



BALANCING PROGRESS AND PRESERVATION: A COMPREHENSIVE ANALYSIS OF GREEN HIGHWAY IN THE INDIAN CONTEXT

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Abstract:

Transportation plays a pivotal role in a country's economic development, and India boasts the world's second-largest road network, spanning an impressive 58.98 lakh kms (1). However, the expansion of road highways, while integral to economic progress, raises concerns about its environmental impact, including deforestation (2). In response to this environmental compromise, the concept of a 'green highway' emerges, seeking to balance transportation functionality with ecological considerations (3). Notably, while Western countries have long established methods for evaluating green highways, it was only in September 2015 that the Ministry of Road Transport & Highways (MoRTH) in India formulated the Green Highway policy (4). This research aims to delve into the existing guidelines for evaluating green highways, scrutinizing their applicability within the Indian context. The study employs a comprehensive approach, drawing insights from literature reviews and real-world case studies. By synthesizing this information, the objective is to develop a framework of guidelines tailored to the unique dynamics of the Indian landscape. The keywords for this research include Green Highway, MoRTH, Transportation, and Green Rating. Through this exploration, we hope to contribute to the sustainable development of transportation infrastructure in India, fostering a harmonious coexistence between economic growth and ecological preservation.

Keywords: Transportation Infrastructure, Green Highway, Environmental Impact, Sustainable Development, Indian Context

1. Introduction

Green Highways in the Indian context represent a forward-looking approach to balance economic development through transportation infrastructure with environmental sustainability. The term "Green Highway" encapsulates a holistic vision where the road network not only serves its primary function of facilitating transportation but also integrates ecological considerations, aiming to minimize environmental impact and enhance overall sustainability. India's vast road network, the second-largest in the world at 58.98 lakh kms, plays a crucial role in the nation's economic growth (1). However, the expansion of road highways has raised concerns, particularly regarding issues such as deforestation and habitat disruption. The introduction of the Green Highway concept seeks to address these challenges by adopting a comprehensive strategy that considers both transportation functionality and ecological preservation (3). The Ministry of Road Transport & Highways (MoRTH) in India formulated the Green Highway policy in September 2015, marking a significant step toward aligning infrastructure development with environmental consciousness (4). This policy provides a framework for evaluating and implementing green practices within the transportation sector. It emphasizes the need for sustainable practices in planning, construction, and maintenance of highways, with a focus on minimizing environmental degradation. One of the key aspects of Green Highways in India is the incorporation of green belts along the road corridors. These green belts serve multiple purposes, including carbon sequestration, biodiversity conservation, and creating a more visually appealing and pleasant environment for travelers. The vegetation in these green belts acts as a natural barrier, reducing air and noise pollution and contributing to overall air quality improvement. To ensure the success of Green Highways, it is crucial to consider factors such as afforestation, soil conservation, and water management. Afforestation initiatives involve planting native trees and vegetation along the highways, contributing not only to environmental conservation but also to the overall aesthetics of the landscape. Soil conservation measures, including erosion control and slope stabilization, are implemented to safeguard against the negative impacts of highway construction on soil quality and structure. Water management practices within the Green Highway framework focus on minimizing water runoff, preventing soil erosion, and promoting groundwater recharge. These initiatives not only protect local ecosystems but also contribute to the sustainable use of water resources in the region. The

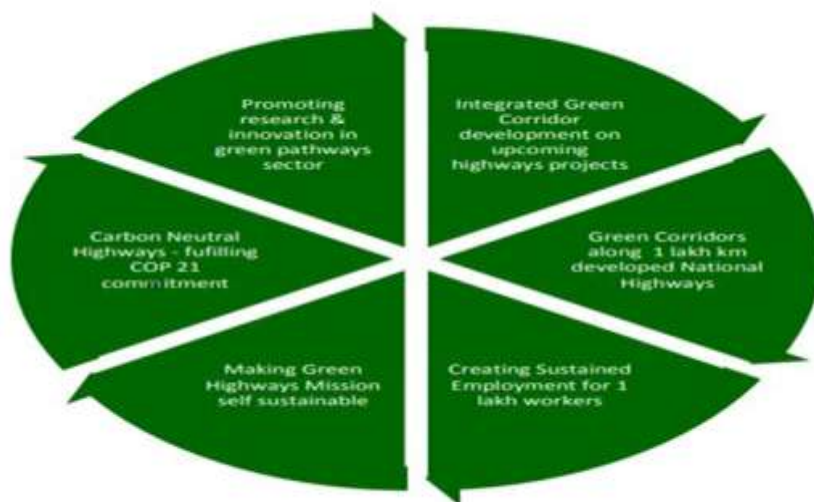
concept of a Green Highway is not merely a policy document but a commitment to sustainable development. It encourages innovation in construction materials and techniques, promoting the use of eco-friendly materials and technologies that reduce the environmental footprint of highway projects. Additionally, it emphasizes the incorporation of environmentally friendly features in the design and maintenance of highways.

In conclusion, Green Highways in the Indian context represent a crucial paradigm shift in the approach to infrastructure development. By combining transportation functionality with ecological requirements, Green Highways aim to create a harmonious balance between economic growth and environmental sustainability. As India continues to expand its road network, the implementation and success of Green Highways will play a pivotal role in shaping the future of sustainable transportation infrastructure in the country. In 2007, the landscape of sustainable highway development witnessed a significant milestone with the introduction of a formal rating system known as Green Road by researchers from Washington State (6). Subsequently, between 2009 and 2012, a plethora of other rating systems, including Green Guide, STARS, BE2ST, Green Roads, Green Lites, Green Paves, I-Last, Envision, CEEQUAL, and INVEST, entered the market (7). This marked a crucial era where the emphasis shifted from conventional highway construction to a more eco-conscious approach, taking into account various environmental and sustainability parameters. To provide clarity in this evolving realm, the definition of a Green Highway is derived from the insights of Mr. James Bryce, revolving around five key features. Firstly, Watershed Driven Storm Water Management aims to address stormwater runoff by integrating bio-swales and wetlands alongside highways, effectively treating and preventing environmental damage. Secondly, the focus on Life Cycle Energy and Emission Reduction considers the entire spectrum of energy consumption, from the production of construction materials to the energy expended in the construction and maintenance of highways. The utilization of alternative materials, such as fly ash and slag, has proven to be more energy-efficient, contributing to a reduction in the overall carbon footprint. The third key feature, Recycle, Reuse, and Renewable, advocates for the use of recyclable materials to curtail the extraction of virgin resources. This approach not only sustains resources for future generations but also reduces energy and greenhouse gas emissions, ultimately contributing to water conservation.

The fourth feature, Conservation and Ecosystem Management, underscores the importance of designing highways with a conscientious consideration of their impact on the natural environment. Techniques such as providing animal crossing structures and underpasses play a crucial role in mitigating the negative effects of highway construction on ecosystems, with studies showing a remarkable 97 percent reduction in vehicle-wildlife collisions. Lastly, the fifth key feature, Overall Societal Benefits, emphasizes the integral role of a well-designed highway in enhancing the aesthetic appeal of an area. Beyond aesthetics, such highways stimulate economic activity, attracting businesses and thereby providing local communities with job opportunities and a platform for socio-economic growth (6). In summary, the advent of formal rating systems for Green Highways, coupled with the adoption of comprehensive definitions and key features, signifies a paradigm shift toward environmentally conscious and sustainable highway development practices. These principles not only address immediate environmental concerns but also contribute to the long-term well-being of ecosystems and societies, fostering a harmonious coexistence between infrastructure development and ecological preservation. In a noteworthy shift towards

environmental consciousness, India embraced the concept of Green Highways in September 2015, marked by the unveiling of the Green Highways (Plantation, Transplantation, and Beautification & Maintenance) Policy 2015. This policy, a pioneering initiative in the country, laid down a mandate for allocating 1% of the project cost for the development and upkeep of green canopies along the highways. This marked a significant departure from traditional highway development approaches, signifying a commitment to integrate sustainable and eco-friendly practices into infrastructure projects.

According to Shri Vijay Chhibber, Secretary of the Ministry of Road Transport and Highways, the Green Highways Policy is strategically aligned with the objectives of the National Forest Policy, which advocates for a 33% forest cover. However, the current notified forest cover stands at only about 22%, highlighting the need for proactive measures to bridge this gap (8). In this context, the Green Highways Policy emerges as a vital tool to not only address the immediate environmental concerns associated with highway development but also to contribute towards fulfilling larger national goals related to forest conservation.



Green Highways for Sustainable Environment & Inclusive Growth

Figure 1

The overarching objective of the Green Highway Policy is encapsulated in Figure 1, outlining a comprehensive vision for sustainable highway development. This vision encompasses elements of plantation, transplantation, beautification, and

maintenance, reflecting a holistic approach that goes beyond conventional infrastructure development paradigms. By incorporating greenery and sustainable practices into the very fabric of highway projects, the policy aims to mitigate the impact on the environment

and, concurrently, contribute to the enhancement of India's forest cover. The strategic allocation of resources for green canopy development and maintenance underscores the government's commitment to striking a balance between infrastructure expansion and ecological preservation. This approach not only aligns with global trends in sustainable development but also positions India as a proactive participant in the global effort to combat environmental challenges. As India progresses on its journey towards green highway development, the Green Highways Policy stands as a beacon of sustainable infrastructure planning, setting the stage for a future where economic progress and environmental stewardship coalesce harmoniously. The successful implementation of this policy holds the potential to serve as a model for other nations grappling with similar challenges, showcasing the transformative power of integrating green practices into the fabric of national development initiatives.

Review of Literature

In their 2015 literature review on green highways in Malaysia, Nusa et al. extensively examined existing knowledge on the subject. They identified key trends and challenges in implementing green highway practices in Malaysia. The findings highlighted the need for a tailored approach that considers the unique environmental characteristics and infrastructure demands of the region. The researchers emphasized the importance of incorporating sustainable practices in highway development to align with global environmental goals (Nusa et al., 2015). Nikumbh, K., & Aher, P. D. (2017), Nikumbh and Aher's 2017 review paper critically analyzed various green highway rating systems. The research findings highlighted the diversity in existing rating systems and underscored the need for a standardized approach. They identified strengths and weaknesses in different systems, providing valuable insights for policymakers and practitioners. The researchers concluded that an integrated and universally applicable green highway rating system would enhance the effectiveness of sustainable highway development initiatives. Kalyani, V. L., Joshi, S., & Choudhary, V. (2015), the 2015 study by Kalyani et al. delved into the concept of smart highways for the future, emphasizing the utilization of green energy. The research findings demonstrated the potential of integrating renewable energy sources into highway infrastructure. The researchers highlighted the role of smart highways in reducing environmental impact and promoting energy efficiency, offering a forward-looking perspective on the future of transportation infrastructure. Attahiru, Y. B., Aziz, M. M. A., Kassim, K. A., Shahid, S., Bakar, W. A. W. A., NSashruddin, T. F., & Ahamed, M. I. (2019), Attahiru

et al.'s 2019 review focused on the intersection of green economy principles and the development of environmentally friendly roads and highways. The findings underscored the potential of using carbon-neutral materials for sustainable development. The researchers provided insights into the economic and environmental benefits of adopting green practices in road construction, emphasizing the importance of aligning infrastructure development with broader sustainability goals.

Singh, P., Kumar, A., Singh, S., Rajput, R., & Singh, C. L. (2019), investigated the use of plastic waste in flexible pavement for green highways. The findings highlighted the feasibility and benefits of incorporating plastic waste into pavement materials. The researchers identified a sustainable solution for managing plastic waste while enhancing the durability and performance of flexible pavements. The study provided practical insights into mitigating environmental challenges through innovative approaches in highway construction. Bajaj, A. (2010), in the 2010 exploration of the Karnataka State Highway Improvement Project, Bajaj provided an insightful analysis of sustainable infrastructure development in India. The research findings showcased the project's impact on enhancing transportation infrastructure while considering environmental sustainability. Bajaj's work served as a valuable case study, illustrating the practical implementation of sustainable practices at the state level in India. The 2019 research by Metkari et al. investigated the implementation of a smart highway utilizing green energy. The findings highlighted the feasibility and efficiency of integrating renewable energy sources into highway infrastructure. The researchers emphasized the potential of this approach to enhance sustainability in transportation, providing a glimpse into the future of energy-efficient smart highways. Rahman, M. A., Mukta, M. Y., Asyhari, A. T., Moustafa, N., Patwary, M. N., Yousuf, A., ... & Gupta, B. B. (2022), study delved into the application of multiscale Internet of Things (IoT) for renewable energy redistribution in the context of 6G-oriented green highway management. The research findings demonstrated the potential of IoT in optimizing energy usage and distribution for sustainable highway operations. The researchers provided insights into the technological advancements that can contribute to a greener and more efficient highway management system. Seng, F. K. (2018), in 2018, Seng focused on the development of a computer-based green highway energy efficiency index assessment for Malaysia. The findings of this research contributed to the creation of a comprehensive assessment tool for evaluating the energy efficiency of highways. The researcher

highlighted the importance of such tools in guiding sustainable highway development practices in Malaysia.

Yousif, O. S., Zakaria, R., Aminudin, E., Shamsuddin, S. M., Rahman, M. F. A., & Ahmad, N. F. (2022), Study presented an integration method for a web-based visualization framework of the Green Highway Index and Carbon Footprint Calculator. The findings demonstrated the efficacy of integrating these tools for a holistic assessment of green highway performance. The researchers emphasized the potential of web-based visualization in promoting transparency and accessibility in monitoring and managing highway sustainability. Rathore, S. S. (2011), research focused on the development of the green highways concept in India. The findings highlighted the evolution of this concept, emphasizing its importance in addressing environmental concerns associated with highway construction. The researcher provided insights into the key principles and considerations that underpin the green highways concept in the Indian context.

Yousif, O. S., & Zakaria, R. (2022), framework aimed at integrating green highway performance data with

the carbon footprint calculator in Malaysia. The research findings demonstrated the potential of such integration for comprehensive sustainability assessments. The researchers emphasized the importance of data-driven decision-making in promoting green practices in highway development.

Case Studies

Case Study 1: The Mehsana – Himmatnagar State Highway

The first case study involves the expansion of the Mehsana – Himmatnagar State Highway (SH-55) from a two-lane to a four-lane facility, spanning a length of 60.75 km. Several green practices were incorporated into this project as part of the widening initiative. Notable practices included the use of Warm Mix Asphalt, resulting in a remarkable 30% reduction in energy consumption. Additionally, the recycling of pavement, stipulated in the construction contract, mandated the reuse of a minimum of 20% of excavated pavement.



Figure 2 - The Mehsana – Himmatnagar State Highway

To embrace renewable energy sources, the project proposed the implementation of battery-mounted solar street lights along the corridor, including junctions, truck lay bays, and bus stops. Landscaping efforts comprised the plantation of trees along the highway on government land, augmenting the existing green cover. Preserving existing trees within a girth size of 30 to 90 cm was an integral aspect of the landscape requirement. Solid Waste Management initiatives mandated the installation of dustbins to discourage open waste disposal. The introduction of Noise

Barriers aimed to mitigate the impact of highway noise pollution. Case Study 2: Chennai to Cuddalore - State Highway 49 The second case study centers around State Highway 49, a 160 km two-lane highway connecting Chennai to Cuddalore. Green practices incorporated into this project encompassed various environmentally conscious elements. Contaminated Site Development involved utilizing areas affected by environmental contamination. Landscape considerations dictated covering 20% of the total area with green cover through tree plantation.



Figure – 3 Chennai to Cuddalore - State Highway\

Efforts to combat Night Sky Pollution focused on reducing light pollution to enhance night sky visibility. Plantation of Drought Tolerant Species aimed to elevate the groundwater table through effective rainwater management. The project also advocated for the use of low VOC materials to minimize emissions. Design Innovation played a crucial role, guiding the alignment selection to incorporate unwanted land and public densified areas into the final alignment plan.

2. Conclusion:

The findings from these case studies underscore several critical points. Firstly, there is a discernible need for India to develop or adopt a comprehensive Green Highway rating system to encourage sustainable road construction practices. Despite the existing Green Highway Policy by the Government of India, certain shortcomings were identified, particularly in addressing water, energy, materials, and innovation aspects. The policy, while acknowledging the reduction in noise, light, and air pollution through avenue plantation, falls short in advocating measures to assess such reductions. The case studies demonstrated that achieving green practices beyond the policy's scope is feasible. These practices included the use of energy-efficient equipment, pavement recycling, renewable energy utilization, solid waste management, environmental monitoring, low VOC materials, and strategic alignment selection. Despite the importance of sustainable practices, limited research has been conducted on developing a rating system tailored to the Indian context. Existing research lacks clear certification criteria, such as minimum points for Silver, Gold, or Platinum ratings. Consequently, there is an urgent need for detailed research to establish comprehensive criteria and a code of practice for Green Highway initiatives in India.

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