11. Details of locations in the proposed alignment involving migratory path of animals, details about fauna, habitat and period of the year in which activity takes place
12. Details of the locations along the proposed alignment where forest patches, sacred groves, mangrove patches, wetlands, flood plains etc. are located
13. Details of the possible changes in the drainage pattern after the proposed activity
14. Details of the houses and other built structures on either side of the proposed alignment
15. Water requirement during the construction and operation phases
16. Requirement of construction materials
17. Locations and details of places from where the requirement of stones of different types will be accessed
18. Manpower requirements including categorization such as skilled and unskilled etc., during planning, construction and operation phases
19. Locations and details of proposed solar energy installations
20. Details of realistic Project implementation schedule

Therefore, the magnitude and intensity of activities are assigned qualitatively on a scale of 0 to 5, considering the project description.

During the Planning phase, the alignment fixing is mostly done through remotely sensed data. The geotechnical investigation is carried out by drilling 127 boreholes at 5 km intervals, approximately, and at other selected sites. From these spots, selective removal of vegetation is required. The topographical survey is done through Light Detection and Ranging (LiDAR) Survey. The land demarcation and acquisition are envisaged all along the stretch of 530 km of the proposed track and its buffer. The process involves a series of community interactions to build consensus and social trust, detailed assessment and valuation of land and buildings, compensation and complaint resolutions, rehabilitation and resettlement etc. Accordingly, the magnitude of activities involved during the planning phase varies from 1 to 5.

The construction activities will take place in 1458 Ha of land of which 74.2% will be the track alignment, 16.9% will be stations, 5.2% will be service roads, 3% will be depot, 0.7% will be service stations. 2,69,700 m^2 of building construction is envisaged out of which 95% is for stations and the rest for real-estate development. During the Construction phase, the site clearing and removal of vegetation along with the demolition of built structures are envisaged all along the landward stretch of the track. This requires significant involvement of men and machinery as well as debris removal and disposal. However, the magnitude of these activities is not Stated in the detailed project report.

The key activity of the project involving earthworks and constructions takes place subsequently. The earthworm involves cutting, stripping, tunnelling, excavation, earth movement, filling, levelling and compaction. The tunnelling, cutting and cut and cover are proposed for 11.528 km, 101.737 km and 24.789 km respectively. The details on stripping, excavation, earth movement, filling, levelling and compaction are not given in the DPR.

This will be followed by massive construction activities which will include setting up labour camps, clearing and levelling of lands, construction of embankments, bridges and viaducts, tunnels, stations, depots and other buildings etc. These constructions require the extraction of construction materials, transportation and storage of materials, extraction of water, usage of equipment and machinery etc. The construction involves 11 stations, 2 depots, 5 RORO loading/unloading points and other allied buildings. Tunnels to the length of 11.528 km, Bridges to the length of 12.991 Km, Viaducts to the length of 88.412 Km and Embankments to the length of 292.728 Km. However, the volume of earthwork involved and the construction envisaged are not given in the DPR.

The construction requires the use of a large quantity of rocks, soil, cement, steel, water etc., but the quantum of requirement is not estimated in the DPR. Therefore, the transportation requirement, increase in traffic etc are not indicated in the DPR. The quantity and locations from where the rock, sand and soil are proposed to be extracted, their transportation and storage requirements etc. are not detailed in the DPR. It is Stated that the extractions will be from quarries located at Attingal, Kundara, Mahadevapuram, Kanyannur, Naduvattom, Vellarkad and Kundil.

The information from the project description indicated that approximately 30 MLD (Million Liter per Day) of water will be required during the construction phase and 5 MLD of water during the operational phase. It is Stated that water will be drawn from local sources as the demand will be distributed all along the alignment, at the stations, construction camps, maintenance depots etc. Rails will be laid all along the track facilitating double lines. Electrical and mechanical installation works, construction of protective barriers etc are also involved during the construction phase, about which also the quantitative information is not available in the DPR.

During the operation phase, most of the activities are routine in nature such as the facilitation for running the high-speed train, ensuring uninterrupted power supply, operation and maintenance of the stations and depot, operation and maintenance of bogies and engines involving cleaning, overhauling, repair etc. There will also be drawl, use and discharge of water mainly at 13 locations. The quantum of energy use, human resources involved, nature of doing repair and maintenance, management of fuel, oil and lubricants, water and wastewater management details etc. are not available for assessing the magnitude of such activities involved. Therefore, impact assessment is not attempted for the operation phase.

Since it is essential to have the magnitude of various activities involved during the three phases and there is a lack of such information in the DPR and other literature on the project, the magnitude of each activity is assigned qualitatively. This, of course, is a major drawback of this study. The assigned values of magnitude (M) of each activity on a scale of 0 to 5 are also given in Table 5.1.

Table 5.1 Activities and their magnitude envisaged in the SilverLine Rail Project

Planning phase			**Construction phase**		
No	Activity	M	No	Activity	M
1	Alignment fixing	1	1	Vegetation removal	4
2	Geotechnical study	2	2	Demolition	5
3	Site clearing	3	3	Debris disposal	4
4	Topographic survey	3	4	Earthwork	5
5	Land acquisition	5	5	Material extraction	5
			6	Extraction of water	5
			7	Transportation	5
			8	Material storage	2
			9	Labour camps	3
			10	Construction	5
			11	Laying of rails	4
			12	Electrification	4

5.2 Environmental Aspects of Project Location

The environmental aspects of significance to the project site and surrounding impact zone are delineated based on the inference from the baseline environmental studies. The environmental aspects and their level of significance or importance (I) to the overall environmental settings of the area through which the SilverLine Rail Project is planned is given in Table 5.2.

Table 5.2 Environmental Aspects of Significance to the SilverLine Rail Project area

Land environment		Water environment		Bio-environment		Air environment		Social environment	
Aspects	**I**	**Aspects**	**I**	**Aspects**	**I**	**Aspects**	**I**	**Aspects**	**I**
Landscape	5	Surface water	5	T. flora	5	Air quality	3	Human settlement	5
Land use	5	Groundwater	5	T. fauna	5	Visibility	2	Economy	5
Soil	3	S. water quality	4	Aquatic flora	5	Noise level	3	Employment	4
Land stability	5	G. water quality	4	Aquatic fauna	5			Physical safety	5
								Aesthetics	5
								Psychological Well being	5
								Culture	3

5.2.1. Land environment

The project area mostly falls in the lowland and midland terrain of the State where the landscape is characterised by coastal plains, flood plains, alluvial plains, valley floors, low rolling terrain, moderately undulating terrain, laterite mesa, waterlogged areas, etc. The water-logged areas include rivers, paddy fields, estuaries etc. The landscape through which the project is envisaged is highly important in terms of demography, infrastructure and economic activity. The land required for the track (1082 Ha) includes low land such as paddy wetland (55%), hills/ridges (26%), valley floor (16%) and water course (3%). The land required for the construction of stations (229 Ha) includes plain land (27%), wetland (47%) and inhabited plain (26%). In addition, service roads require another 76 Ha of land. The land use along the project area is characterised by agriculture, settlements and homesteads, other built-up including infrastructures, barren land, marshy areas etc.

The land use inventory along the proposed alignment based on field mapping conducted by the local volunteers brought out the details of an area of 5554 Ha in the 200 m zone of the alignment. It indicates 53% of wetlands including ponds, chira and backwaters, 11% of marshy stretches, 9% of cultivated paddy land, 11% of uncultivated paddy land, 2% of mangroves, 1% of sacred groves, 1% of natural vegetation and 12% of hilly tracts with sparse vegetation. About 73% of the area falls in flood plains. The project area is characterised by different types of soils such as coastal sands, coastal alluvium, riverine alluvium, Onattukara soil, hydromorphic soil, acid saline soil, laterite soil etc. 89% of the alignment falls in coastal alluvial sand, 7% in saline peat soil and 4% in laterite soil. The spatial distribution and physicochemical properties of these soils are mostly consistent with the lithological diversities of rocks as well as physiographic and vegetational distribution patterns.

Almost 97% of the alignment falls in gentle slope regions where the maximum slope is up to 10^o, 3% falls in areas with slope varying from 10^o to 20^o and 1% in slope up to 30^o. Land stability refers to larger-scale movements due to the formation of unstable soil or rock masses. It results in the mass movement of soil bodies, land subsidence and disturbance to the natural landscape. The proposed project site at places has unstable soil wherein there are possibilities of erosion, slips, subsidence, soil piping etc which leads to land stability issues.The land stability in the project area is aggravated due to natural hazards, especially floods as most stretches of the project area are vulnerable to floods.

5.2.2. Water Environment

The terrain through which the project is proposed is characterised by the distributaries of 28 rivers, chain of 27 estuaries and 7 lagoons lying parallel to the coastline and mostly interconnected natural and man-made canals. The alignment crosses 96 first order streams, 72 second order streams, 25 third order streams, 18 fourth order streams and 28 rivers stretch in addition to backwaters. The surface water is plentiful in the project area but is mostly saline due to seawater ingression which aggravates during summer.

The river flow in all the rivers in Kerala is reducing significantly during summer and in six rivers it is reducing even during monsoon. The reduction in river flow enhances the pollution level of surface water in the project area. The major water quality problem is associated with bacteriological contamination; main causative factor is indiscriminate sewage disposal. The project area is characterized by reducing groundwater potential. The groundwater development in the area is on the increase as evident from the increase in a number of dug wells, bore wells and tube wells in the area. The mode of groundwater development is also changed significantly to mechanized pumping without any regulations considering the safe yields. The pollution level of groundwater, especially of the dug wells are also high, mainly due to chemical and biological contaminants.

5.2.3. Bio-environment

The floral diversity along the proposed alignment is rich and has characteristics of the coastal and midland zones of Kerala. The riparian flora in the area is dominated by herbs followed by trees, climbers and shrubs. Almost 55% of the herbs are aquatic or semi-aquatic confined to rivers, marshes, paddy fields, ponds etc. The trees and shrubs include mangrove species and their associates. The flora also included cultivated species and exotic species and 39% of the exotic species are reported as invasive. The floral diversity also includes species under the red-list category, 50 species under the endemic category. 37% of the floral species are found to be useful for medicinal purposes.

The majority of the area under the proposed rail corridor is cultivated and abandoned paddy fields, homestead gardens with coconut, areca nut and trees with very high timber value and plantations dominated by Rubber. Patches of mangroves with rich species diversity are dominantly seen in Kozhikode, Kannur and Kasaragod districts. There are also rare, endangered and threatened species reported from the project area. The agro-biodiversity of the project zone is also significant. The faunal diversity of the project area includes mammals, birds, reptiles, amphibians and 84 freshwater fishes. The estuaries and backwaters of Kerala are known for penaeid shrimps, fishes, giant prawns, mud crabs and clams. The project area stretches through wetlands of international importance, rivers, estuaries, paddy fields etc., where the species diversity of birds is very high.

The third largest waterfowl population in India during the winter months is reported from the Kol wetlands which also form part of the project area. About 37% of the mammal diversity in the region is reported vulnerable. 47 threatened fishes are reported from the project area, out of which 2 are critically endangered, 27 are endangered and 18 are vulnerable species. The area is also known for insects and reptile diversity as well as a large number of vertebrate species. 7% of the vertebral species are reported in the threatened category of which 11% are critically endangered, 44% endangered and 45% vulnerable. The livestock population in the region exhibits a declining trend though the poultry population registered a significant increase over the years.

5.2.4. Air environment

The air quality in the project area is characterised by an increasing trend of respirable suspended particulate matter (RSPM), sulphur dioxide (SO_2) and nitrogen dioxide (NO_x). As per the monitoring report of the Kerala State Pollution Control Board, the RSPM values vary from 31 to 63 μg/m^3 with an average value of 47 μg/m^3 against a permissible limit of 60 μg/m^3. The SO_2 values vary from 2 to 7.82 μg/m^3 with an average value of 3.5 μg/m^3 against a permissible limit of 50 μg/m^3. The NO_x values vary from 4.5 to 26.14 μg/m^3 with an average value of 13.6 μg/m^3 against a permissible limit of 40 μg/m^3. The parameter of air quality concern is only the RSPM which is mainly due to the high traffic density, especially in the coastal side of the State. The road density in Kerala is 5290/1000 km^2 against the national average of 1926/1000 km^2 (ENVIS, 2021).

The total road length in Kerala during 2021 is 2,38,773 km of which 84% is local roads under Local Governments, 12% is PWD roads, 1% is National Highway and 3% is other roads under KSEB, Irrigation, Forest, Railways etc. 90% of the road network is single lane. The National Highway carries 40% of the traffic and PWD and other major roads carry 40% of traffic indicating that 80% of the traffic is handled by 13% of the road length. The road density and traffic density are the highest in the coastal zone and hence the area experiences the highest concentration of RSPM.

The area experiences good visibility throughout the year except during a few days in the winter and monsoon season. This is mainly due to themeteorological conditions and airborne particles. The noise level in the project area will also be very high consequent to the higher traffic density, industrial and commercial activities and urban agglomeration. From the literature, it is understood that the noise level along the project area during the night time varies from 35-53 dB and daytime varies from 47-82 dB. The stipulated limit for noise level for the residential zone in the night and day time is 45 dB and 55 dB respectively.

5.2.5. Social environment

The project is envisaged through human habitation. Kerala is characterized by a homestead type of habitation with population density varying from 559 to 2097 per sq. kilometre as per the 2011 census. However, the density of the population is highest in the coastal and adjoining areas of the State and therefore, the implications of the project will be very high due to high population density and built structures including infrastructure facilities.

The economy of the State as well as the project area is largely dependent on trade in services and resulting remittances. Other major economic activities in the project area include agriculture, micro, small and medium industries, marine and inland fishing, tourism etc. Marine food production is on the decline and the share of inland fish production is only 29%. The State and the project area have unique and diverse agro-climatic specialties with potential for many types of crops.

But over the years, there has been a gradual shift from food crops to cash crops. The project area is dominated by coconut, arecanut, paddy, banana etc. The aesthetic aspects of Kerala, particularly that of the region through which the project is envisaged characterized by very long coastal lines, beaches, backwaters, lakes, riverine network in the project area are known for its tourists’ attractions, internationally.

The aesthetics of the project area is also due to the presence of historical and archaeological locations of importance in and around the project area. The unemployment status of the State is dominated by educated unemployment as a person cannot find a desired job according to his educational qualification. The unemployment rate of Kerala (11.4%), is higher than the national average of India (6.1%) (*Economic Review 2020 (Volume-I))* .

A safe physical environment is crucial to an individual's health and well-being. Physical safety refers to the absence of harm or injury that can be experienced by any person due to diseases, accidents and hazards. Communicable diseases, accidents, road and traffic safety, natural hazards such as flood, coastal erosion, lightning etc., crime and violence etc. affect the physical safety of the region. Psychological well-being refers to positive mental states, such as happiness or satisfaction mostly with respect to the living condition and anxiety. These are mostly subjective but important to rate the quality of life. The income, livelihood, basic services etc of the habitation play a dominant role in psychological well-being.

5.3. Impact during phases

5.3.1. Impact during the Planning Phase

This is assessed based on the impacts of various activities envisaged during the Planning phase on the various environmental aspects listed under land, water, biological, air and social environments. The major activities envisaged during this phase are Alignment fixing, Geotechnical study, Site clearing, Topographic survey and Land acquisition. A questionnaire, consisting of 93 questions detailed in the Chapter on Methodology is used to identify the impacts and their implications.

During this phase, there will not be a significant alteration of land or removal of vegetation or built structures as there will only be minimal intrusive activities on land. Most of the activities in the land will cease gradually upon assignment of land for the project and there will be a virtual division of land parcels impacting the continuity of land-based activities, in turn affecting local area development. The ceasing of activities will lead to vegetation growth reducing the overland flow, decreasing soil erosion and enhancing groundwater recharge, temporarily.

The reduced activities in the earmarked land will only be of beneficial implications on the ecology and air environment as the existing activities cease temporarily. However, the impact on socio-economic aspects will be very high, especially due to land acquisition. Though it is stated that the land acquisition will be done as per the LA Act, 2013, there are various loopholes and contradictions which are not in favour of the owners of land and properties. As per the DPR, the Right of Way considered for land acquisition is 15m for the viaduct, 25m for cutting and cut& cover and 20m for embankments. Accordingly, the land area required for the project is estimated as 1383 ha for the project corridor of length of 529.450 km which includes 1198 ha of private land (86.62% of the total land area required) and 185 ha of Railway land. However, the area required for service roads, estimated as 76 Ha, is not added, thereby there will be peripheral encroachments.

A Major portion of the private land will comprise productive agricultural land, the one-time compensation for which is not adequately conceived. Though the DPR states about the requirement of demolition of about 10349 structures/buildings only, the actual impacted structures will be about 1,19,340 within the 200 m zone.

The reversible and irreversible impacts due to loss of land, livelihood, community resources etc., and displacement due to land acquisition and dismantling of structures will be extremely severe and adverse. There will also be an irreversible impact due to loss of agriculture in 2273 Ha of land within the 30m zone of the alignment and 14810 Ha of land within a 200m zone of the alignment. Further, the fragmentation and transformation impact on the ecosystem will also be irreversible, very severe and adverse as 1599 Ha of the productive ecosystem within the 30m zone and 10,665 Ha of the productive ecosystem within the 200m zone will be destroyed.

The psychological impact on the affected population will, therefore, be very severe and adverse due to uncertainty, apprehensions, lack of transparent actions, misinformation, anxiety etc.

5.3.2. Impact during the Construction Phase

The construction phase commences with clearing of vegetation which will lead to the loss of biological diversity all along the alignment stretch. The biodiversity loss is caused mainly due to the destruction of habitat. It may lead to total extinction of the species of restricted distribution and local genotypes will be lost for more widespread species. The activity will also result in fragmentation due to which contiguous areas of habitat get separated into several or smaller areas.

Fragmentation impacts include the creation of small isolated populations with limited gene flow between populations, leading to inbreeding depression and reduced potential to adapt to environmental change. Fragmentation also leads to the loss or severe modification of the interactions between species, including those interactions that are important for the survival of species. Small isolated populations may be subject to local extinction from stochastic events. The hostility of the surrounding (cleared) environment is a major factor in limiting the movement of organisms between patches. The physical environment within patches may be altered as a result of the creation of edges and anthropogenic influences. Clearing of vegetation in riparian zones may alter the organisms inhabiting there and may lead to bank erosion, sedimentation, reduced nutrient filtering capacity and changes to stream behaviour. The vegetation loss also increases the emission of greenhouse gases, both from the burning of cleared vegetation and from the loss of soil organic matter.

The clearing of leaf litter and fallen logs and burning of the litter removes habitat for a wide variety of vertebrates and invertebrates which live in the leaf litter and the fallen logs - including reptiles, small mammals, invertebrates, for example, spiders, molluscs, millipedes, ants etc., thus affecting ecological functioning, adversely.

Demolition can lead to excessive dust, noise, smoke, odour and possibly asbestos dust. The composition and quantities of demolition wastes depend on the type of structure, building materials used and the age of the structure being demolished. The most common types of wastes generated from demolition activities are concrete, wood, asphalt (from roads and roofing shingles, gypsum (the main component of drywall), metals, bricks, glass, plastics, salvaged building components (doors, windows, and plumbing fixtures), trees, stumps, earth, and rock from clearing sites, rubble, aggregates, and ceramics. Conventionally, the demolition waste generated is 300-500 kg per sqm of destruction.

Blast demolition enhances the health risk factor of inhabitants in the area due to the concentration of particulate matter, particularly breathable particulates resulting from the blasting of concrete, brick and wood structures. If the structures have asbestos in their composition, the risk factor for the health of inhabitants increases significantly due to the carcinogenic effect of asbestos. The demolition of buildings by blasting involves vibrations and the possibility of resonance and amplification causing serious damage to nearby constructions.

As per the existing data, only 50% of the construction and demolition waste is recycled in India and the rest is used for filling land and water bodies causing severe and irreversible adverse impacts such as fragmentation of land, reduction of carrying capacity of water bodies, contamination of surface and the ground water affecting aquatic life as well as animals due to the impacts on their natural habitat etc. The disposal of demolition waste also leads to air pollution as it may carry dust, particulate matter like PM10, asbestos and other pollutants that may get mixed with air. Though we have the Construction & Demolition Waste Management Rules, 2016 under the Environmental Protection Act, the level of its implementation is yet to be standardized.

The demolition will impact about 691 Ha of land with settlements, built-up areas and linear infrastructure. As per the DPR, there will be the demolition of 10,349 structures/buildings in addition to linear infrastructure facilities but the actual impact will be about 1,19,340 structures within the 200 m zone. The project does not indicate adequate precautionary measures to manage the demolition waste and its disposal and therefore, the impact due to this major activity will be very significant and irreversible.

Earthwork is one of the major activities during the construction phase. It is involved in the construction of embankments, viaducts, bridges and buildings for stations and depots and also during cutting, cut and cover and tunnelling. 55% of the alignment stretch will have embankments which require huge earthwork. The stations at Kollam, Kottayam and Thrissur are in wetlands necessitating enhance requirements of earthwork. Earthworks operations include the excavation, transport, placement and compaction of fill materials to construct earth structures. Exposing land surfaces through earthwork activities can increase sediment loads that are discharged to water bodies which deteriorates the water quality and the ability of aquatic organisms to survive and/or migrate.

The increased siltation of the water bodies reduces the carrying capacity and can increase the hazard potential such as flooding. Dust from earthwork activities can have a potential effect on amenity values at a local scale. The level of dust generated by earthworks is dependent on several matters including soil characteristics, rainfall, wind and method of excavation. Noise is an indirect effect associated with earthworks as it involves the operation of heavy machinery.

Earthworks that result in the modification of landform patterns can have an adverse impact on the visual coherence of an area through the degradation or, in some cases, removal of a natural landform. The removal of vegetation, particularly indigenous vegetation, can result in the loss of habitat and visual amenity. In addition, exposed soil can cause other effects such as erosion, increased surface water and sediment run off and dust nuisances. Earthwork activities have also the potential to alter, disturb, modify or destroy heritage or archaeological sites. The quantum of earthwork involved in the project is not detailed in the DPR and therefore quantitative assessment could not be carried out.

The project envisages laying of the rail line to a length of about 530 km and the construction of buildings, stations and depots (2,69,700 m^2), embankments (292.73 km), viaduct (88.41km), bridges (12.99 km), tunnels (11.53 km), cutting (101.74 km) and cut and cover (24.79 km). The bridges include 65 large ones and 300 small ones. There will also be 109 road crossings. The constructions require concrete, steel, wood etc in huge quantities.

No details regarding the requirement of construction materials are given in the DPR. Therefore, the impact of material extraction can be discussed only qualitatively. The requirement of stone ballast is estimated to be approximately 28,60,000 m^3. The stone ballast is proposed to be brought from Eraniel / Aralvaymozhi, Kanyakumari District of Tamilnadu, Madukkarai, Coimbatore District, Tamilnadu and Mangaluru / K.Puttur, D.Kanada District, Karnataka. For blanket material requirements, 7 quarries at Attingal, Kundara, Mahadevapuram, Kanayannur, Naduvattom, Vellarkad and Kundill are spotted. These quarries are located at 75-100 km intervals for improved reach to the construction site. However, the availability of the materials in each proposed site, the proposed extraction from each site and the specific location of the sites are not given. Therefore, specific impacts of material extraction cannot be assessed.

The impacts such as land degradation, the possibility for landslides and land subsidence, air and water pollution, occupational noise pollution, loss of biodiversity, loss of hydraulic continuity etc are common while quarrying. The impacts will enhance as the extraction of materials will be at a higher rate due to the compulsion of quick construction requirements.

The impacts due to blast and consequent vibration will be extremely high in Kerala as the density of houses and buildings are very high. According to various studies, each square meter constructed will result in an average emission of 0.5 tons of carbon dioxide and an energy consumption of 1,600 kWh (which will vary depending on the design) if only the material impacts are taken into account. On the whole, the impact due to material extraction in the given project scenario will be very high and mostly irreversible.

The transportation of material to the project area, extending to a length of about 530km, from 7 quarries, 3 stone ballast sites and various other locations during the construction phase will have significant adverse impacts, many of which will be for short-term duration. The transportation will lead to air pollution due to particulates, nitrous oxide and carbon dioxide, in turn contributing to global warming. Most of the transportation will be using trucks which will have a very high emission factor of 0.1693 kg of CO_2 per ton-mile.

Since the construction activity in different stretches of the tract will be taken up together, the vehicular movement will be very high and hence the impact of emission. The transportation will also lead to severe traffic congestion as many of the roads are narrow and the traffic density in Kerala is generally high. There will also be an increase in noise levels and emission of carbon monoxide due to intensive transportation activity. The typical noise level generated by trucks is 82-94 dB(A) which is higher than the permissible level. Transportation environments, in general, have their peak vibration levels below 100 Hz, and levels are generally rolling-off above 200 Hz. Elastic ground vibrations caused by controlled or uncontrolled human operational activities (e.g., transport-borne vibration) give results in para-seismic form waves. The vibrations coming from the operating elements of the transport infrastructure and means of transportation, propagated by the ground into the environment, in selected time intervals can be classified as a para-seismic, random, stationary—ergodic—process. The health effects of transport emissions are also of concern.

The requirement of water during the construction phase is projected as 30 MLD at the construction sites and labour camps. The demand is distributed all along the alignment and the withdrawal will be from the nearest freshwater source. Since the alignment is mostly through the plain terrain of the State and it crosses 96 first-order streams, 72 second-order streams, 25 third-order streams, 8 fourth-orderr streams and 28 river stretches in addition to backwaters, major ponds, chira etc., there will be adequate access to fresh water sources. Therefore, the impact of the withdrawal of the water may not be very significant. However, if the requirement is met from groundwater sources, there will be a serious impact due to the sudden lowering of the water table and consequent saline intrusion at places. The discharge of wash water, if not properly treated, will contaminate the sources. The construction phase also involves the storage of materials for construction at places, the impact due to which is anticipated as moderately adverse as the storage will be distributed all along the stretch and therefore, the land requirement at places will be limited.

As part of the construction, there will be Labour camps at major construction sites. This is expected to come up with temporary sheds and make-shift essential service facilities. There will be an inflow of migrant labour which will lead to a feeling of insecurity among the local residents due to the intrusion of insular culture. The additional inflow of people to the site will lead to overloading on the local facilities and essential services such as health, water supply and sanitation, transportation etc. The inadequacy of facilities in the labour camps and their temporary nature will lead to unhygienic situations which in turn will lead to land and water pollution. The piling up of solid wastes, putrefaction of organic waste, discharge of sewage from leach-pits etc will have impacts in and around the site. Prevalence of exploitation mentality, the mingling of cultures, possible vandalism and fighting etc are also to be anticipated. Amidst these adverse impacts, there will be increased local economic activity due to increased monetary inflow to the locality.

Construction involves building the stations and depots to the tune of 2,69,700 m^2, constructing embankments of length 292.73 km), a viaduct to a length of 88.41km, 65 large and 30 small bridges to a length of 12.99 k), tunnels to a length of 11.53km, cutting to a length of 101.74km and cut and cover to a length of 24.79km, laying of rails to a length of about 530m and electrification all along the stretch and for the buildings. Apart from this, short-stay homes of employees or labourers, storage yards of construction materials, service roads, roads leading to the stations and depots will also be constructed. The construction activities will lead to landscape modification, soil compaction, soil contamination due to muck disposal, erosion etc.

The construction sector is known to contribute 23% of air pollution, 50% of climate change factors, 40% of drinking water pollution and 50% of landfill wastes. Building materials such as concrete, aluminium and steel are directly responsible for large quantities of CO_2 emission due to the high content of embodied energy content. The construction of embankments (55% of the alignment) will prevent the hydraulic continuity of the fluvial systems cutting across the alignment to a large extent leading to increased flood, soil erosion, reduced assimilative capacity of water etc. This will divide the natural habitat to a large extent, lead to cultural partition and aesthetic divide and cause feelings of insecurity due to accidents. These impacts will be permanent and extremely adverse.

The construction of viaducts and bridges will need piling works which will enhance the noise and vibration levels in the region. The typical noise levels of Pneumatic pavement breaker is 102-108 dB(A), pile drivers is 95-105 dB(A), Jackhammer and rock drills is 81-98 dB(A), Truck is 82-94 dB(A), Compressor is 74-86 dB(A), Generator is 71-82 dB(A), Crane is 86-88 dB(A), concrete pump is 81-83 dB(A), Concrete mixer is 75-88 dB(A), Scraper & Grader is 80-93 dB(A) and earth mover is 72-96 dB(A). The individual and combined operation of these machinery will be generating intermittent noise levels much beyond the permissible limit.

The alignment crosses 96 first-order streams, 72 second-order streams, 25 third-order streams, 18 fourth-order streams and 28 river stretches in addition to backwaters. The proposal also includes the construction of 65 large bridges and 300 small bridges. The viaduct will cover a distance of 88.41 km. These areas will be the highest construction hotspots. The maximum allowable Peak Particle Velocity (PPV) is fixed at 15mm/s based on trial blasts and the ground vibration monitoring near structures during blasting for the protection of critical structures (*refer Table 1 on DGMS guidelines*). ISO 2631-1 suggests that the vibration peak acceleration of0.015 m/s2is an acceptable vibration level for building occupants. As per studies, the ground vibration and air blast at sensitive sites must not exceed 5 mm/s (PPV) and 115 dB (Lin Peak) respectively.

The piling work can generate ground vibration with peak particle velocity ranging from 12 mm/s to 35 mm/s against buildings' maximum permissible limit of 15 mm/s. The vibration with a peak particle velocity of 1 mm/s is noticeable and beyond that 6 mm/s is strongly felt. During the construction of bridges and other structures, ground vibration is generated with peak particle velocity varying from 0.28 mm/s to 45 mm/s depending on the type of equipment used and the terrain characteristics. However, it is desirable to bring down the peak particle velocity to 4.5 mm/s by adopting control measures.

5.3.3. Impact during Operation Phase

Though impact assessment and evaluation are not done for the operation phase in the absence of details required, the possible impacts are examined hereunder. The activities envisaged during the operation phase include Power supply, Movement of rolling stock, Maintenance of Track, Rakes and Wagons, Extraction of water and upkeep of buildings. The un-interrupted electric power supply is essential for this project 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.

The electrical power is proposed to be sourced from the Kerala State Electricity Board Ltd and supplemented by renewable energy supplies. The energy consumption is expected to increase from 279 MU in 2023-26 to 497 in 2052-53 and power demand from 104 MVA to 184 MVA during the same years. There will be 8 substations, five with 220 kV capacity and three with 110 kV capacity distributed all along the tract. It is proposed to use power from renewable sources like solar by in-house production, purchase of renewable power from a third party and KSEBL to make the project green and sustainable. The possible areas for placing the solar panels are viaducts, rooftop of all the buildings (Station and Depot), compound wall of alignment and free land wherever available. The proposal to harness and avail green energy to the maximum reduces the adverse impact of the project appreciably.

The Rolling Stock is provided with an anti-skid, durable and aesthetically pleasing interior floor making it easy for regular cleaning and protective against accidents. The blended braking system using regenerative braking and pneumatic braking and the provision of four sliding plug type external access doors provides additional safety. The ‘Roll On Roll Off (RORO)’ service provides a rail transportation system. It is proposed to run 6 RORO trips in each direction per day considering 40 wagons per RORO train, 3 trips during the daytime in non-peak hours and 3 trips in the night-time in each direction. This is expected to save considerable energy and reduce road traffic congestion significantly.

The daily inspection, preventive maintenance, major maintenances, overhauls, corrective maintenance and other activities such as cleaning, waste disposal etc. are proposed to be done at the maintenance depots & workshop facilities at Kollam and Kasaragod. The requirement for land and water at these locations is expected to be very high. The land earmarked at Kollam is a wetland and its reclamation will lead to various irreversible impacts on the environment. Kasaragod is a water-stress region and the availability of water is questionable. Therefore, these aspects will pose appreciably adverse environmental impacts. The employment opportunities will increase due to operational and maintenance requirements during the operational phase as the organization will require engineers, skilled staff, managerial personnel and unskilled staff for manual labour. All crucial safety related maintenance work is proposed to be done in-house and the non-core activities like building maintenance, electric substation maintenance, road transport, housekeeping work etc. are proposed to be outsourced. The increased employment opportunities and operational income are beneficial to the social environment. However, in the absence of data, the magnitude of the beneficial impact cannot be assessed.

5.4. Impact potential

The impact potential is assessed using the Leopold matrix method. Due to subjective judgment, which may vary from individual to individual and constraints to have specific guidelines while attributing importance rating and weightage, there may be ambiguities in the assessment. The method also does not address the inter-relationships between impacts and component-to-component interaction. It is also difficult to clearly distinguish the primary, secondary and tertiary impacts using the matrix method. Despite these limitations, the matrix method is highly useful to convey a holistic view of the environmental impact of the project as well as to communicate the results of EIA. The impact potential during the pre-project, project construction and project operation phases are given in Tables 5.3, 5.4 and 5.5.

Table 5.3: Impact Potential of Project Planning Phase

Attributes and Aspects		Alignment fixing (1)	Geo-technical study (2)	Site clearing (3)	Topogr phical survey	Land acquisit n (5)	Impact Score
Land	Landscape (5)	-	-	-15	-	-	**-15**
	Land use (5)	-5	-	-15	-	-	**-20**
	Soil (3)	-	-6	-15	-	-	**-21**
	Land stability (5)	-	-10	-15	-	-	**-25**
Water	Surface water (5)	-	-	-15	-	-	**-15**
	Groundwater (5)	-	-	-	-	-	**-**
	Surface water quality (4)	-	-	-12	-	-	**-12**
	Groundwater quality (4)	-	-	-	-	-	**-**
Air	Air quality (3)	-	-6	-9	-	-	**-15**
	Visibility (2)	-	-	-6	-	-	**-6**
	Noise level (3)	-	-6	-9	-	-	**-15**
Biology	Terrestrial flora (5)	-	-	-15	-	-	**-15**
	Terrestrial fauna (5)	-5	-10	-15	-15	-	**-45**
	Aquatic flora (5)	-	-	-	-	-	**-**

	Aquatic fauna (5)	-	-	-	-	-	-
Social Environment	Physical safety (5)	-	-	-15	-	-	**-15**
	Psychological well-being (5	-5	-10	-15	-15	-25	**-70**
	Human settlement (5)	-5	-10	-15	-15	-25	**-70**
	Economy (5)	-5	-	-15	-15	25	**-10**
	Culture (3)	-	-6	-9	-	-	**-15**
	Employment (4)	4	8	12	12	-	**36**
	Aesthetics (5)	-	-	-15	-	-	**-15**
TOTAL		**-21**	**-56**	**-203**	**-48**	**-25**	**-353**
Total - Normalised to 100		**-12.84**					

Table 5.4: Impact Potential of Project Construction Phase

Attributes and Aspects		**Vegetation removal (4)**	**Demolition (5)**	**Debris removal (4)**	**Earthwork (5)**	**Material extraction (5)**	**Extraction of water (5)**	**Transportation (5)**	**Material storage (2)**	**Labour camps (3)**	**Construction (5)**	**Laying of rails (4)**	**Electrification (4)**	**Impact Score**
Land	Landscape (5)	-	-25	-20	-25	-	-	-	-10	-	-25	-	-	**-105**
	Land use (5)	-20	-25	-20	-25	-25	-	-	-10	-15	-25	-	-	**-165**
	Soil (3)	-12	-15	-12	-15	-15	-	-	-6	-	-15	-	-	**-90**
	Land stability (5)	-20	-25	-20	-25	-25	-25	-25	-10	-	-25	-	-	**-200**
Water	Surface water (5)	-	-	-20	-25	-25	-25	-	-	-15	-25	-	-	**-135**
	Groundwater (5)	-20	-	-	-25	-25	-25	-	-	-15	-25	-	-	**-135**
	Surface water quality (4)	-16	-20	-16	-20	-20	-20	-20	-8	-12	-20	-	-	**-172**
	Groundwater quality (4)	-16	-	-	-20	-	-20	-	-	-12	-20	-	-	**-88**
Air	Air quality (3)	-12	-15	-12	-15	-15	-	-15	-	-9	-15	-	-	**-108**
	Visibility (2)	-8	-10	-8	-10	-	-	-10	-	-	-10	-	-	**-56**

	Noise level (3)	-12	-15	-12	-15	-15	-	-15	-	-	-15	-12	-	**-111**
Biology	Terrestrial flora (5)	-20	-25	-20	-25	-25	-	-25	-	-	-25	-	-	**-165**
	Terrestrial fauna (5)	-20	-25	-20	-25	-25	-	-25	-	-15	-25	-20	-	**-200**
	Aquatic flora (5)	-	-	-20	-25	-25	-	-25	-	-	-25	-	-	**-120**
	Aquatic fauna (5)	-	-	-20	-25	-25	-25	-25	-	-15	-25	-	-	**-160**
Social Environment	Physical safety (5)	-20	-25	-20	-25	-25	-	-25	-10	-	-25	-20	-20	**-215**
	Psychological well-being (5)	-20	-25	-20	-25	-25	-25	-25	-10	-15	-25	-20	-	**-235**
	Human settlement (5)	-20	-25	-20	-25	-25	-25	-25	-10	-15	-25	-	-	**-215**
	Economy (5)	-20	-25	-20	-25	25	-25	-25	-10	15	-25	-20	-20	**-175**
	Culture (3)	-12	-15	-12	-15	-15	-	-15	-	-9	-15	-12	-12	**-132**
	Employment (4)	16	20	16	20	20	20	20	8	-	20	16	16	**+192**
	Aesthetics (5)	-20	-25	-20	-25	-25	-	-25	-10	-15	-20	-	-	**-185**
TOTAL		**-272**	**-320**	**-316**	**-440**	**-335**	**-195**	**-305**	**-86**	**-147**	**-435**	**-88**	**-36**	**-2975**
Normalised to 100									**-45.08**					

The above two tables indicate that the environmental impact potential during the project planning phase is minimally adverse and that during the construction phase is appreciably adverse. The activities proposed during the phase will lead to irreversible modification of various environmental aspects, particularly to land, water, ecological and social environments. Many of the impacts assessed for the construction phase are adverse and irreversible. Kerala, as a whole, is known for its fragile state of environment with its environmental carrying capacity constrained due to various limitations, particularly, land, density of population, increasing anthropogenic pollution, natural disasters such as coastal erosion, drought, flood, landslides, soil piping, lightning etc and climate uncertainties. The proposed project is aligned through the coastal and the lowland-midland interphase region which is considered to be the most constrained zone with respect to dwindling environmental carrying capacity. The appreciable adverse environmental impact predicted due to the project, that too mostly irreversible nature of impact, is detrimental to the connecting ecosystems and hence is highly undesirable.

5.5. Impact evaluation

5.5.1. Land environment

The project will lead to severe and irreversible modification of the land environment. The landscape and land use will get significantly altered and the alteration will not be consistent with the surrounding areas and hence there will be significant soil loss and land stability issues. The impact on the built environment will extend significantly to areas on both sides of the proposed alignment causing severe damage and inconvenience to the residents beyond the land acquired for the purpose.

The data indicate that the almost 74% (392 km) length of the proposed alignment (529.45km) cut across unhindered fluvial zones in the form of rivers, streams, other water bodies, paddy fields, valley floors etc. The environment of Kerala is endowed with three natural regions, namely lowlands, midland and highland; vivacious hydrology enriched with multitudes of fluvial systems and congregations of lively micro-ecosystems (SoE Report, 2007). The alignment mostly falls in the lowland and lowland-midland interface regions characterized by distinct altitudinal variations, especially north of Kollam. The environmental carrying capacity of this region is dominantly sustained by the fluvial system. However, it is severely constrained due to dwindling resource-supportive capacity and inadequate assimilative capacity, especially due to the high population density, consequent demand for the development and resultant anthropogenic pollution. The proposed construction of an embankment to a length of 292.72 km (74% of the fluvial zone) will deteriorate the environment beyond restoration both on the eastern and western sides of the alignment. The fluvial system maintains the assimilative capacity of the environment s being the lifeline of any environmental system, the blockage of the fluvial zone is not a permissible activity from the point of sustaining the dwindling environmental carrying capacity as well as from the community health point of view.

The change in the landscape, land use and soil character along the alignment region will get permanently fragmented and modified. This will destroy the spatial continuity of ecosystems consequent to which there will be irreversible damage to biodiversity, which in turn, reduces the environmental carrying capacity further. The primary impact will be on 5554 Ha of land, if we consider the immediate impact zone of 200m width consisting of water bodies (54%), paddy fields and marshy land (31%) and mangroves, sacred groves and other natural vegetation (15%). There will be secondary and tertiary impacts extending beyond the 200m zone. These impacts will be acute and irreversible. This will have a compounding effect on an already depleting and degrading geomorphology, habitats and ecosystems in the midlands and lowlands of the State. The landscape units impacted due to the project are given in the tables below.

Table 5.5: Landscape units impacted due to the Embankments (in Ha)

Districts	Laterite hills	Mangrove forests	Wetland	Backwaters	Ponds	River
Thiruvananthapuram			3.02		0.02	0.048
Kollam			13.07		0.61	
Pathanamthitta	0.52		12.20			
Alappuzha	0.2		6.60			
Kottayam			19.27		0.01	0.92
Ernakulam			20.41			0.63
Thrissur			39.91		0.06	0.09
Malappuram		0.07	16.84			0.001
Kozhikode		1.33	1.19		0.54	0.002
Kannur		4.65	11.253	0.25	0.15	0.01
Kasaragod		1.89	17.89		0.13	0.04
Total	**0.72**	**7.94**	**161.65**	**0.25**	**1.52**	**1.74**

Table 5.6: Landscape units impacted due to the Bridges (in Ha)

Districts	Laterite hills	Mangrove forests	Wetland	Marshy areas	Back waters	Ponds	River	Estuary
Thiruvananthapuram					0.40	0.09	0.47	
Kollam							0.53	
Pathanamthitta			0.11				0.54	
Alappuzha	0.04		0.30				0.15	
Kottayam			0.03				0.48	
Ernakulam			1.01				3.68	
Thrissur			0.15				0.62	
Malappuram			0.03				2.81	0.49
Kozhikode		0.65			1.68		1.28	1.77

Mahe							0.00	
Kannur		0.66	0.24		3.99		0.53	
Kasaragod		0.12	0.25		1.66		3.31	
Total	**0.04**	**1.43**	**2.12**	**0**	**7.73**	**0.09**	**14.40**	**2.26**

The land use categories impacted due to the various structures are given in the Tables below.

Table 5.7: Land use Categories impacted due to Viaducts (in Ha)

Districts	Agri-culture	Settlements & home-steads	Other built up	Linear Infra-structure	Barren land	Mining	Canals
Th'ananthapuram	9.65	3.02		0.26	0.09		0.02
Kollam	14.48	6.0		0.42	0.81		
Pathanamthitta	1.82	0.42		0.04	0.04		
Alappuzha	1.15	0	0	0	0	0	0.06
Kottayam	21.2	4.98	0.002	0.43	1.39	0.45	0.18
Ernakulam	17.67	4.83	2.12	0.87	0.93		0.22
Thrissur	28.08	14.22	1.60	3.93	5.00		0.22
Malappuram	2.87	0.86		0.06	0.06		0.41
Kozhikode	7.41	7.66	0.57	1.03	1.03		
Mahe							
Kannur	10.61	7.06	1.02	1.42	0.44		
Kasaragod	0.10	2.46		0.09		zz	
Total	**115.04**	**51.51**	**5.312**	**8.55**	**9.79**	**0.45**	**1.11**

Table 5.8: Land use Categories impacted due to Bridges (In Ha)

Districts	Agri-culture	Settlements & homesteads	Other built up	linear Infrastructure	Barren land	Mining	Canal s
Th'ananthapuram	1.16	0.22					0.05
Kollam	0.32						
Pathanamthitta	0.10	0.02					
Alappuzha	0.09						0.17
Kottayam	0.17	0.01	0.08	0.01		0.46	
Ernakulam	0.17	0.22		0.0013	0.03		

Thrissur	0.06	0.06			0.03		0.09
Malappuram	0.46			0.04			
Kozhikode	0.45	0.05		0.03			
Mahe							
Kannur	0.86	0.08		0.21	0.22		
Kasaragod	0.78	0.27	0.05	0.037	0.02		
Total	**4.62**	**0.93**	**0.13**	**0.3283**	**0.3**	**0.46**	**0.31**

Table 5.9: Land use Categories impacted due to Embankments (In Ha)

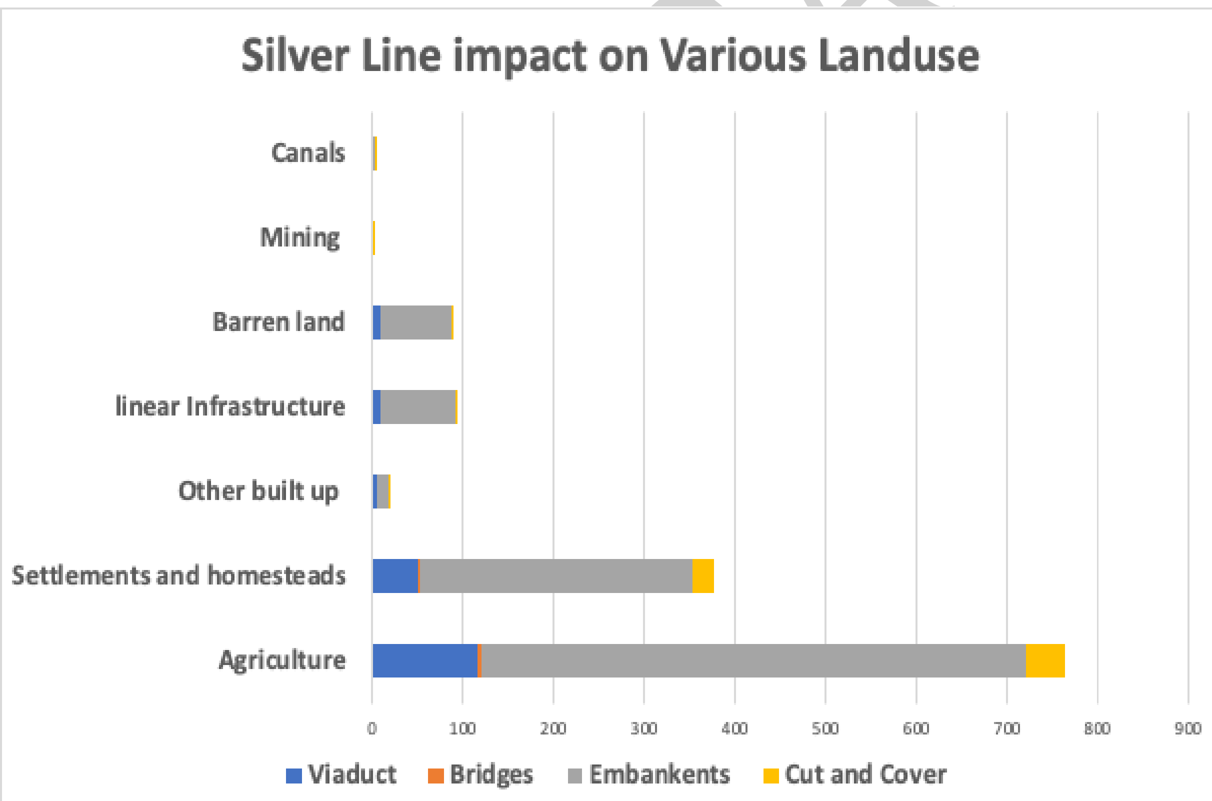
Districts	**Agriculture**	**Settlements & homesteads**	**Other built up**	**linear Infrastructure**	**Barren land**	**Mining**	**Canals**
Thiruvananthapuram	38.87	38.16	0.83	4.77	2.33		0.01
Kollam	39.30	23.54	0.06	1.48	4.27		0.19
Pathanamthitta	33.34	7.22		1.30	0.95		0.15
Alappuzha	22.21	6.34	0.56	0.52	0.54		0.11
Kottayam	53.64	19.58	0.24	1.96	3.09	0.21	0.10
Ernakulam	48.95	17.89	1.75	3.606	8.3		0.09
Thrissur	65.69	24.78	1.051	3.71	3.64		0.62
Malappuram	83.41	22.98	1.95	16.07	15.06		0.03
Kozhikode	71.08	70.25	1.536	22.65	13.68		0.09
Mahe	0.70	0.86		0.02			
Kannur	79.273	33.65	3.21	7.01	7.17		0.21
Kasaragod	63.39	34.781	2.17	19.43	19.44		0.05
Total	**599.853**	**300.031**	**13.357**	**82.526**	**78.47**	**0.21**	**1.65**

Table 5.10: Land use Categories impacted due to Cut & Cover (In Ha)

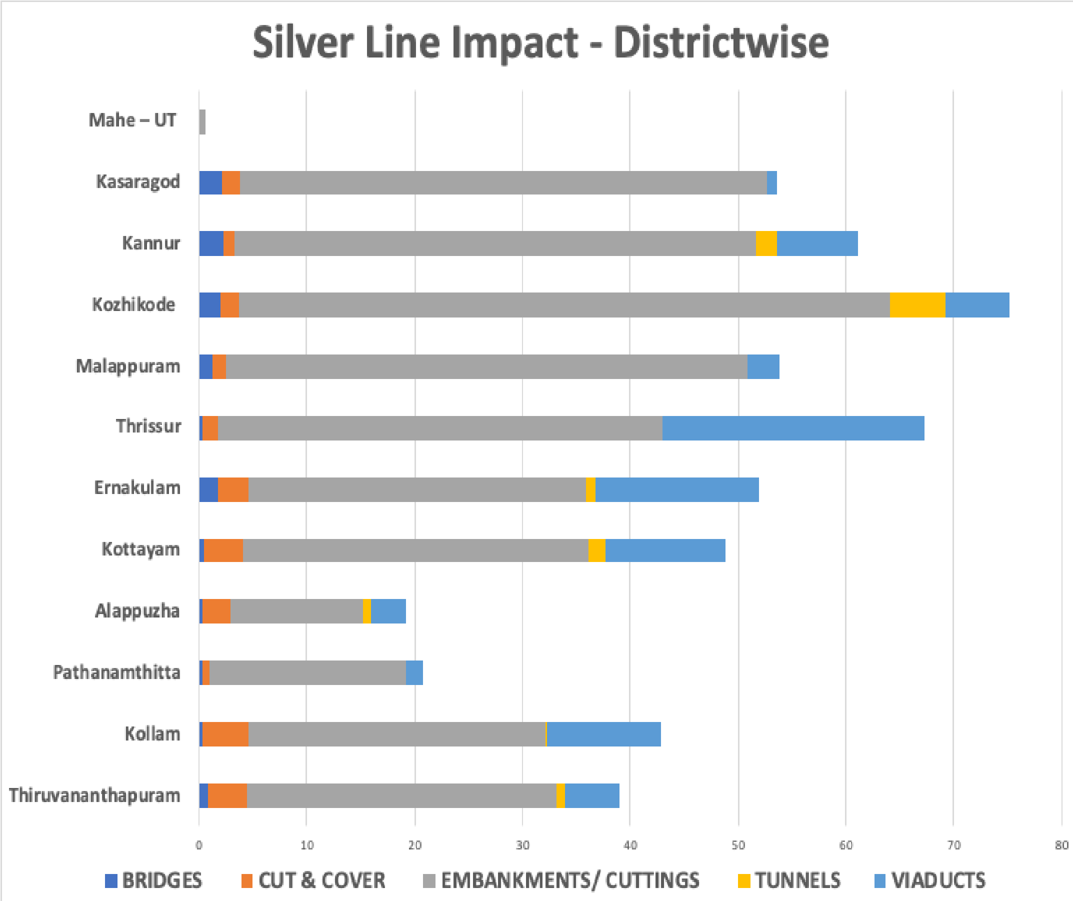
Districts	**Agriculture**	**Settlements & homesteads**	**Other built ups**	**linear Infrastructure**	**Barren land**	**Mining**	**Canals**
Thiruvananthapuram	6.27	4.057		0.21	0.14	0.16	
Kollam	7.07	5.24	0.14	0.32	0.29		0.00019
Pathanamthitta	1.97	0.03		0.01	0.00		

Alappuzha	5.59	1.46		0.17	0.54		0.07
Kottayam	6.31	3.94		0.22	0.37	0.02	
Ernakulam	7.03	1.38		0.09	0.27		
Thrissur	2.16	1.02	0.27	0.121	0.00		
Malappuram	2.36	1.42		0.23	0.00		
Kozhikode	1.74	2.6		0.41	0.23		
Mahe		0.13		0.001			
Kannur	2.35	0.67		0.04	0.18		
Kasaragod	1.36	3.38		0.20	0.04		
Total	**44.21**	**25.33**	**0.41**	**2.02**	**2.06**	**0.18**	**0.07**

The impact of the structures of the proposed Silverline project on different land use categories is depicted in the chart given below.



The major interventions during the construction phase are given in the following chart.



Accordingly, the maximum land alterations and constructions will be there at Kozhikode district followed by Thrissur, Kannur, Kasaragod, Malappuram, Ernakulam and Kottayam districts. The least land alterations are at Alappuzha, Pathanamthitta and Kollam district where the SilverLine rail supposedly goes through bridges apart from the viaducts and embankments. These districts have a maximum area of wetlands and waterbodies and their impacts could be assessed only through modelling studies. Since all these areas are prone to severe floods during monsoons for the last few years, it is to be assumed that the impact will be extremely high. It is also to be noted that the alignment is proposed, necessarily, through the most populated and productive zone with relatively high infrastructure and residential facilities as well as wetlands and associated ecosystems, the economic loss will also be significant.

The total earth that has to be removed due to cutting, tunnelling and cut and cover will be to the tune of 52,30,380 m^3. The earthen material required for the construction of the embankment will be of the order of 1,75, 63,680 m^3. Therefore, there is a requirement of huge earthen materials for filling the embankments and approach road to viaducts and bridges in addition to that obtained from the cutting and tunnelling. The impact of extracting the huge quantity of earthen materials depends on the locations from where it is proposed to be extracted.

5.5.2. Water environment

The rivers in Kerala are under severe deterioration, both in terms of flow and quality. The summer flow in all the rivers exhibits a long-term declining trend. All the central and southern Kerala rivers exhibit a declining trend of river flow even during monsoon. The total annual average flow also indicated a declining trend and the flow estimated during 2009 was only 74% of that in the year 1974 (Central Water Commission, 2009). The declining river flow, uncertain rainfall trend and increased discharge of pollutants enhanced the water quality deterioration. The numerous fluvial systems and their perennial nature provide very effective flushing and enhanced assimilative capacity. The increased interventions and encroachments have deteriorated the micro fluvial systems which significantly impacted the river systems adversely. All 44 rivers, 6 major rivulets, 3 freshwater lakes, 7 estuarine lakes and 11 major reservoirs indicate faecal contamination. As per the water quality criteria of the Central Pollution Control Board, 25 river waters fall in Class E type of water which is the worst polluted water useful only for irrigation and industrial cooling. In 2 rivers, the water quality fall in Class D types which is useful for wildlife propagation and fisheries. In 14 rivers, the water quality is C-Class which is useful as a drinking water source after conventional treatment and disinfection. Water in only 3 rivers falls in Class B which is useful for outdoor bathing. No rivers in Kerala have water of Class A type which could be used as drinking water without treatment. This being the status, any intervention involving water sources will be detrimental to the water environment of Kerala. The obstructions to the fluvial systems due to the construction of embankments and other structures across the fluvial path will lead to ponding phenomena, both in the upstream and downstream portions of the proposed alignment. This will lead to an extremely adverse impact on the hydrology of the State which will mostly be irreversible. The ponding effect will also enhance the flood havoc significantly.

It is estimated that 392 km of wetland and floodplain of varying nature will get impacted due to the construction, thereby 12 sq. km of wetlands and floodplain will be lost within the impact zone of 30 metres, and 78 sq km area will be affected in the 200 metre zone. Out of this only 101 km were covered by viaducts and bridges are proposed to ensure uninterrupted flood flow. It indicates that the 291 km stretch of embankments will block the flood waters, affecting significant areas upstream and downstream. Even though viaducts and bridges are meant for the uninterrupted flow of flood water the pillars and stilts can affect the smooth flow of flood waters, as the drainage systems and watersheds are already altered through reclamations and modifications. The recent incidences of landslides and lightning floods in the Koottikkal, Mundakayam and Kanjirappally regions indicated that the interventions such as constructions in flood plains, check dams, bridges and other modifications in the watersheds contributed significantly as the causative factors (Srikumar et.al., 2021). This impact will get accentuated with erratic high rainfall incidences predicted for Kerala due to climate change. Detailed impact on human habitation and agriculture can be assessed only through detailed studies including modelling studies that can estimate the height and temporal and spatial coverage of flood waters that may occur due to embankments and other structures. This will lead to spatial enhancement of floodplain areas leading to significant loss of crop production and productivity, impacting the livelihood, besides other socio-economic implications.

The impact of 291 km long embankments through wetlands is much more than the 58 sq. (200 m zone) area as it is a linear infrastructure cutting the wetlands and altering the water cycle of the wetland system. This can cause drying out on one side and flooding on the other side and complete degradation of wetland habitat. Thus the productivity and ecosystem services of the total wetland system will be significantly reduced beyond the project area. This will also be a violation of Section 11 of the Kerala Wetland Conservation Act (GoK, 2008). From the field level inventory, it is observed that about 48 sq. km of aquatic ecosystems will be lost for ecosystem services such as water purification, environmental cleansing, water storage, breeding etc. within the 200 m zone of the project corridor. The district-wise area of wetland and flood plain within 30 m and 200 m zone of impact is given in the Table below. It indicates that the impact due to the loss of aquatic ecosystems will be significantly high, adverse and irreversible to a large extent.

Table 5.11. Flood plain and wetland areas affected within 30m and 200m zone of impact.

	Wetland (Ha)		**Cultivable fallow (Ha)**		**Paddy (Ha)**		**Marshy areas (Ha)**		**Total (Ha)**	
	30m	**200m**	**30m**	**200m**	**30m**	**200m**	**30m**	**200m**	**30 M**	**200 M**
Th'ananthapuram	5.6	30.9	1.5	6.6	4.9	42.1	1.5	6.6	**13.5**	**86.2**
Kollam	50.0	291.7	4.7	32.4	0.6	1.0	4.7	32.4	**60**	**357.5**
Pathanamthitta	26.5	184.3	0.9	4.0	1.7	11.2	0.9	4.0	**30**	**203.5**
Alappuzha	31.4	202.0	1.5	7.7			1.5	7.7	**34.4**	**217.4**
Kottayam	33.7	220.8	15.5	84.7	12.3	74.2	15.5	84.7	**77**	**464.4**
Ernakulam	0.3	1.1	49.5	326.8	33.3	211.1	49.5	326.8	**132.6**	**865.8**
Thrissur	54.2	355.0	21.1	133.1	50.0	310.7	21.1	133.1	**146.4**	**931.9**
Malappuram	24.2	149.6	0	0	32.0	230.7	0	0	**56.2**	**380.3**
Kozhikode	0	0	0.5	7.7	2.5	16.2	0.5	7.7	**3.5**	**31.6**
Mahe	0	0	0	0	0	0	0	0	**0**	**0**
Kannur	2.6	14.4	4.0	39.6	5.2	33.4	4.0	39.6	**15.8**	**127**
Kasaragod	0	0	3.3	31.9	31.2	159.3	3.3	31.9	**37.8**	**223.1**
Total	**228.5**	**1450.0**	**102.5**	**674.6**	**173.4**	**1090.0**	**102.5**	**674.6**	**607.2**	**3888.7**

The proposed rail corridor passes through flood plains to a total length of 208km. As a result, 608 Ha of floodplain area will be impacted within the 30m project corridor and 4034 Ha of floodplain will be impacted within the 200 m impact corridor. The flood plains impacted due to various constructions are given in the table below.

Table 5.12. Flood plains impacted due to various proposed activities (in Ha)

District / UT	Bridges	Cut & Cover	Embankments / Cuttings	Tunnels	Viaducts
Thiruvananthapuram	1.067	0.983	16.134	0	9.254
Kollam	0.841	1.882	24.816	0	13.474
Pathanamthitta	0.396	0.284	21.432	0	2.435
Alappuzha	0.757	0.098	13.379	0	7.857
Kottayam	0.690	1.271	34.206	0.181	14.458
Ernakulam	5.093	2.283	43.558	0.236	32.746
Thrissur	1.007	0.205	61.725	0	48.964
Malappuram	3.269	0.221	46.970	0	6.173
Kozhikode	4.558	0	32.678	1.068	3.381
Kannur	6.154	0.255	64.210	0.158	3.419
Kasaragod	6.072	0.619	66.054	0	1.135
Mahe – UT	0	0	0	0	0
Total	29.904	8.101	425.162	1.643	143.296

The stations and maintenance facilities are proposed to be built on 229 Ha of the land of which 106 Ha (46%) falls into a wetland which will be reclaimed. This is in addition to the wetland reclaimed for a 30 m wide project corridor. The degradation and loss of wetlands including paddy wetlands due to the project corridor will impart a significant adverse impact as the monetary value of the services of this ecosystem is estimated as Rs.22 lakh/Ha for inland wetlands and Rs.107 lakh/Ha for coastal wetlands.

5.5.3. Biological environment

The natural habitat along the track length of about 417 km which excludes the length of the viaduct, bridges and tunnel is expected to get fragmented due to the proposed corridor. However, the fragmentation impact along the track length of 216 km from Tirur to Kasaragod will be marginal. The loss of vegetation area is estimated to be around 1500 Ha which includes the elimination of mangrove forests in 8.35 Ha impacting the ecosystem services significantly. In addition, there will be adverse impacts on 31 Ha of natural vegetation, 55 Ha of mangroves and associates, 61 Ha of sacred groves, 1131 Ha of paddy wetland, and 3532 Ha of aquatic systems affecting both terrestrial and aquatic flora and fauna. The fragmentation of various ecosystems will affect 200 species of aquatic angiosperms of which 12 are threatened and is in the IUCN red list. There will be impact on 250 freshwater species of fish, molluscs and odonates of which 102 are endemic and 42 are threatened according to the IUCN red list. There will also be impacts due to the migration of commercially valuable fishes, such as 'varaal' and 'mushi'. The avian fauna uses wetlands as the nesting and feeding grounds, and many species are listed as endangered in the IUCN red list, and the proposed project would significantly impact the avian biota, which defines the aesthetics of Kerala. The proposed corridor also cut across various Key Biodiversity Areas (KBAs) such as Kavvayi, Peruvamba, Kuppam, Madayipara, Kattampally, Kadalundi, Upper Kuttanad, Ashtamudi, Paravur etc leading irreversible and extremely adverse impacts.

Mangroves protect nearby habitations by preventing erosion, slowing down water flows and encouraging sediment deposition. The complex mangrove root systems help to bind and build soils and filter nitrates, phosphates and other pollutants from the water, improving thewater quality. Mangrove forests capture massive amounts of carbon dioxide emissions and other greenhouse gases from the atmosphere, and then trap and store them in their carbon-rich flooded soils for millennia. This is an important ecosystem service in the backdrop of climate change. Mangrove forests also provide habitat and refuge to a wide array of wildlife such as birds, fish, invertebrates, mammals and plants. It is often an important spawning and nursery territory for juvenile marine species including shrimp, crabs, and many sport and commercial fish species such as redfish, snook and tarpons. Mangroves also act as bird rookeries and nesting areas for coastal wading birds. It provides nature experiences for people such as birding, fishing, snorkelling, kayaking, paddle boarding, and the therapeutic calm and relaxation that comes from enjoying a peaceful time in nature. However, this habitat is facing severe degradation as its spread in Kerala reduced from 70,000 Ha in 1957 to 2500 Ha currently recording a 95% loss. The proposed project corridor is predicted to impact 55 Ha of mangrove patches of which 62% is in Kannur, 16% in Kollam and 14% in Kasaragod.

The total biomass area within the 30 meter project corridor, 50 meter impact corridor and 200 meter impact corridor is 1,602 Ha, 2670 Ha and 10,678 Ha respectively. Correspondingly, the total biomass production is assessed as 1,94,585 MT, 3,21,800 MT and 12,90,042 MT. Metric ton for 30m and 200m impact zone respectively. The carbon sequestration potential estimated is 91,455 MT and 6,06,320 MT respectively for the 30 meter project corridor and 200 meter impact corridor. The loss of this potential will have far-reaching adverse impacts on climate.

5.5.4. Air environment

The air quality of Kerala is known to be good except for an increase in suspended and respiratory particulate matter, that too in certain hotspots. However, during the construction stage, there will be increased emission of particulates, gases like CO2 and other GHGs due to the operation of machinery, transportation vehicles, extraction of construction materials etc. Due to the non-usage of fossil fuels, air quality deterioration is not anticipated during the operational stages. The projected ridership of 80,000 people per day will bring about 40,000 vehicles to the 11 stations enhancing gaseous emissions. The envisaged RORO services during the operational stage will reduce the gaseous emission providing beneficial impacts.

The project will lead to enhanced noise level and vibration impacts during the construction and operation phases. The machinery used during the construction phase will lead to a maximum noise level of 108 dB(A). The individual and combined operation of various machinery will be generating intermittent noise levels much beyond the permissible limit. The different works can generate ground vibration with peak particle velocity ranging from 0.28 mm/s to 45 mm/s against a maximum permissible limit of 15 mm/s at buildings. The vibration with a peak particle velocity of 1 mm/s is noticeable and that beyond 6 mm/s is strongly felt. The noise level and vibration beyond the permissible level can cause sleep disturbance, stress, irritation and annoyance, anxiety etc. This will adversely affect the psychological well-being of the inhabitants and may affect the physical safety of built structures and their users. During the operation phase, there will be increased noise and vibration levels due to traction noise, rolling noise and aerodynamic noise as well as the movement impact. The noise level measured for German HSR at 200 km/hr was over 80 dB(A) at 25 m from the track which is more than the allowed noise levels of 55 dB(A) for residential areas during day time.

Vibration may lead to structure-borne noise in the surrounding built environment and it can lead to safety implications for the buildings. Vibration can generate ground waves which interact with nearby structures and cause cracks. Studies in China and Taiwan indicated that sound and vibration impacts can reach beyond 200 m in the case of high-speed rails. If so, the vibration due to the proposed project will impact 50926 houses, 286 apartments, 62000 facilities and services, 592 institutions and 1148 cultural centres.

5.5.5. Social environment

There will be an economic loss forever due to the conversion of 904 Ha of agricultural land falling in the 30m project corridor. Consequently, the production from 50697 Ha of land within the 200m impact zone will get either lost or severely diminished due to the proposed project. The loss or degradation of agricultural systems including wetlands of differing nature will lead to significant loss of ecosystem values, which is not estimated while assessing the adverse impact, that will be forever. There will be a loss of existing infrastructure and human settlements leading to significant economic loss. This will not be confined to the alignment alone as the impact zone will extend both sides of the alignment based on the magnitude of vibration due to the high-speed movement of the train along different types of alignment structures. The vibration characteristics of the high-speed train are not detailed in the DPR and therefore, the impact zone in different types of geological terrain could not be assessed. There will also be the impact on linear infrastructure i.e., the existing roads and transportation system as many of the existing systems will be lost forever leading to the loss of investment made. Further, there will be a curtailment of movement due to the permanent partition of land due to the elevated rail impacting the livelihood, safety, psychological well-being etc. of the human settlements.

The proposed north-south corridor with an elevated structure of 2 to 8m will lead to an east-west divide across Kerala. The existing transport facilities such as public and private roads will mostly be impacted curtailing the movement of inhabitants. Though it is proposed to provide 65 large and 300 small bridges at 116 locations, it is inadequate even to cover the water bodies. The argument of providing underpasses at every 500m is not pragmatic as it may not provide connectivity to the existing east-west pathways. This will impact the movement of local inhabitants and block their access to their properties and current livelihood. In addition, the existing transport facilities built across Kerala with an investment of crores of rupees will become redundant.

The proposed project will clear off 329 Ha of land within the 30 meter project corridor. As a result, 8465 built-up structures will be demolished within the 30 meter Project corridor. The project will also lead to the loss of utility of 11949 built structures along a 50m wide impact corridor. There will also be a severe adverse impact on 1,14,952 built structures falling in the 200 m impact corridor. There will be a requirement of relocating 72 sacred religious structures within the 30m project corridor and 88 sacred religious structures within the 50 m impact zone. There will be a loss of 677 Ha of sensitive ecosystems comprising floodplains and wetlands which will be totally lost. Considering the impact zone of 200m, the total area of the sensitive ecosystem lost is estimated as 4476 Ha.

The continuum of natural landform and landscape with undulating hills, forests, rivers, backwaters, canal network, paddy fields, and vegetation provide the aesthetics that sustain the beauty of the State. Part of the track length of about 314 km extending from Murukkumpuzha (Thiruvananthapuram) to Tirur will severely affect the aesthetics by positioning the track and the embankments as an eyesore. This includes 12 ha of mangroves and a 40 km stretch of marshy area. The sector from Tirur to Kasaragod (209 km) is adjacent to the existing train track and the additional impact on aesthetics is limited except due to embankments. There will also be severe obstructions to social communications expected for more than 50000 families staying within 200 m of the track. Socialising with friends and families will be affected because of the Silverline track and embankments. There are over 7000 other establishments including religious, cultural and educational establishments which drive social communications and relationships. It takes more time, money and travel to reach through the underpasses for access to friends and relatives and other establishments which may restrict regular interactions and visits undermining the social fabric of the local societies. This will be more severe in the sector from Murukkumpuzha to Tirur.

The studies revealed that the 202 km length of the project corridor is flood-prone affecting 608 Ha of fertile land within the 30m project corridor and 4034 Ha of within the 200 m impact corridor. Only 50% of the flood-prone stretch is covered with viaduct indicating that 101 km of the project corridor will block the storm waters causing significant adverse impacts. The urban heat island intensity of the State increased by a factor of 4.3 in 2019 consequent to the increase in built-up area. The State recorded a built-up area of 17% in the year 2002 which increased to 23% in 2013. Considering that the number of weather-related disasters increased by a factor of 5 over the last 50 years worldwide and the wetlands that absorb the flood waters are lost or fragmented due to the project corridor, the adverse impacts will be extremely severe.

Chapter VI – Highlights, Conclusion and Recommendations

The main highlights from the People's Participatory Environmental Impact Assessment carried out by the Kerala Sasthra Sahithya Parishad are:

- About 73% of the project area falls in flood plains. The landform, land use, soil characteristics and natural hazard scenario of the project area indicate that the land environment is highly fragile and the land stability is highly vulnerable.
- The reversible and irreversible impacts due to loss of land, livelihood, community resources etc., and displacement due to land acquisition and dismantling of structures will be extremely severe and adverse.
- The total biomass along the SilverLine track is assessed as 1,94,585 MT, 3,21,800 MT and 12,90,042 MT for 30 m, 50 m and 200 m impact zone respectively. The carbon sequestration potential estimated is 91,455 MT and 6, 06,320 MT respectively for 30 m project corridor and 200 m impact corridor, which will be lost permanently/partially.
- The DPR has failed to provide sufficient data support to prove the project is green. Carbon savings based on overestimation of ridership due to shifted traffic volume to rail is unrealistic.
- The floral diversity that will be affected includes species under the red-list category and 50 species under the endemic category. Flora that will be affected includes mangrove species and their associates spread for about 55 ha.
- About 37% of the mammal diversity in the region through which the rail alignment passes are reported vulnerable. 47 threatened fishes are reported from the project area, out of which 2 are critically endangered, 27 are endangered and 18 are vulnerable species.
- In house production and purchase of green energy from other sources for the projected requirement of green energy, as proposed by K-Rail – SilverLine is not substantiated. With an 80% dependence of the country on coal and oil based fuel, purchase of green energy from other sources is not viable.
- The impact zone of SilverLine is characterized by high density of population, high remittances from trade and services and other major economic activities including agriculture, micro, small and medium industries, marine and inland fishing, tourism, etc.
- The impact potential during the project construction phase is (-) 45.08 which is interpreted as appreciably adverse as the activities proposed during the phase will lead to

irreversible modification to various environmental aspects, particularly to land, water, ecological and social environments.

The K-Rail – SilverLine project of the KRDCL and its impacts on the environmental, social and financial system of the State as studied by KSSP is consolidated and given below in brief.

The Government of Kerala proposes to develop a semi-high-speed rail connectivity namely K-Rail-SilverLine from Thiruvananthapuram to Kasaragod as an alternative solution to the increasing congestion in the road transport network of Kerala that may even become worse in the coming years. This has triggered serious discussions on its financial, environmental and social impacts. The KSSP also discussed the matter in detail and decided that it is necessary to assess the implications of the project on the environmental, social and economic systems of the State to take an informed view of the environmental damages that may affect the environmental sustainability of the State. Thus, the KSSP has undertaken this study with the participation of its volunteers, and scientist and technologist members. More than 1000 volunteers from the localities through which the rail is planned and about 25 scientists and technocrats took part in the study.

The proposed K-Rail – Silver Line is planned along the entire stretch of Kerala from Thiruvananthapuram to Kasaragod for a distance of 529.45 km (Thiruvananthapuram station centre to Kasaragod station centre) with a maximum operating speed of 200 km/hr. This project is being executed by K-Rail Development Corporation Ltd (KRDCL), a joint venture by Govt. of Kerala and the Ministry of Railways, Govt. of India. As per the proposal, the K-Rail will ease the transport between the north and south ends of the State and decrease i) the travel time to 4 hours, ii) road accidents substantially, iii) traffic congestion and iv) carbon emissions. In addition, the rail leads to job creation, development of new townships and better tourism facilities.

The KRDCL prepared the DPR and a rapid EIA report in 2020 and initiated the preparation of a comprehensive EIA. As per the DPR, the estimated cost of the project is Rs 63,940.67 crores which is planned to be mobilised through public-private partnership. From the DPR, it is understood that the project activities include the construction of 529.45 km long rails which consists of 292.73 km long embankments, 101.74 km cuttings, 88.41 km viaducts, 24.79 km cut and cover, 12.99 km bridges, 11.53 km tunnel, 11 stations, 2 maintenance depots, 4 ballast depots, RORO stations and numerous underpasses. The land requirement is 1421.26 ha of which 189.80 ha belong to railways.

The DPR says that 10,349 buildings/structures are likely to be affected. It also recommends that the State government may freeze construction activities within 30 m of the centre of the alignment.

The project evoked heated and fierce public discussions and political protests in the State. This was mainly on account of the stand-alone nature of the railway line; the standard gauge which cannot be integrated into the existing railway network; the possible environmental and social impacts of the project; the inaccuracies in the project budget and business plan; the underestimated budget; uninformed and intrusive survey procedure; and many other technical deficiencies of the DPR.

The KSSP studied the DPR in detail and pointed out 20 major deficiencies in the DPR in addition to various environmental, social and economic discrepancies.

Since the concern about the environmental impact of such a big project is extremely high in the background of the environmental fragility of the region through which it passes, the KSSP decided to conduct a participatory environmental impact assessment (PPEIA) involving trained volunteers and relevant subject experts and economists, technocrats and environmentalists who have been meticulously following the various aspects of the project.

The methodology adopted involved environmental and social assessment of the impact zone of the project based on participatory field level data collection, interpretation of remotely sensed data and geospatial analysis, delineation of critical environmental aspects of the impact zone and project activities and impact assessment using Leopold Matrix Method. The methodology for the study was developed by an Expert Committee considering different aspects and methods of environmental impact assessment.

The study does not include the complete steps and procedures of a comprehensive EIA but it systematically documented the ecological and social characteristics of the regions where the project is proposed through a field survey, studied the proposed activities at each location using the DPR, and analysed the possible impact of the specific activity at the specific region using geospatial techniques.

The attempt is to understand from a people's perspective, the possible environmental damages, hazard possibilities and social problems that could arise due to the implementation of the project. The baseline environmental status is assessed through field visits by the trained volunteers, selected inventories by the subject experts, geospatial analysis of satellite imageries, secondary data collected from relevant reports and a detailed literature search.

The important findings from the study are discussed below;

The project area mostly falls in the lowland and midland terrain of the State where the landscape is characterised by coastal plain, flood plains, alluvial plains, valley floors, low rolling terrain, moderately undulating terrain, laterite mesa, waterlogged areas, etc. The water-logged areas include rivers, paddy fields, estuaries etc. The land required for the track (1082 ha) includes low land such as paddy wetland (55%), hills/ridges (26%), valley floor (16%) and water course (3%). The land required for construction of stations (229 ha) includes plain land (27%), wetland (47%) and inhabited plain (26%).

In addition, service roads require another 76 ha of land. The land use along the project area is characterised by agriculture, settlements and homesteads, other built-up infrastructures, barren land, marshy areas, etc. The land use inventory along the proposed alignment indicates 53% wetlands including ponds, chira and backwaters, 11% of marshy stretches, 9% of cultivated paddy land, 11% of uncultivated paddy land, 2% of mangroves, 1% of sacred groves, 1% of natural vegetation and 12% of hilly tracts with sparse vegetation. About 73% of the area falls in flood plains. The landform, land use, soil characteristics and natural hazard scenario of the project area indicate that the land environment is highly fragile and the land stability is highly vulnerable.

The terrain through which the project is proposed is characterised by the distributaries of 28 rivers, a chain of 27 estuaries and 7 lagoons lying parallel to the coastline and mostly interconnected natural and man-made canals. The alignment crosses 96 first-order streams, 72 second-order streams, 25 third-order streams, 18 fourth-order streams and 28 river stretches in addition to backwaters. The river flow in all the rivers in Kerala is reducing significantly during summer and in six rivers it is reducing even during monsoon. But the flood impact of rivers due to erratic rainfall and the chemical and bacteriological pollution of water bodies due to reduction in river flow and indiscriminate industrial and sewage discharges are found extremely severe. The project area is also characterized by lowering groundwater potential and yield due to indiscriminate development including mechanized pumping without considering sustainable yield characteristics.

The floral diversity along the proposed alignment is rich and has characteristics of the coastal and midland zones of Kerala. The riparian flora in the area is dominated by herbs followed by trees, climbers and shrubs. Almost 55% of the herbs are aquatic or semi-aquatic confined to rivers, marshes, paddy fields, ponds etc. The trees and shrubs include mangrove species and their associates. The flora also included cultivated species and exotic species and 39% of the exotic species are reported as invasive. The floral diversity also includes species under the red-list category and 50 species under the endemic category.

The majority of the area under the proposed rail corridor is cultivated and abandoned paddy fields, homestead gardens with coconut, areca nut and trees with very high timber value and plantations dominated by Rubber. Patches of mangroves with rich species diversity are dominantly seen towards the northern portion of the impact zone. The faunal diversity of the project area is dominated by freshwater fishes and birds as the project area stretches through wetlands of international importance, rivers, estuaries, paddy fields, etc. About 37% of the mammal diversity in the region is reported vulnerable. 47 threatened fishes are reported from the project area, out of which 2 are critically endangered, 27 are endangered and 18 are vulnerable species. The area is also known for insects and reptile diversity as well as a large number of vertebrate species. 7% of the vertebral species are reported in the threatened category of which 11% are critically endangered, 44% endangered and 45% vulnerable. The livestock population in the region also exhibited a declining trend.

The air quality in the project area is characterised by an increasing trend of respirable suspended particulate matter (RSPM), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2), particularly due to the high road traffic density, especially in the coastal side of the State. The area experiences good visibility throughout the year. The noise level in the project area will also be very high consequent to the higher traffic density, industrial and commercial activities and urban agglomeration.

The project is envisaged through human habitation with a very high density of population and built structures including infrastructure facilities in the coastal and adjoining areas of the State. The impact zone is also characterized by high remittances from trade and services and other major economic activities including agriculture, micro, small and medium industries, marine and inland fishing, tourism etc.

The aesthetic aspects of the project impact zone which are characterized by very long coastal tracts, beaches, backwaters, lakes, and riverine network in the project area are known for its tourist attractions, internationally. The aesthetics of the project area is also due to the presence of historical and archaeological locations of importance in and around the project area.

The physical safety aspect of the project impact zone is also a serious concern due to increasing communicable diseases, accidents, road and traffic safety, natural hazards such as flood, coastal erosion, lightning etc., crime and violence etc. The uncertainties in the income, livelihood, basic services etc. of the habitation in the impact zone are found to seriously affect the psychological well-being of the local people.

The impact assessment of the project is essentially a cause-effect analysis in which the causative factors are the activities involved in the project and the effect is the impact on various environmental, social and economic aspects of the project impact zone. To assess the project impact, five activities of the project during the planning phase and 12 activities during the implementation phases are identified. The magnitude of these activities is assigned on a scale of 1-5 based on the details given in the DPR. During the operation phase, most of the activities are routine in nature and an impact assessment for this phase is not attempted due to lack of information available for this phase. As required, 22 environmental aspects of significance to the project site and surrounding impact zone are delineated based on the inference from the baseline environmental studies and their level of significance or importance to the overall environmental settings of the impact zone is assigned in the scale of 1-5.

It is inferred that during the Planning phase, there will not be a significant alteration of land or removal of vegetation or built structures as there will only be minimal intrusive activities. The adverse impact on socio-economic aspects will be very high, especially due to the land acquisition, uncertainties, virtual division of land parcels and cultural discontinuity affecting local area development.

Though the land area required for the project is estimated as 1,383 ha excluding the area required for service roads, there will be peripheral encroachments, demolition of about 10349 structures/buildings (as per the DPR) and severe structural impacts on buildings and built structures of about 1,19,340 within the 200 m zone. The reversible and irreversible impacts due to loss of land, livelihood, community resources etc., and displacement due to land acquisition and dismantling of structures will be extremely severe and adverse.

Further, the fragmentation and transformation impact on the ecosystem will also be irreversible, very severe and adverse. The psychological impact on the affected population will also be very severe and adverse due to uncertainty, apprehensions, lack of transparent actions, misinformation, anxiety etc.

The construction phase commences with the clearing of vegetation, land modification, landfilling, reclamation of wetlands etc. leading to the loss of biological diversity, destruction of habitat, and possible extinction of species of restricted distribution and local genotypes. The fragmentation of land will lead to the separation of contiguous areas of habitat creating small isolated populations with limited gene flow between populations, situations of inbreeding depression and reduced potential to adapt to environmental change, loss or severe modifications of the interactions between species, including those interactions that are important for the survival of species.

Small isolated populations may be subject to local extinction from stochastic events. The hostility of the surrounding (cleared) environment is a major factor in limiting the movement of organisms between patches. There will also be bank erosion, sedimentation, reduced nutrient filtering capacity and changes to stream behaviour, increased emission of greenhouse gases etc. Demolition can lead to excessive dust, noise, smoke, odour and possibly asbestos dust. Blast demolition enhances the health risk factor of inhabitants in the area due to the concentration of particulate matter, particularly breathable particulates. The risk factor enhances if the structures have asbestos in their composition.

Earthwork and construction of embankments, viaducts, bridges and buildings (for stations and depots) and cutting, cut and cover and tunnelling result in the modification of landform patterns can have an adverse impact on the visual coherence of the area through the degradation or, in some cases, removal of a natural landform. Three stations are to come up in wetlands enhancing the requirement of earthwork and consequent adverse impacts. The increased siltation of the water bodies and deteriorated water quality reduces the carrying capacity of the impact zone and increases the hazard potential such as flooding.

Earthwork activities have also the potential to alter, disturb, modify or destroy heritage or archaeological sites. The impact due to material extraction and transportation will be very high and mostly irreversible as the impacts include land degradation, the possibility for landslides and land subsidence, air and water pollution, occupational noise pollution, loss of biodiversity, loss of hydraulic continuity etc. are common while quarrying.

The impacts due to blast and consequent vibration will also be extremely high as the density of houses and buildings are very high. According to various studies, each square meter constructed will result in an average emission of 0.5 tons of carbon dioxide and an energy consumption of 1,600 KWh (which will vary depending on the design) if only the material impacts are taken into account. Most of the transportation will be using trucks which will have a very high emission factor of 0.1693 kg of CO_2 per ton-mile. The transportation will also lead to severe traffic congestion as many of the roads are narrow and the traffic density in Kerala is generally high. The typical noise level generated by trucks is 82-94 dB(A) which is higher than the permissible level.

The claim of SilverLine project as green is mainly based on traffic shift from road to rail which is a highly overestimated figure. The projection of the expected number of passengers as 79,900/day is a clear overestimation when compared with the projection of 40,000/day for the Mumbai-Ahmedabad bullet train project, connecting the two busiest cities in India. Carbon emission based on overestimated passengers and reduction in vehicles number is unrealistic.

The DPR itself mentions that the projected emission reduction is feasible only if there is a strong certainty that the traffic diversion volumes will be significant. The above figures accounts only for the emissions once the SilverLine becomes operational. It has not accounted for emissions during the construction phase which includes railway lines, tunnels, bridges, stations, rolling stocks, service roads, townships, etc. The ‘green project claim’ becomes hollow with such overestimation of passengers and reduction in vehicles on road.

Power (green energy) requirement of SilverLine which is 279 million units of electricity for operational purposes in 2025-26, 321 million units in 2032-33, 427 million units in 2042-43 and 497 million in 2052-53, is proposed to be sourced through in-house production, purchase from third party and KSEBL. Presently the solar energy production of Kerala is negligible when compared to the demand as given above. Details of how Kerala will purchase green energy from third party are not given.

It is also a well-known fact that about 80% of the country’s energy currently comes from coal, oil and water sources and the claim that green energy will be purchased from third party seems to be unrealistic. The KSEB does not have any proposal for major projects to increase its investment in renewable energy, without which it won’t be able to supply the required green energy. Green energy is also proposed to be produced from solar panels installed across corridors, via- duct walls, stations and depots. However other than this general statement, DPR does not provide a realistic explanation how much power will be generated and exact locations of these installations.

Other general statements like green protocol for building constructions, solar energy for staff quarters, stations, etc., use of LED lights, rain water harvesting, etc. have also been projected for claiming the project to be green. With such infirmities in the statements the project could not be called green. SilverLine project will have to use conventional energy sources to alarge extent which cause about 3-5 lakh metric tonnes of carbon emission every year. It is very clear that the operation of SilverLine rail system using green energy is not going to happen in the near future.

The requirement of water during the construction phase is projected as 30MLD at the construction sites and labour camps and the demand is distributed all along the alignment and the withdrawal will be from the nearest fresh water source. There will be an inflow of migrant labour which will lead to feelings of insecurity among the residents due to the intrusion of insular culture.

The additional inflow of people to the site will lead to overloading on the local facilities and essential services such as health, water supply and sanitation, transportation etc. Prevalence of exploitation mentality, mingling of cultures, possible vandalism and fighting etc. are also to be anticipated. Amidst these adverse impacts, there will be increased local economic activity due to increased monetary inflow to the locality. The construction sector is known to contribute 23% of air pollution, 50% of climate change factors, 40% of drinking water pollution and 50% of landfill wastes. ISO 2631-1 suggests that the vibration peak acceleration of 0.015 m/s2 is an acceptable vibration level for building occupants. As per studies, the ground vibration and air blast at sensitive sites must not exceed 5 mm/s and 115dB (Lin Peak) respectively. The piling work can generate ground vibration with peak particle velocity ranging from 12 mm/s to 35 mm/s against buildings' maximum permissible limit of 15 mm/s.

The impact potential during the Project planning phase, assessed using Leopold matrix method, indicated that it is (-) 12.84 on a normalized scale of 0 to 100 which is interpreted as minimally adverse. The impact potential during the Project construction phase is (-) 45.08 which is interpreted as appreciably adverse as the activities proposed during the phase will lead to irreversible modification to various environmental aspects, particularly to land, water, ecological and social environments.

Kerala, as a whole, is known as fragile state of the environment with its environmental carrying capacity constrained due to various limitations, particularly, land, the density of population, increasing anthropogenic pollution, natural disasters such as coastal erosion, drought, flood, landslides, soil piping, lightning etc. and climate uncertainties. The proposed project is aligned through the coastal and the lowland-midland interphase region which is considered to be the most constrained zone concerning dwindling environmental carrying capacity. The appreciable adverse environmental impact predicted due to the project, that too, mostly irreversible nature of the impact, is detrimental to the connecting ecosystems and such a scenario is highly undesirable. It indicates that the Project is highly unviable from an environmental point of view.

The main conclusions are summarised below:

1) The impact potential during the Project construction phase, assessed using Leopold matrix method, is (-) 45.08 which shows it is appreciably adverse. Activities proposed during the construction phase will lead to irreversible modification to various environmental aspects, particularly to land, water, ecological and social environments.

2) It has been amply demonstrated that the expected expenditure for K-Rail-SilverLine will significantly increase the public debt burden. The situation is more alarming with the observation of NITI Ayog that the projected cost estimate of K-Rail-SilverLine of Rs.63940.67 crore by KRDCL is grossly underestimated and the actual cost would be about Rs. 1.26 lakh crore.

3) K-Rail – SilverLine alignment removes green biomass of 19,4585 M tons at 30 m width whereas 200 m width, the value is enhanced to 1,29,0041 M tons. When biomass value is converted to carbon sequestration potential, the value changed to 91,454.20 M tons of carbon at 30 m width and 6,06,320 M tons at 200 m width. It has detrimental impact on carbon sinks. Added to this is the increased carbon emission due to the proposed township development at 10 stations, associated infrastructure like approach roads and reconstruction of demolished buildings. Removal of huge quantities of green biomass during the construction phase and new sources of carbon emission during the operational phase elucidate that the project will not reduce carbon emission as projected in the DPR.

4) The DPR has failed to provide sufficient data support to prove the project is green. Carbon savings based on overestimation of ridership due to shifted traffic volume to rail is unrealistic. Similarly, the carbon emission is not scientifically worked out. Sources of green energy production is not clearly mentioned with details. No detailed study is conducted to assess carbon sink due to clear-felling of vegetation along alignment route. It is clear that KSEB or other private or public sources in Kerala do not have solar installations so far for the supply of total 279 million units (2025-2026) of green energy used in train operations in the initial phase of SilverLine project (1554 million units of electricity will be utilized for 2025- 2052 period). The claim of SilverLine project as green is mainly based on traffic shift from road to rail which is only a hypothetical estimation without giving sufficient scientific data base. Therefore, the contention that the SilverLine SHSR is a green project is highly unrealistic.

5) The present assessment indicates that the project is going through the habitat of 47 IUCN-threatened fishes of which 37 shall face serious threat with this project and 10 partially. This includes two Critically Endangered (CR) fishes, 27 Endangered (EN) and 18 Vulnerable (VU) species. The DPR has ignored this very important aspect which is crucial for biodiversity conservation. The critical ecosystems such as mangroves, sacred groves and lateritic hills are subjected to irreversible damages due to the proposed project.

6) The proposed rail line crosses 261 streams of different order including rivers and the proposed embankments will obstruct the flood plains. The total area of the floodplain that could be affected by the proposed alignment with a width 30 m is estimated as 607.67 ha and that of 200 m width is 4033.70 ha. Flood levels in these segments reach up to 15 to 20 m. There are many perennial streams, but no bridges are proposed in the DPR. These will exasperate the flood impact, as was felt during the 2018 floods. The given DPR is very moderate in assessing such damages.

7) About 263 km of the SilverLine stretch passes through loose sediments. The ground stability has not been properly addressed in the DPR.

8) Drainage blockage and impediments to the free flow of water and impacts due to fragmentation of landscape have not been addressed properly from a climate change perspective.

9) Kerala should consider less capital-intensive options to improve public transport, especially the existing railway system. Modernising the signal system and straightening existing and new lines could significantly increase train speeds and reduce travel time. This would reduce the project's cost and ensure interoperability with the Indian Railway system. The Indian Railway has already initiated the process of modernising signals and straightening rail lines with the recent introduction of the Vande Bharat Express, an Indian made semi-high-speed train. It has also begun laying a third line designed for semi-high-speed trains. The Detailed Project Report should have considered these alternative options, including the possibility of an additional fourth line. This would have provided an alternative for comparison of impacts and costs, which is a critical function of a DPR.

10) A total of 8,085 buildings are falling in the 30 metre buffer zone and 55,426 buildings are falling under the 200 metre buffer zone. These buildings include houses, flats, facilities and services, institutions, and cultural amenities. There is more than 1,031.45 Ha of paddy, 1012.18 Ha of rubber, and 1,928.29 Ha of mixed agriculture along the rail line. With the above background, it is sure that the construction activities planned under the SilverLine project may cause substantial disturbance to the livelihood activities and income of a large section of people and cause significant modifications to the geomorphology and ecosystem and cause fragmentation of landscapes.

11) Over 50,000 families residing within 200 meters of the track will experience severe disruptions to their social interactions. Additionally, over 7,000 establishments, including religious, cultural, and educational institutions, play a vital role in fostering social connections and relationships within this area. The SilverLine track and embankments will hinder socialising with friends and families through frequent visits and close interactions. This restriction on regular interactions and visits could potentially undermine the social fabric of local communities. A comprehensive study on community

isolation caused by transit cut-off, leading to social backwardness, is essential and should be undertaken seriously. Since the SilverLine traverses an entirely new path from Murukkumpuzha to Tirur, the social impacts could be more pronounced in this alignment, even though less built-up area appears to be directly affected. These critical aspects of the socio-economic well-being of the people are not adequately addressed in the DPR.

A critical review of the DPR has revealed that it is incomplete and defective. The KRDCL should not have proceeded with such an incomplete and defective DPR to initiate the implementation process of such a major project. The DPR should be reviewed and revised to address all shortcomings before proceeding with the project.

The appreciable adverse environmental impact predicted due to the project, which is mostly irreversible in the nature of impact, is detrimental to the connecting ecosystems and such a scenario is highly undesirable for a State like Kerala in the context of climate change. It indicates that the Project is highly unviable from an environmental point of view. The DPR does not adequately address the environmental impact of the project. Also, given the scenario of permanent destructions to existing bio mas and environment, the claim of a green project is not adequately substantiated in the DPR.

The environmental and socio-economic aspects have been grossly underestimated in the DPR. It means that the true costs of the project are not being fully accounted for.

Considering the above, the State Government may reconsider its earlier decision to embark on the K-Rail – SilverLine project in its present form.

Kerala should consider less capital-intensive options to improve public transport, especially the existing railway system. Alternate options like modernising the signal system and straightening the existing and new lines to increase speed have been suggested. Railways have already initiated the work for a third line which is expected to be designed for semi-high-speed trains like Vande Bharath. The State should seriously consider the viability of alternate options suggested, including the possibility of an additional fourth line, which will considerably reduce the cost of the project and also ensure interoperability with the existing network of the Indian Railway system.

Annexure 1: List of Tables

Annexure 2: List of Maps

Annexure 3: K-Rail – SilverLine PEIA Analysis Tables (Additional)

Table A1: Detailed Lithological characteristics of the project area (Annexure II)

Dist/ UT	Lithology	Length (KM)	Area (In Ha)	
			30 M buffer	200 M Buffer
Thiruvananthapuram	Garnet Gneiss	1.33	4.00	26.23
	Quartzite	0.17	0.49	1.55
	Sand (Active Channel)	8.57	25.72	170.11
	Terri Sand	11.99	35.98	247.16
	Sandstone	6.22	18.63	114.15
	Pyroxene Granulite	0.38	1.10	5.93
	Gar-Bio-Sill Gneiss + Graphite + Kyanite	10.29	30.93	214.95
Kollam	Sand (Active Channel)	10.10	30.13	185.21
	Pebble Bed	0.12	0.36	2.14
	Sandstone	20.16	60.63	419.46
	Garnet-Biotite Gneiss			2.55
	Biotite Gneiss	2.21	6.63	43.46
	Acid To Intermediate Charnockite	0.18	0.55	3.61
	Pyroxene Granulite	0.26	0.76	4.89
	Gar-Bio-Sill Gneiss + Graphite + Kyanite	6.07	18.20	120.41
	Garnet-Sillimanite-Gneiss +Graphite+Cordierite	3.76	11.27	74.05
Pathanamthitta	Sand (Active Channel)	3.02	9.55	62.64
	Sandstone	1.53	4.59	31.25
	Hornblende-Biotite Syenite	1.57	4.70	32.61
	Biotite Gneiss	0.51	1.54	10.83
	Acid to Intermediate Charnockite	13.93	41.79	277.53
Alappuzha	Sand (Active Channel)	4.44	13.79	88.91
	Sandstone	5.85	17.55	118.89
	Hornblende-Biotite Syenite	1.00	3.00	18.74
	Acid to Intermediate Charnockite	7.70	23.09	155.30
Kottay	Sand (Active Channel)	7.83	24.01	155.93
	Garnet-Biotite Gneiss	6.30	18.91	127.00

am	Cordierite Gneiss	0.30	0.90	5.50
	Acid To Intermediate Charnockite	34.17	102.43	688.39
Ernakulam	Sand (Active Channel)	10.59	32.23	221.46
	Clay (Palaeo Tidal Flat)	4.63	13.87	89.84
	Sand	0.19	0.57	4.32
	Laterite	1.54	4.60	31.53
	Biotite Gneiss	3.04	9.11	59.69
	Acid To Intermediate Charnockite	31.81	95.45	630.34
Thrissur	Sand (Active Channel)	32.15	96.68	629.96
	Laterite	1.78	5.32	31.75
	Biotite Gneiss	19.59	59.10	401.93
	Acid To Intermediate Charnockite	13.63	40.80	282.80
Malappuram	Sand (Active Channel)	18.47	56.07	395.14
	Clay (Palaeo Tidal Flat)	0.18	0.54	3.00
	Terri Sand	22.85	68.51	441.27
	Laterite	0.58	1.74	11.70
	Acid To Intermediate Charnockite	11.57	34.59	224.90
Kozhikode	Sand (Active Channel)	6.93	21.23	141.22
	Clay (Palaeo Tidal Flat)	4.24	12.73	85.07
	Clayey Sand	32.86	98.62	656.71
	Pebble Bed	1.05	3.17	20.89
	Terri Sand	10.73	32.21	215.73
	Sandstone	0.71	2.14	13.88
	Hornblende Gneiss	0.99	2.98	19.83
	Hornblende-Biotite Gneiss	7.04	21.15	139.58
	Biotite Hornblende Gneiss	6.96	20.89	139.68
	Acid To Intermediate Charnockite	3.37	10.10	66.78
	Banded Iron Formation	0.10	0.30	2.05
Kannur	Grey Fine Sand (Active Beach Ridge)			1.92
	Sand (Active Channel)	23.6	71.24	480.77
	Clay (Palaeo Tidal Flat)	2.33	6.85	43.36
	Clayey Sand	7.68	22.94	151.95
	Sand	1.50	4.61	31.19
	Sandstone	6.34	19.04	126.66

	Laterite			1.04
	Hornblende-Biotite Gneiss	8.05	24.39	162.53
	Biotite Hornblende Gneiss	9.67	29.01	186.50
	Grey Hornblende Biotite Gneiss	0.87	2.64	14.68
	Banded Iron Formation	0.17	0.50	2.54
	Sillimanite-Kyanite-Quartz Schist	0.79	2.38	23.39
Kasaragod	Grey Fine Sand (Active Beach Ridge)			1.19
	Sand (Active Channel)	26.21	79.34	527.05
	Clayey Sand	4.82	14.46	100.71
	Sand	11.94	35.63	229.54
	Acid To Intermediate Charnockite	7.90	23.71	161.76
	Granite Gneiss	2.58	7.73	51.14
UT-Mahe	Sand (Active Channel)			0.56
	Hornblende-Biotite Gneiss	0.61	1.71	11.05

Table A2. Geomorphology of the area through which the proposed rail line passes

District/UT	**Landform**	**Length (KM)**	**Area (Ha)**	
			30 M Buffer	**200 M buffer**
Thiruvananthapuram	Coastal Plain	10.10	30.44	202
	Pediment Pediplain Complex	28.21	84.94	566.75
	Quarry and Mine Dump	0	0	0.91
	Waterbodies-Other	0.31	0.93	6.64
	Waterbody - River	0.18	0.53	3.79
Kollam	Flood Plain	1.81	5.37	29.96
	Pediment Pediplain Complex	40.21	121.21	809.86
	Waterbodies-Other	0.08	0.21	1.6
	Waterbody - River	0.57	1.73	14.35
Pathanamthitta	Flood Plain	0	0	0.47
	Pediment Pediplain Complex	20.38	61.43	409.37

	Waterbody - River	0.25	0.74	5.01
Alappuzha	Flood Plain	1.12	3.35	21.61
	Pediment Pediplain Complex	15.19	45.74	9.73
	Waterbodies-Other	2.76	8.31	54.84
Kottayam	Flood Plain	3.70	11.09	75.34
	Pediment Pediplain Complex	44.38	133.73	886.94
	Waterbody - River	0.46	1.42	14.53
Ernakulam	Flood Plain	6.17	18.84	138.27
	Pediment Pediplain Complex	41.53	125.1	831.44
	Waterbody - River	4.02	11.87	67.47
Thrissur	Coastal Plain	0.47	1.42	9.73
	Flood Plain	16.54	49.87	325.35
	Pediment Pediplain Complex	48.82	146.92	986
	Water Bodies-Other	0.12	0.11	1.17
	Waterbody - River	1.19	3.58	24.18
Malappuram	Coastal Plain	19.51	58.96	407.03
	Flood Plain	8.84	26.58	173.72
	Pediment Pediplain Complex	24.63	74.11	483.95
	Waterbody - River	0.61	1.81	11.31
Kozhikode	Coastal Plain	27.93	84.16	557.36
	Flood Plain	6.48	19.59	126.74
	Pediment Pediplain Complex	38.91	117.19	785.7
	Water Bodies-Other	0.23	0.68	3.77
	Waterbody - River	1.27	3.88	27.86
Kannur	Coastal Plain	20.48	61.66	406.1
	Flood Plain	1.75	5.26	37.18
	Low Dissected	0.03	0.08	0.55

	Hills and Valleys			
	Low Dissected Plateau	0.94	2.84	19.88
	Pediment Pediplain Complex	34.03	102.62	683
	Waterbody - River	3.67	11.15	79.82
Kasaragod	Coastal Plain	40.88	122.96	801.8
	Flood Plain	3.07	9.23	61.42
	Low Dissected Plateau	0.30	0.91	6.32
	Pediment Pediplain Complex	7.79	23.72	172.54
	Water Bodies-Other	0.20	0.59	4.23
	Waterbody - River	1.46	4.42	31.98
UT-Mahe	Pediment Pediplain Complex	0.61	1.71	11.6

Table A4. Crop Area from GIS Analysis

District	Vegetable		Pineapple		Fish farming		Rubber		Pokkali		Paddy		Mix-Agriculture		Coconut		Banana	
	30 M	200 M	30 M	200 M	30 M	200 M	30 M	200 M	30 m	200 m	30m	200m	30m	200m	30m	200m	30m	200m
TVM	0.1	0.4	0	0	0.1	0.4	43.6	292.6	0	0	4.9	42.1	90.3	567.9	3.3	15.4	0	0
KLM	2.0	15.2	0	0	2.0	15.2	76.0	508.6	0	0	0.6	1.0	72.6	465.6	1.7	15.0	0	0
PTA	0	0	0	0	0	0	56.1	358.0	0	0	1.7	11.2	34.2	229.3	0	0	0	0
ALP	0	0	0	0	0	0	54.9	374.6	0	0	0	0	20.5	146.4	0	0	0	0
KTM	3.4	15.5	0.3	0.77	3.4	15.5	88.0	590.8	0	0	12.3	74.2	102.0	697.8	2.2	11.4	2.5	9.3
EKM	0	0.5	1.2	6.92	0	0.5	76.0	476.3	0	0	33.3	211.1	74.3	484.3	0	1.5	2.7	27.4
TSR	1.3	12.1	0	0	1.3	12.1	7.4	38.6	0	0	50.0	310.7	148.8	921.1	26.2	186.9	0.8	7.3
MPM	0	0	0	0	0	0	0	0	0	0	32.0	230.7	142.3	977.4	45.5	360.9	0	0
KKD	0	0	0	0	0	0	0	0	0	0.3	2.5	16.2	168.6	1199.9	35.3	270.5	0	0
Mahe	0	0	0	0	0	0	0	0	0	0	0	0	1.7	8.5	0	0.0	0	0
KNR	0	0	0	0	0	0	0	0	1.1	7.5	5.2	33.4	160.2	877.3	69.1	444.2	0.2	0.5

KGD	0	0	0	0	0	0	0	0	0	0	31.2	159.3	74.7	533.3	56.0	445.5	0	0
Total	**6.8**	**43.7**	**1.5**	**7.7**	**6.8**	**43.7**	**402.0**	**2639.5**	**1.1**	**7.7**	**173.4**	**1090.0**	**1090.3**	**7108.8**	**239.2**	**1751.5**	**6.2**	**44.5**

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