

# Sustainability in Highway Projects: A Concise Review

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**Abstract** - Along with the building, many other industries apply sustainable development ideas. Highway infrastructure development and operation will make a significant contribution to the goal of sustainable development. According to previous research, the majority of conventional roadways are not sustainable in numerous respects. Highways have significant challenges, including their deteriorating state, traffic, energy availability, and a lack of money for upkeep and capacity expansion to meet rising demand. But at the same time, they use a tremendous amount of natural resources and energy, produce trash, and emit gases that contribute to warming and climate change. Sustainable design, building, operation, and maintenance thus took precedence at this time.

The main question is how to provide innovative and high serviceability roads all by preserving the environment. Additionally, it is pointed out how the traditional highway construction process can be improved by incorporating the basic guidelines of sustainable development.

In this, I review various types of highway projects. in which we see what what types of problems or hazards they face in their projects.

**Key Words:** Sustainable construction and design, Green Highway Policy, Green highway.

## 1. INTRODUCTION

A sustainable highway is a system of roads which limits their impact on the environment to a minimum through different sustainable practices. The goal is to maximize the lifetime of a highway while restricting its emissions. With the knowledge that roads are one component of the transportation infrastructure and that transportation is one means of addressing human needs, sustainability in highways should be addressed. The creation of a sustainable highway should priorities access (rather than simply mobility), transporting people and commodities (rather than just cars), and giving people a variety of transportation options, such as safe and comfortable paths for walking, bicycling, and public transportation. Highway sustainability must be approached with the understanding that transportation is necessary to meet human needs and that roads are a key component of the transportation infrastructure. The creation of sustainable highways should focus on achieving access (rather than just mobility), transporting people and goods (rather than just vehicles), and providing people with transportation options, such as

safe and comfortable roads for walking, cycling, and public transportation, in addition to handling environmental and natural resource requirements [1].

1. Reviewing a few case studies can help us pinpoint the issues that cause Indian roads to deteriorate and fall apart more quickly than those in other countries.
2. To evaluate a document, recognize a new development, and discover issues in a report or file.
3. Many experts view the phrase "sustainable roads" as paradoxical given the massive material consumption and negative effects on the environment caused by the building of new motorways and the usage of existing ones by automobiles. The social and economic benefits that our roadways give, such as access, mobility, and the economic advantages of transporting people and commodities, must also be taken into account when carefully considering the triple bottom line principles. In that case, roads are a very important component of our infrastructure and unquestionably a required component of our society's infrastructure.

This paper describes a portion of a larger study that sought to: -

1. Define social sustainability for highway construction.
2. Identify the key factors contributing to social sustainability.
3. Evaluate the significance of the identified factors and the likelihood that they will be implemented in highway projects.
4. Assess the agreement among experts regarding the significance of the identified factors.
5. Provide performance measures for the identified factors.

## 1.1 FINDING AND RECOMMENDATIONS-

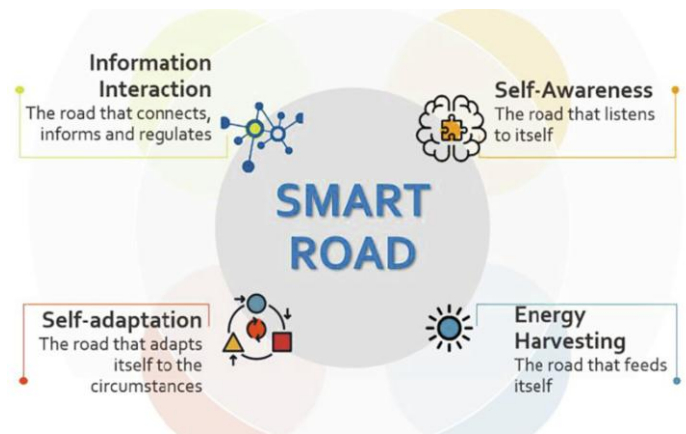
In order to improve efforts toward applying sustainability and avoid non applicable elements in other existing systems,

which involve non-existing conditions in the nature of highway construction projects, this research set out to establish an extensive rating system specifically for sustainable highways in India [2].

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The phrase "smart highway" has numerous definitions, but the most basic one is that it refers to a variety of technology that have been integrated into roadways. In a more profound sense, it is a comprehensive vision for future transportation systems that examines creative suggestions for effectively using the potential presented by emerging technology. So, a smart roadway integrates physical infrastructures with software and data, as we might say. Accordingly, the road itself may serve as a venue for improvements. A smart highway will make it possible to incorporate technology, such as linked devices and the Internet of Things (IoT), onto existing transportation routes in order to improve transportation efficiency, pedestrian and vehicle safety, clean energy usage, and sustainability [4].

Getting back to the global scene, according to INDRA's ITS Industry Report 2019, smart road technologies are a growing industry with a wide range of market opportunities. According to the analysis, this market will develop at a rate of 7% annually over the next few years, with a forecast for 2022 that this market will be worth more than 2 billion euros annually in Europe. This study seeks to provide an overview of the smart approach to road engineering in this inventive and dynamic environment by putting forth a thorough but not exhaustive assessment of the most recent advances in smart road improvements.



**Figure 1-Key features for Smart Road.**

Source: Andrea Pompigna ↑, Raffaele Mauro

Key features for Smart Road.

Smart roads address four fundamental issues:

Self-awareness, or the capacity to automatically and in real-time monitor road conditions, including traffic status

Information Interaction, or the capacity to link intelligent devices for monitoring roads and vehicles, as well as to connect sensor networks and databases within an intelligent communication system

Self-Adaptation, or the capacity to automatically adapt to changing road conditions. energy harvesting, or the capacity to extract renewable energy from subgrade, pavements, and other infrastructures and deliver it to other things like the entire smart road system.

The environmental implications, interdependence of the transportation components, government or public organisation managed regulation, and capital intensity of the highway infrastructure.

The Chinese government continued to invest in roadway development in 2013. The significance of the "One Belt, One Road" has been apparent as a result of China attaching considerable attention to infrastructure's strong economic and environmental effects [5].

Highway infrastructure needs to meet a number of requirements, including those for construction tools, funding, building techniques, and the kinds of designers, builders, and owners [5].

33.43 billion metric tonnes of freight were moved by road in China in 2015, accounting for 76% of total freight movement; 40.79 percent of this was transported by highway.

On the other side, there is a growing understanding that the growth of highway projects has an influence on the environment, including soil wasting, noise pollution, landscape, biodiversity, and ecosystems.

Site preparation, earthmoving, material trucking, paving of roadway surfaces, building of structures, and the application of architectural coatings are all steps in the development of a highway project. Prior to site preparation, some projects might also call for the demolition of buildings. In addition to noise, these activities have the potential to emit greenhouse gases, air pollutants, such as CO<sub>2</sub>, CO, NO<sub>x</sub>, HC, SO<sub>2</sub>, and PM, as well as noise.[3]

According to Demich (2009), it is preferable to begin building the highway in a sustainable fashion to minimise any negative effects while maintaining the need for new highway construction and road improvements.

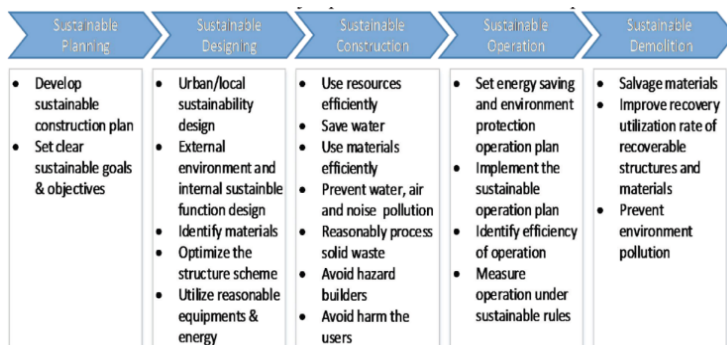


Figure 2-Sustainable Construction Life-cycle

Source: Zhang Junjie, Shaun Lund

The roadway has negative effects on the environment and society while also being crucial for economic growth and quality of life. However, while developing a long-term strategy, a sustainable highway should not only be built to fulfil present development needs, but also provide some room for future social and economic growth. Eventually, assist in putting the "One Belt, One Road" policy into action.

The trade-offs that are part of every engineering choice in general, and the design of highways in particular, are what tie the aspects of sustainable development together. Basic concepts like minimising the use of non-renewable energy and natural resources, minimising adverse environmental effects, developing sustainable technologies, evaluating the economic effects of road projects, and balancing the costs and benefits of various options are tools that can be used to implement sustainability in highway construction. In order to create a more sustainable road project, it is the responsibility of the highway engineer to incorporate science, technology, experience, and creativity into highway building [6].

Any transportation system must have highway transportation as a key component. Currently, the economy and society are centred around roads and vehicles. Every project is different, which is a key idea in highway design. Every highway project has specific variables that designers must take into account, such as the setting and character of the place, community values, needs, and possibilities for highway users. A sustainable highway is one that addresses both environmental and human needs while also taking into account efficient traffic and safety concerns. In order to meet fundamental functional criteria including access, capacity, level of service, safety, and travel time, routes are chosen, alignments are designed, and crossings are placed primarily based on engineering considerations [5].

The goal of these infrastructure-focused solutions is to deliver the highest quality service at the most affordable price. The combination of functional requirements while improving the constructed, natural, and social surroundings is the essence of a sustainable roadway. According to ecological economists, a highway project can be planned, developed, built, and operated in such a way that, when the environment is considered as a whole, it shows a net benefit. The concept of sustainable roadways may initially seem contradictory, but it actually offers a chance whose time has come, according to Hal Kiss-off.

The development of a more sustainable approach to highway construction leads-

- Sustainable management of natural resources: The consumption and exploitation of vast quantities of aggregate and asphalt materials is a characteristic of highway engineering. It would be ideal to use industrial byproduct materials in place of natural soils, aggregates, and cements. Utilizing waste and byproducts is an application of re-use and recycling techniques that has a number of observable benefits, including a decrease in the amount of unnecessary materials that need to be disposed of, the preservation of natural resources for materials, a decrease in energy consumption, and a decrease in environmental pollution. Recycling requires a comprehensive strategy.

To establish research priorities and technical standards, government and business must collaborate. Government must establish guidelines for incorporating recycling into national culture. Industry must create its own marketing strategies, invest in recycling, organise itself, comprehend societal issues, and seek out markets for its goods. Each of these partners has certain requirements and standards for evaluation and measurement. Sometimes, this leads to conflicting goals. It is necessary to develop standardised language, examinations, and cutting-edge technologies. It is necessary to build and improve channels for broadcasting and communication.

- New environmentally friendly technologies: Since technology is one of the most essential ways that humans

interact with our environment, it is vitally crucial for sustainable development. Sustainable technologies offer workable answers for achieving economic growth and human fulfilment while preserving the environment. By lowering risk, increasing cost effectiveness, expanding process efficiency, and developing processes, products, or services that are ecologically friendly or benign while benefiting humans, these technologies help to contribute to, support, or promote sustainable development. Utilizing new equipment or capital investments, as well as the creation of innovative production methods and procedures, are all ways to bring about technological progress. This shift typically takes work; it typically calls for incentives to use environmental policies to be created through research and development.

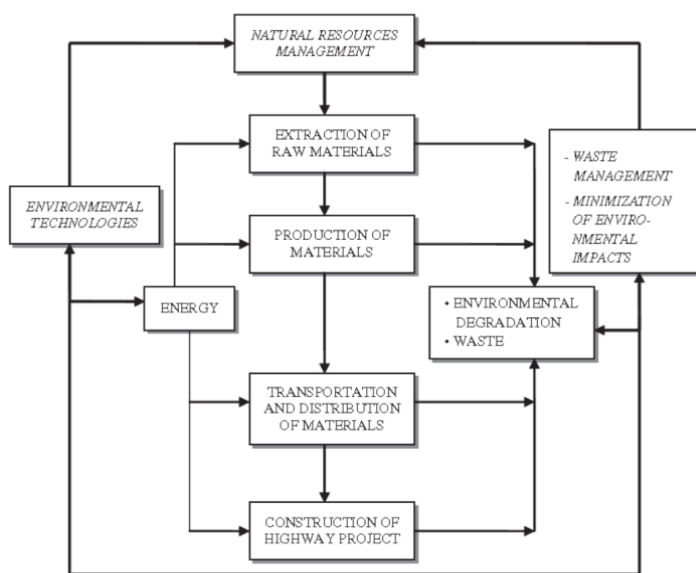


Figure 3-The framework of a sustainable highway construction process.

Source: Zhang Junjie, Shaun Lund

Along with building, many other industries apply sustainable development ideas. Highway infrastructure development and operation will make a significant contribution to the goal of sustainable development. According to previous research, the majority of conventional roadways are not sustainable in numerous respects [7]. Highways have significant challenges, including their deteriorating state, traffic, energy availability, and a lack of money for upkeep and capacity expansion to meet rising demand. But at the same time, they use a tremendous number of natural resources and energy, produce trash, and emit gases that contribute to warming and climate change. Sustainable design, building, operation, and maintenance consequently took precedence at this time. Since green highway technology was created in the United States in 2002, it is being promoted here even though Green Highway Partnership is deemed to as public non-public engagement. The Indian government created the Green

Highway Policy in 2015 [8]. This policy encourages the creation of environmentally appropriate national route corridors throughout the nation with the help of farmers, the nonprofit sector, and governmental organisations like the Forest Department. This paper reviews design and construction methods for green motorways while taking into account Indian city perspectives. The transformation of the conventional highway into a green highway will begin with the design approach and continue with the needed modifications throughout the phases of construction and maintenance. Understanding the Green highway practises to be adhered to throughout the method of design, construction, and maintenance of the highway is continually helpful before the formation of common characteristics of Green highway technology. We also need to keep in mind that the Green Highway initiative is a voluntary social group made up of the route's environmental and ecological department's government representatives, other involved departments, social institutions, private contractors, labour unions, and parties involved in carrying out the Green Highway's social objectives [9].

#### BENEFITS OF GREEN HIGHWAYS:

Benefits to society, the environment, the economy, and human health are connected to the Green Highway. The advantages of green infrastructure are particularly highlighted in urban and suburban residential areas where green space [10]

Green infrastructure embraces following benefits:

- i. Social advantages: The highway has a significant effect on local businesses. A road will bring a business into the community, creating jobs and generating income for the government. Because there will be less materials in the landfill, the houses there will be demolished, which will lower costs for residents in the neighbourhoods surrounding the landfill. The quality of life in the area will rise when noise and pollution from roadways are decreased. The society may benefit from a variety of benefits, including reduced water use, the utilisation of recycled materials, protection of life, reduced levels of contaminants in surface runoff, improved stream and recreational water quality, etc.
- ii. Green infrastructure solutions boost storm water infiltration rates, which reduces the amount of runoff that enters sewer systems and eventually ends up at lakes, rivers, and streams. This results in reduced and delayed storm water runoff volumes.
- iii. Faster groundwater recharge: Green infrastructure technologies' natural infiltration capabilities will hasten the rate at which well water tables recharge. Increased well water recharge could increase the

availability of drinking water for both private and public usage.

- iv. Green highway solutions soak runoff near to its source and make it easier to prevent contaminants from being carried to nearby surface waters. iv) Reducing storm water waste. Plants and bacteria will naturally filter and degrade a number of common wastes found in storm water once runoff has filtered into soil.
- v. Green infrastructure makes it easier to incorporate trees and vegetation into urban landscapes, which improves air quality. This may result in better air quality. Through leaf uptake and contact removal, trees and other vegetation remove bound toxins from the air. Trees and plants can even cool the air and lower worker temperatures if they are widely grown in areas that are covered. dependent reaction that causes gas pollution at ground level.
- vi. Recreational spaces & wildlife habitat: Greenways, parks, urban forests, wetlands, and vegetated swales are all examples of green infrastructure that improve access to outdoor spaces & wildlife surroundings.
- vii. Improved human health: Greenery and vegetation will be good for people's health.
- viii. Increase in land value: Land closer to the highway will be worth more due to clean and green infrastructure.[7]

#### INDIAN SCENARIO OF GREEN HIGHWAY:

One of the most cost-effective and widely used forms of transportation for both freight and passengers is regarded as being road travel. India has a vast 4,24-million-kilometer road network, which is the second largest in the world [1]. The main road system of the nation is operated by the 70,934 km long National Highways. Calculations show that more than 70% of the nation's freight and 85% of its passenger traffic are transported by roadways. Only approximately two percent of all roads are highways or expressways; the remainder are motorways, major district roads, district roads, rural and alternative roads that are considered low traffic roads [2].

Transportation experts must incorporate green ideas into the processes of transportation designing, designing, building, and operating as a result of growing public awareness of climate change. Although the concept of a "green highway" is relatively new, the use of the relevant technologies has been encouraged for some time. Although green roads might not initially resemble traditional ones, a driver can detect subtle differences upon closer inspection.

On the shoulder, more flora is growing, and more trees are being planted for ridding and life-buffering purposes. A

green highway is defined by five broad topics, including conservation and system management, water shed driven robust water management, life cycle energy and emissions reduction, recycles use and renewable energy, and overall social group edges. In towns, highways become more aesthetically pleasing, and in rural areas routes become a more natural part of the setting.

#### Green Highway Consideration During Maintenance Of Highway:

- 1) Monitoring plantation expansion and putting techniques into practise to increase the quantitative relationship between plantations and survival.
- 2) Close observation of construction-related noise and air quality.
- 3) The common vehicles operating on the route, such as S.T. buses, trucks, multi-axle vehicles, etc., will be evaluated for their life maintenance, fuel consumptions, travel distances (in kilometers), and other factors in order to estimate the GHG emission by installation as a whole and methodology to reduce the same and reduce the connected carbon footprints. Property transportation aims to protect the environment and conserve natural resources while considering societal needs and the cost-benefit ratio. To reduce the emission of GHG and other harmful filthy gases that affect the environment, efforts must be made in conjunction with the transportation sector.
- 4) Monitoring and reducing traffic accidents.

It will take some time for India to adopt this technology and fully implement it throughout the national highway system spread across the country wherever it is possible to do so based on Green Highway Policy because green highway is not a new concept in the world, but its utilization has only been widely considered in India from the last few years.[5]

### 3. CONCLUSIONS

A highway project that is a success will incorporate social well-being, economic viability, and environmental integrity. This will help the region thrive.

Highway engineers must support and participate in interdisciplinary teams with other professionals, such as ecologists, economists, and sociologists, in order to successfully handle the issues and challenges of sustainable development. Road authorities are responsible to the community for more than just constructing roads. By incorporating the greatest environmental management practices into road planning and construction, sustainable highways are made a reality.

Road construction is only one of the responsibilities that road agencies have to the community. By implementing best

practices in environmental management during the planning and construction of roadways, sustainable highways are made a reality.

Sustainability has grown to be a significant issue for the highway and construction industries. It made reference to the strategy's green support and direction.

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### REFERENCES

- [1] ministry of road transport and highway, "Green Highways," 2020.
- [2] S. S. Patel and M. T. Student, "STUDY ON HIGHWAY FAILURE AND ITS MAINTENANCE," *Int. J. Creat. Res. Thoughts*, pp. 262–266, 2018.
- [3] Z. Junjie and S. Lund, "The Development of Sustainable Highway Infrastructure in the Strategy of One Belt and One road," *First Int. Symp. Bus. Coop. Dev. South-East South Asia under B&R Initiat.*, pp. 172–175, 2016.
- [4] A. Pompigna and R. Mauro, "Engineering Science and Technology , an International Journal Smart roads : A state of the art of highways innovations in the Smart Age," *Eng. Sci. Technol. an Int. J.*, vol. 25, p. 100986, 2022, doi: 10.1016/j.jestch.2021.04.005.
- [5] F. Kehagia, "THE IMPLEMENTATION OF SUSTAINABILITY IN HIGHWAY PROJECTS," vol. 4, no. 1, pp. 61–69, 2009, doi: 10.2495/SDP-V4-N1-61-69.
- [6] C K Rudresh, "green-roads-for-healthy-environment.pdf."
- [7] D. Patel, "Design & construction of Green Highway in India considering the Sustainable International Conference on, ' GREEN HIGHWAY CONSTRUCTION – A Sustainable Approach ' Design & construction of Green Highway in India considering the Sustainable Development," no. August, 2022.
- [8] A. H. Ibrahim and M. A. Shaker, "Sustainability index for highway construction projects," *Alexandria Eng. J.*, vol. 58, no. 4, pp. 1399–1411, 2019, doi:

10.1016/j.aej.2019.11.011.

- [9] O. Ademila and A. I. Olayinka, "Geotechnical investigation of pavement failure; causes and inherent solutions for sustainable highway construction in Sub-Saharan Africa," pp. 103–114, 2020, doi: 10.17794/rgn.2020.4.9.
- [10] TKMCE, "Green-highway," 2017.

### BIOGRAPHIES



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