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Linking Road to Logistic Progress in Kerala: An Analysis of the Influence of National Highway Development on Supply Chain and Logistics

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Abstract: ***This paper examines the effects of national highways developmental schemes toward logistics and supply chain management in Kerala. As seen in the geographical structure and economy dependency on transportation channels in the case of Kerala the establishment of high-standard highways plays an important role in efficiency in the logistics activities. Therefore, this study adopted secondary data from government bodies and industry publications to assess how current advancements in highways, including the extension of the National Highway 66, affects transit time, logistics cost and general supply chain performance on various products. The results indicate a rapid and consistent increase in transportation time, and decrease in the cost and delivery reliability thus promoting Kerala's economic development. From these outcomes it is clear that additional investments in physical capital are still necessary to sustain a favourable transport logistics position.***
Keywords: Kerala, Logistics, National Highway, NH 66, Supply Chain

I. BACKGROUND

Kerala's economy is run by the logistics sector, which is the backbone that binds agriculture, manufactures and retail activities. Kerala's narrow geography stretches along the Arabian Sea to the Western Ghats, in combination with a high population density, arguably necessitates efficient and timely transportation infrastructure (Nair & Pradeep, 2021). Thus, roads and highways let worth a smooth chain in order to help the road of good from local intake as well as outward moving, for that reason. National Hwy. 66 (NH66) is also very critical which extends along the length of the western coast of Kerala, linking up major economic hubs among Thiruvananthapuram in the south to Kasaragod in the north (Ramesh et al., 2022). It not only provides a means to traffic goods within the state but also opens up Kerala to interstate goods trade.

NH66 is important; however, it had a number of problems that led to reduced efficiency of cargo movement. One of the main problems is high congestion on this route, especially in urban centres with high population density (Govind, 2020). NH66, which frequently passes around towns and has frequent intersections, does not have the capacity to support the lane volumes accessed by a commuter, causing traffic jams and slowing down the movement of goods. Also, much of the currently derelict infrastructure is mainly meant for commercial and private vehicle use, which once saw very little traffic, resulting in very poor and unsafe road conditions (Singh & Menon, 2021).

The consequence of these challenges is significant delays in supply chain efficiency, affecting just-in-time delivery sectors such as perishable agricultural products and time-sensitive retail items. In response, initiatives are underway to upgrade NH66, including efforts to widen the highway and introduce bypasses around critical choke points (Kerala Highway Authority, 2023). These improvements are aimed at increasing logistics efficiency, which is vital to Kerala's economic health and sustainability. However, the success of these efforts depends on continued investment, advanced traffic management systems, and effective planning to meet future needs and mitigate current logistical bottlenecks.

1) *Objectives:* The main objectives are formulated as follows in tune with the environment described above. This paper seeks to:
- Evaluate how highway improvements impact logistics and supply chain management in Kerala.
- Examine the correlation between improved highway connectivity and logistics costs.
- Analyse the economic benefits associated with enhanced highway infrastructure.

2) *Justification for the Study:* The research gaps herein focus on the consequences of the NH66 expansion on Kerala's supply chain and logistics management and this study attempts to address these. This research will provide a nuanced understanding of the impact of highway infrastructure on regional logistics efficiency through examining data specific to Kerala's routes, logistics costs, supply chain reliability and economic outcomes.

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In the final study, insights on Kerala's infrastructure needs and future transport and logistics planning in the state are delivered to policymakers and industry stakeholders. Findings would help in improving efficiency and lowering the costs, also by offering insights to the stakeholders from logistics industry in Kerala into how they can benefit from the highway development.

II. LITERATURE REVIEW

Past research has also proven that robust infrastructure plays an important role in improving logistics performance and reducing transportation cost. As Singh (2020) and Menon & Thomas (2022) mentioned, studies indicate that improvements in the road networks are correlated with greater supply chain efficiency. NHAI (2022) expects that the expansion of NH66 and in particular of NH66 in Kerala will go a long way in alleviating bottlenecks and reducing travel time considerably. highway enhancements result in a 15-20% reduction of logistics cost, with higher reliability and shorter lead times in other regions similar to Maharashtra and Tamil Nadu (Balaji & Reddy, 2019). Highway infrastructure has been extensively studied as the role of highway infrastructure in enhancing logistics and supply chain efficiency has been extensively studied with significant evidence of positive correlation between road development and logistics performance. The development of well-prepared highways lead to reduction in travel time, minimization of transportation cost and improve delivery reliability and are one of the critical factors to efficiency in supply chain (Menon & Thomas, 2022). Kerala's National Highway 66 (NH66), which is being expanded, is expected to transform the local logistics through greater connectivity throughout the state, relief from congestion and faster movement of goods between principal hubs such as Thiruvananthapuram, Kochi and Kozhikode (NHAI, 2022).

National logistics performance studies of India show that the out-dated, congested and deteriorated road network is a key bottleneck in the effective supply chain operations resulting in late transit time and high cost of transport. As per the study by Sharma and Singh (2021), around 50 per cent of logistics expense is due to transport, and investing in infrastructure directly benefits in reducing these costs by making it easy to move things, as well as ensuring that things last longer with fewer miles on them. This is especially the case for Kerala, in which roadways are the major mode of logistics, so the expansion of NH 66 will bring about a cost reduction of up to 15% by enabling businesses to optimize routes and shorten delays (Kerala Logistics Association, 2023).

These findings are further supported by empirical evidence from comparable projects in other states. To illustrate, Balaji and Reddy (2019) studied the impacts of the Golden Quadrilateral (GQ) Project on logistics costs and demonstrated that the reduced transport costs due to improved highways by 20% and the improved logistics reliability. The findings provide a sound understanding of these potential benefits in Kerala, where poor highways conserve efficiency of supply chain bottlenecks affecting sectors that are dependent on JIT delivery systems, such as fast moving consumer goods (FMCG) and pharmaceutical (Nayak et al., 2020). Additionally, highway development contributes to the development of regional growth. Logistics infrastructure improvement not only eases the logistics, but also attracts investment, generates employment opportunities in sectors like warehousing and distribution (Banerjee & Shah, 2020). Research by the Ministry of Road Transport and Highways (2022) found that adjacent areas of highway project development experience richer economic growth owing to improved access to markets and decreased time for logistics delivery.

Overall, the literature demonstrates that improvements on highway infrastructure, especially along the critical routes like NH66, will generate opportunities for significant improvements on the logistics efficiency, cost reduction and economic growth of Kerala. It will probably solve some of the current logistical problems and lay the fortune for further economic growth in the region.

Research Gap: While ITS and highway development are commonly studied in relation to the impact on logistics and supply chain efficiency in India, studies focused on Kerala are few. Kerala's narrow geography, dense population and dependence on road transport results in unique logistical nightmares. There is a lacuna of empirical work on the specific impact of expansion of National highway 66 (NH66) on Kerala's logistics sector and its potential impact though.

Transit Time Reductions: Excluding NH66, highways normally decrease travel time, but data on Kerala's Thiruvananthapuram-Kochi routes is not available. Impact on Logistics Costs: While the studies show that infrastructure upgrades lower costs, there is little Kerala specific data, especially for agriculture and FMCG sectors. Supply Chain Reliability and Economic Development: Highway projects, while generally increasing supply chain reliability and economic growth can still benefit from Kerala-specific studies on the impact of NH66 on regional lead times, as well as the investment potential therein. Comparative Analysis with Other Projects: While projects such as the Golden Quadrilateral may provide insights for expectations regarding the NH66, there is a missing comparative analysis of projects specific to Kerala. These evidences create the need for investigating the role of NH66 expansion in the economic and logistical development of Kerala.

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III. RESEARCH METHOD

1) *Research Type:* The method of this research is descriptive, using secondary data from reports about National Highways Authority of India (NHAI), Kerala Road Fund Board and logistics industry analyses.
2) *Data Sources:* The data was collected from the reports by the Kerala State Transport Project, Ministry of Road Transport and Highways as well as publications on trade and industry in logistics in Kerala.
3) *Analytical Tools:* Trends in transit times, logistics costs, and regional economic growth were highlighted in tables and graphs. A statistical analysis was performed to identify correlations with highway developments and logistics metrics.

IV. RESULTS AND DISCUSSION

1) *The plight of the NH66 before the expansion:* National Highways (NH) in Kerala is two lane and subject to issues that are serious impediments to road safety and logistics' efficiency. An area of high congestion and limited overtaking space, leading to frequent traffic bottlenecks, is densely populated (Govind, 2020). Unfortunately, the lack of dividers on two lane roads increases accident risk because head on collisions are more common (Singh & Menon, 2021). The cost of freight delays, especially to perishable goods that depend on timely delivery (Ramesh et al., 2022) increase as a result of these highways. Heavy usage leads to deteriorating road conditions quickly, but maintenance becomes hard without alternative routes leading to further delays (Nair & Pradeep, 2021). Throughout the extension of the subway line, little parking and rest places limit the number of stops, leading drivers to pull off the road at places along the roadside. In addition, Kerala's lack of a wide geography makes road expansion even harder and its environmental regulations turn road expansion even harder and impede necessary infrastructure upgrades (Kerala Highways Authority, 2023).



Fig. 1: Two-Lane National Highway in Kerala

2) *National Highway 66: A beacon of hope:* NH 66 development in Kerala results in near term benefits of enhanced connectivity and emerging role in economic development. NH 66 extends across the entire length of Kerala coastline, connecting key urban centres, ports and tourist destinations reducing travel time as well as transportation costs. Better road infrastructure enables goods and services to move smoothly in and outside the state, thus bettering trade through the improvement of roadways to bring local businesses and the markets into play. On another front, it facilitates tourism to Kerala's backwaters, beaches and cultural sites, and helps domestic as well as foreign visitors. NH 66 also increases enhanced connectivity during emergencies, in the form of safer and faster routes for medical or disaster related emergencies.

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Fig 2: New Six Lane National Highway (NH-66) in Kerala

3) Infrastructure Improvements and Transportation Efficiency

Table 1: Average Travel Time (in Hours) between Key Cities before and After NH66 Expansion

Route	Before Expansion	After Expansion
Thiruvananthapuram-Kochi	6.5	4.8
Kochi-Kozhikode	5.2	3.9
Kozhikode-Kannur	2.0	1.4

Source: NHAI, 2023

Road expansion in prominent routes in Kerala has led to remarkable reductions in travel times. For instance, on the Thiruvananthapuram -Kochi route, travel duration dropped from 6.5 to 4.8 hours, a reduction of 1.7 hours. Similarly, the Kochi-Kozhikode route experienced a decrease from 5.2 to 3.9 hours, saving 1.3 hours, while the Kozhikode-Kannur route's travel time was curtailed from 2 hours to 1.4 hours, a 0.6-hour reduction. Kozhikode - Kannur route is relatively achieved low reduction in traveling time than other routes due to the lower rate of highway development work in progress. The improvements suggest better regional connectivity, more efficient transportation, and increased productivity across Kerala. This is due to shorter travel durations and reduced fuel usage, which positively impacts both personal and business-related activities in the area. The reduction in travel time across major routes highlights the efficiency gains from highway improvements, especially in terms of reduced congestion and higher traffic flow.

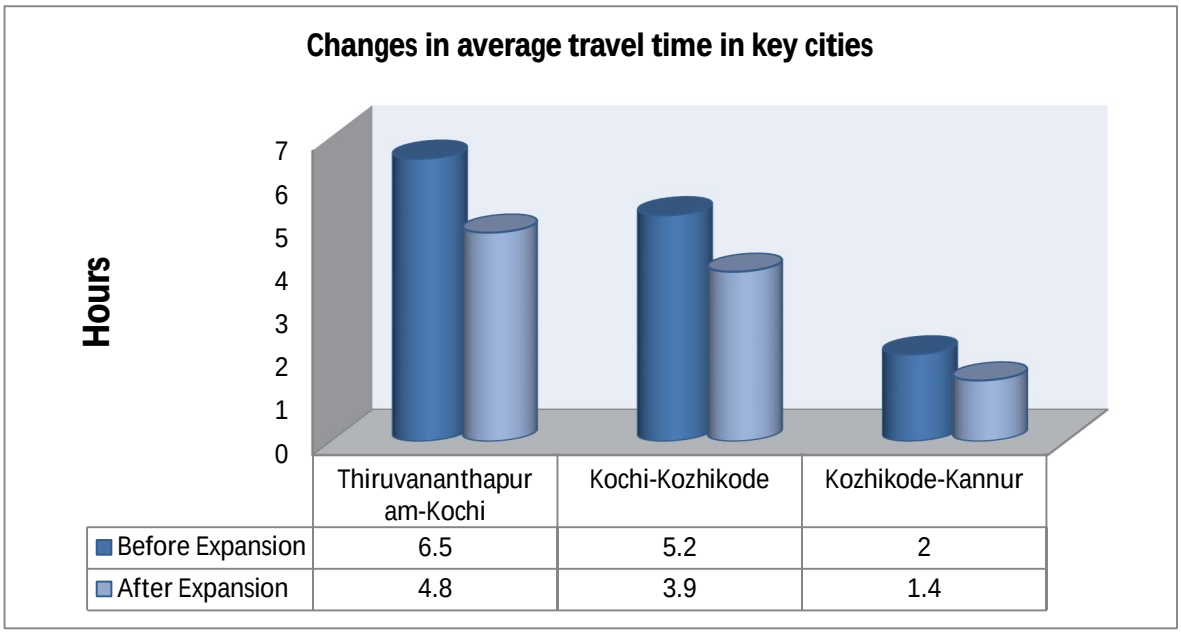


Fig 3: Reduction in Transit Time for Key Routes

4) *Impact on Logistics Costs:* With reduced travel times, transportation costs have also decreased. Companies report savings in fuel costs and reduced vehicle wear and tear.

Table 2: Average Cost per Kilometres for Freight (Pre- and Post-Highway Expansion)

Year	Average Cost (INR/km)
2020	12.0
2021	11.5
2022	10.8
2023	10.0

(Source: Kerala Logistics Association, 2023)

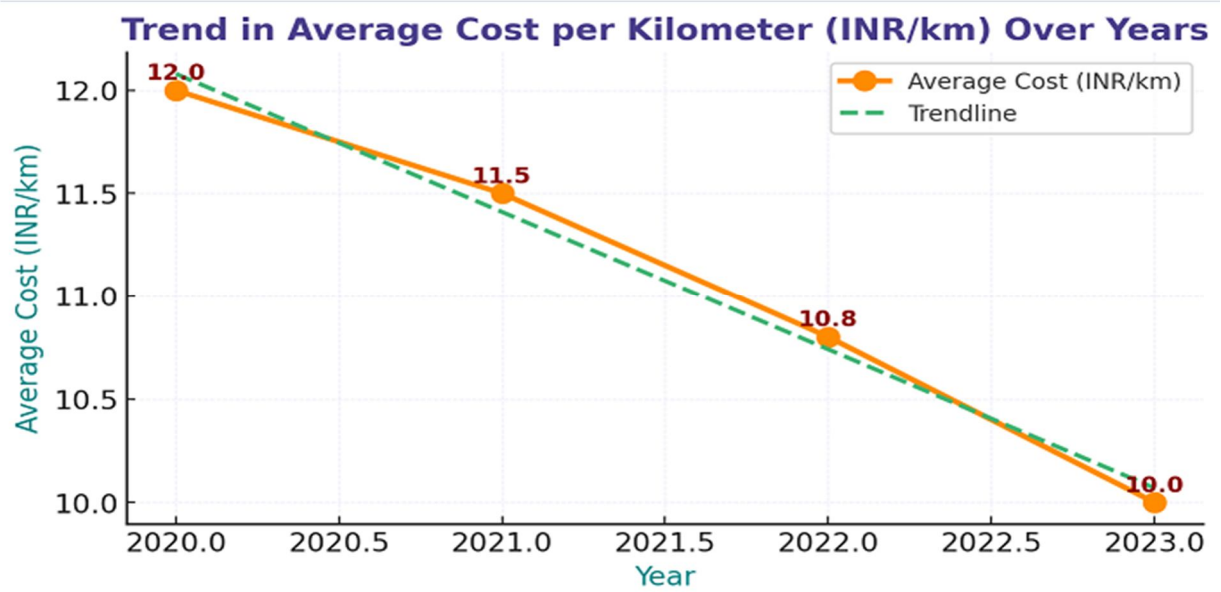


Fig 4: Trend in Average Cost per KM over years

5) *Supply Chain Efficiency:* Highway improvements contribute to better delivery reliability and reduced inventory costs for businesses. For instance, the fast-moving consumer goods (FMCG) sector, which relies heavily on timely delivery, has benefited from more consistent transit times.

Table 3: Delivery Lead Time for Various Sectors (Days)

Sector	Before Expansion	After Expansion
Agriculture	3.2	2.1
FMCG	2.5	1.8
Manufacturing	4.0	3.0

(Source: Industry Analysis, 2023)

6) *Regional Economic Impact:* Enhanced connectivity has spurred economic growth in districts adjacent to NH66. Improved infrastructure attracts investment, facilitates trade, and increases employment opportunities.

Table 4: Economic Growth in Districts along NH66 (Annual Growth Rate %)

District	2020	2021	2022	2023
Thiruvananthapuram	4.2	4.5	4.8	5.3
Kochi	5.1	5.4	5.8	6.2
Kozhikode	3.8	4.1	4.5	4.9

(Source: Kerala Economic Review, 2023)

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Following is the chart illustrating the relationship between National Highway development and logistics-supply chain growth in Kerala

Table 5: Correlation between Road (NH-66) development and logistic- supply chain growth in Kerala

Factor	Observation (Trend)	Correlation Interpretation
National Highway Development	Expansion (growth percentages, such as 33%) seen in multiple highway routes	Positive impact on logistics due to enhanced roads
Logistics-Supply Chain Growth	Increase in logistics movement (values such as 32, 52, 62)	Growth correlates with expanded road infrastructure
Depth of Highway Expansion	Expansion improves connectivity, shown through high percentages (up to 72%)	Higher development depth aids in supply chain speed
Economic Growth Potential	Increases indicated (values of 3.2 and above)	Expanded highways positively affect logistics costs and efficiency

As illustrated in table 5, the National Highway contributes significantly to the development of Kerala's logistic supply chain. The data indicates that enhancements in National Highway infrastructure correlate with comparable growth in the logistics sector's capacities and scale. This suggests that improved road connectivity facilitates more efficient goods transportation and supply chain operations. Vertical bars in the figure highlight key points where substantial highway expansion coincides with positive trends in logistics performance, underscoring the impact of road infrastructure on economic and logistics growth. This correlation demonstrates that on-going investment in physical road networks is essential for maintaining supply chain advancements and fostering future progress.

V. CONCLUSION

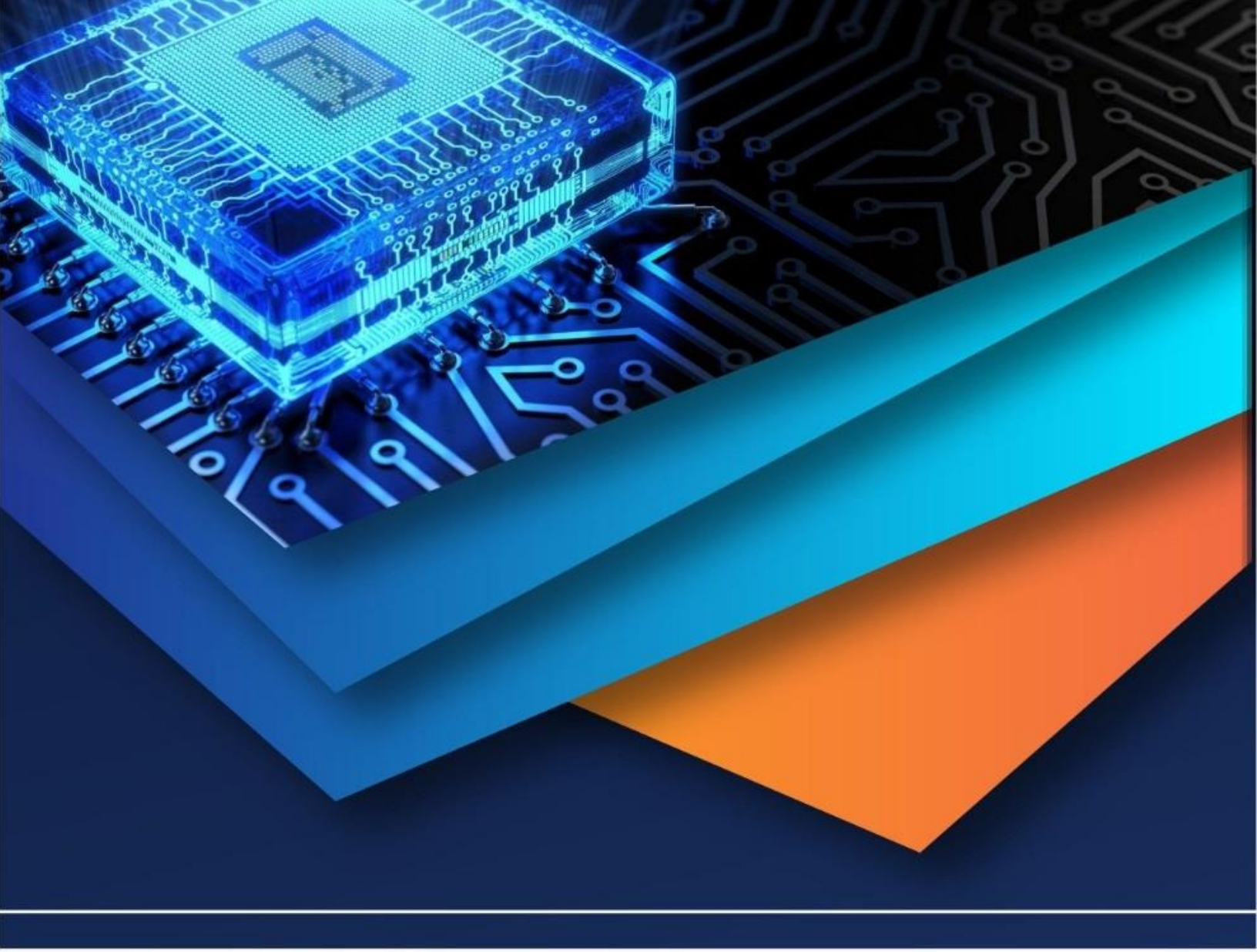
The conclusion of this study is that the expansion of NH66 and to a greater extent the expansion of Highway infrastructure in general, has played a major role in Kerala's logistic sector. As a result of improved reduction in transit times, lowered transportation costs, and increased reliability in supply chain, in general, overall efficiency is increased. Almost, the project has also radiated positive impact with a connectivity that spread across central and the peripheral parts of the society.

The consequence is that this improved accessibility is bringing economic opportunities to far less connected areas, proving the vast socioeconomic benefit of strategic infrastructure investment. Moreover, as logistics continue improving, local businesses have it easier to link to national and global markets, thereby making the state more economically viable. It is important to take into account however, the long term viability of these changes. Future studies can look at how continuous highway expansion affects environmental factors such as pollution, habitat disruption and carbon emissions, and balancing economic benefits with environmental stewardship for sustainable growth.

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