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Managing public road transportation for sustainable and safety during implementation: An empirical study

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Abstract: This study investigates the sustainability of public road construction management in Nepal, emphasizing socioeconomic and environmental factors, as well as opportunities and challenges during the construction phase of highway expansion projects, focusing on the Damauli section of the Mugling–Pokhara road. Primary data were collected through field observations and questionnaire surveys involving consultants, contractors, and local residents (85 respondents). Secondary data were sourced from reports, articles, and online platforms. Descriptive statistics using MS Excel and SPSS were applied to present data through tables and bar charts. The construction phase caused significant disruptions, including traffic congestion, dust, noise, and air pollution, affecting daily life. However, it also created local business and employment opportunities. A newly constructed side lane helped alleviate some negative impacts, illustrating both the challenges and benefits of highway construction. While construction activities pose temporary hardships to communities, they also offer socioeconomic opportunities. Balancing these effects is vital for achieving sustainable road development. The study offers valuable insights for policymakers, planners, regulators, and investors in understanding the dual impacts of road construction and planning more sustainable infrastructure projects that maximize benefits while minimizing disruptions.

Keywords: *Environmental challenges, Public transport management, Socioeconomic impact, Sustainability.*

1. Introduction

The Mugling-Pokhara road, a vital transportation corridor in Nepal, is currently undergoing a significant expansion to transform into a four-lane highway, aimed at enhancing connectivity and facilitating economic growth between key cities. The road will be expanded to four lanes to meet the growing demand. The Damauli section, situated within this larger project, holds strategic importance as it traverses diverse terrains and connects populated areas, presenting unique challenges and opportunities for sustainable development. This section of the road expansion project is crucial for understanding the complexities of infrastructure development in Nepal's context, including environmental considerations, socio-economic impacts, and community engagement. The main SDG goal of this project is to develop quality, reliable, sustainable, and resilient infrastructure, including regional and trans-border infrastructure, to support economic development & human well-being, with a focus on affordable & equitable access for all. Additionally, improved pavement, structural, drainage, safety, and adaptive traffic system components will be included in the design requirements to promote sustainability, safety compliance, and safety awareness. The current route that runs from Mugling to Pokhara (0+000 to 88+583) is a portion of the Prithivi Highway. Environmental profile of the research area, which consists of an explanation of the possible effects on physical, ecological, economic, social, and cultural resources that might occur during the project's influence area's design, building, and operation periods. The background of this study underscores the critical need to assess the sustainability of such infrastructure initiatives, ensuring that they align with national development

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goals while minimizing adverse effects on the environment and local communities. This research aims to contribute valuable insights into sustainable infrastructure planning and management practices within the specific context of the ongoing four-lane Mugling-Pokhara road extension project, particularly focusing on the Damauli section.

Sustainability in construction projects means meeting present needs without compromising future ones. It involves utilizing available resources during project construction without harming the environment, social factors, or economic balance. Road infrastructure is vital for economic and social development but can also impact the environment and society. Sustainability concerns are paramount in all construction projects, with indicators measured in social, economic, and environmental terms. Understanding and implementing sustainability indicators in construction can lead to cost-effective project completion and economic development. Sustainability in construction begins with planning, decision-making, and stakeholder coordination, adopting environmentally responsible practices, and efficient resource use to minimize negative impacts on society and the environment.

Transportation infrastructure should be sustainably evaluated for both the present and the future to address social, environmental, and traffic issues. This research study aims 1 to analyze the results concerning sustainable development indicators and evaluate the feasibility of infrastructure projects based on system interchange [1]. The success of a highway project depends on its technical viability (economic, environmental, and social sustainability). Social sustainability considers the impact on the local population; while assessing sustainability, the social component is given the least consideration. Environmental sustainability focuses on the relationship between infrastructure and natural ecosystems, health, and service quality. Economic sustainability involves accurately estimating project resources [2]. The execution of infrastructure development projects has received particular attention because of their greater effects on the economy, society, and environment. The measures that assess the highway projects' sustainability performance define the dynamic elements influencing the measures' performance by consulting the appropriate feasibility studies [3]. Transportation systems facilitate global goods and service flow, generating jobs and economic growth. Sustainability is crucial for meeting social and economic demands without compromising the environment. Sustainability indicators should represent, measure, and quantify these impacts [4]. This study aims to assess sustainability issues related to road infrastructure by focusing on the specific Damauli Section within a selected location.

Road infrastructure is vital for economic and social development but can also impact the environment and society. Transportation infrastructure should be sustainably evaluated for both the present and the future to address social, environmental, and traffic issues. Sustainability indicators are critical parameters to follow in construction projects, as they ensure economically viable designs that balance with the physical and social environment, meet future traffic needs, and promote consistent and efficient highway operations. Without prioritizing sustainability in construction projects, there is a risk of increased maintenance needs, environmental pollution, degradation, longer travel times, and higher accident rates. In Nepal, sustainability poses significant challenges to project implementation, impacting outcomes, design and economic lifespan, cost and resource management, and overall development objectives. Understanding and implementing sustainability indicators is essential for achieving long-lasting infrastructure projects.

In line with Nepal's constitutional provisions, Article 30 guarantees every citizen a clean and healthy environment as a fundamental right and provides victims with the right to compensation for damage caused by environmental pollution or degradation. The Government of Nepal [5] mandates the preparation of Initial Environmental Examinations (IEE) and Environmental Impact Assessment (EIA) reports to assess the environmental feasibility of projects. The National Planning Commission, in collaboration with the Ministry of Population and Environment, has introduced the Sustainability Development Agenda for Nepal (SDAN) to prioritize environmental and sustainable development goals. Nepal has been committed to sustainable development since 2060 B.S., emphasizing the importance of sustainability in national development agendas. While there have been papers and articles published on the identification and assessment of sustainability indicators in construction projects, particularly

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highway projects in Nepal, much can still be learned from research in other developed and developing countries such as Spain and Ethiopia. Sustainability directly impacts profitability, quality, timeliness, economic prosperity, social well-being, local health, and the design and economic lifespan of projects. Therefore, this research aims to contribute to the understanding and maintenance of sustainability in highway construction projects, addressing key challenges, and enhancing the effectiveness of infrastructure development initiatives in Nepal. The concept of sustainability and sustainable development has been stated by the Brundtland Commission, which defines it as development that meets the needs of current generations without compromising the ability of future generations to meet their needs.

2. Literature Review

Sustainability in construction projects is meeting the present needs without compromising the ability of future needs. In the context of construction projects sustainability is defined as the process of utilizing the available resources required during the construction phases of the project without affecting the environment, social factors, and economic balance of projects. In short, it means the correct utilization of resources.

Ensuring that highway infrastructure projects are constructed sustainably and resolving issues that arise during highway development are the goals of sustainability assessment. As a result, sustainability is attained for the duration of the project. The overall goal of the process is to provide economic, social, and environmental advantages while minimizing adverse effects on the natural environment. Establishing the assessment indicator system, standard, methodology, and application model is the initial stage.

The sustainability of a highway infrastructure project encompasses a variety of factors, including social and economic development, resource and energy utilization, ecological and environmental protection, and many more. The term "sustainable development" is becoming more and more well-known throughout the world, and there are undoubtedly more definitions now. However, there has been significant ambiguity surrounding the meaning of sustainability. Globally, the term "sustainable development" is gaining popularity, and there are more definitions available today. But there has been a lot of confusion about what sustainability means. According to these concepts, engineers and designers should make building projects more cost-effective, use less energy, materials, and resources, and produce less waste and pollution while maximizing the positive social and economic effects. The relationship between construction and the environment was also presented by these early concepts, leading to the development of the first theories of sustainable construction. These project management concepts outline the practical steps to accomplish sustainability in the building by using fewer materials and resources, saving money, and enhancing quality.

When assessing whether a project "contributes to favor economic development and fulfill the transportation needs of the society in a manner consistent with ecological and human values," Sustainability assessment (SA) is used in the context of transportation projects. When assessing whether a project "contributes to favor economic development and fulfills the transportation needs of the society in a manner consistent with ecological and human values," SA is used in the context of transportation projects [6].

By combining important indications from the three facets of sustainability, a new index known as the "road sustainability index" (RSI) has been developed to provide sustainable roadworks. Considering environmental, social, and economic variables in a balanced manner, would guarantee the best economic value, the least amount of greenhouse gas emissions, and the optimal social outcome from a life cycle standpoint [7].

The term "sustainable" transport infrastructure refers to the realization of all sustainability goals (such as economy, resource efficiency, mobility, safety, and environmental quality) to a sufficient degree throughout the infrastructure life cycle [8]. All sustainability goals (such as economy, resource efficiency, mobility, safety, ecological protection, and environmental quality) must be sufficiently

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satisfied throughout the entire life cycle for it to be considered "sustainable" transportation infrastructure [9].

The future of the construction industry is now being challenged by sustainable construction. This new paradigm searches for a balance between project objectives (cost, time, and quality) and between the environment, society, and economy while taking into account human pleasure, minimal consumption of matter and energy, and minimal negative environmental impact. The creation of sustainable structures that serve present and future generations is the ultimate goal. Various techniques have been developed to use numerous indicators to generate an integrated sustainability value. Developed standards (and those still in development, such as the ISO's TC 59/SC 17 standards for sustainability in buildings and civil engineering works) describe how to determine a set of sustainability indicators and manage their application, assessment, and control throughout the project life cycle, from design to construction, operation, and maintenance, to demolition [10].

The idea of sustainability, which demands a paradigm change in the way development is now done, has come to impact fundamental human values that include things like the survival of the human race on a physical, economic, and social level. In light of rising demand, diminishing resources, and ongoing infrastructure degradation, stakeholders have called attention to the necessity of designing, building, and managing infrastructure effectively to maximize return on investment. Civil infrastructure systems are not exempt from this evolution [11].

A method called Envision is used to rank the social, economic, and environmental advantages of civil infrastructure projects of various shapes and sizes. Envision offers an unbiased framework for evaluating project sustainability, raising client knowledge of sustainability issues, and fulfilling project sustainability criteria. For project owners, financing organizations, regulators, specialists, and the general public, the sustainability of civil infrastructure is essential [12].

Achieving enduring development that addresses human needs and improves quality of life is known as sustainable development. Natural resources should be used concurrently, but to the extent and frequency that the environment's capacity for regeneration will allow. Nations that focus economic development over other sustainable development goals eventually deplete the earth's carrying and regenerating capacity. The idea of sustainability is influenced by society, resulting in measuring it less objectively and restricting its application. Stakeholder manipulation and conflicts of interest may also arise. This has made it difficult to assess sustainability projects' actual effects with accuracy [13]. Development that "meets the needs of the present generation without compromising the ability of future generations to meet their own needs" is what is meant to be defined by sustainable development [14].

Sustainable development is a perfect combination of roadway projects with social, economic, and environmental benefits. Benefits to economic growth include more durable roads, lower maintenance costs, and the stimulation of local business. The use of highways to improve community welfare as well as accessibility and attractiveness are examples of societal advantages. Reducing a highway's negative impact on the natural and man-made ecosystems is one of its environmental benefits. A constant in all facets of environmentally friendly construction is the requirement to remain feasible and economical [15].

Nepal's focus on backlog maintenance and upgrades leads to road degradation, reflecting a globally ineffective maintenance investment strategy [16]. The state of highways is deteriorating, traffic, energy availability, and a lack of financing for maintenance and capacity development to keep up with demand are just some of the serious issues they face. Simultaneously, they consume vast amounts of finite natural resources and energy, produce waste and emissions, and damage the global environment, increasing climate change and decreasing the earth's ability to support life [17].

The understanding that highways are an essential component of the transportation infrastructure and that transportation is necessary to meet human needs must guide the handling of sustainability in highway design. Sustainable highway design considers the growth of the local economy and community while preserving the environment by utilizing as few renewable resources as possible. Throughout its

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history, the highway construction industry has prioritized three factors: quality, time, and money. These variables don't account for hazards related to social duty, the environment, or human needs [18].

It is now essential to include the sustainability assessment in the various stages of the road development project to prevent unexpected consequences. The environmental and social assessment of development projects is prominently absent in Iraq. The project life cycle must be taken into account in the economic assessment. Based on the methods and data together, the environmental, social, and economic (ESE) assessment indicators are chosen [19].

Many obstacles stand in the way of implementing the idea into practice, including inadequate training on sustainability, inadequate team member communication, and a lack of experience with the methods and the necessary skills to apply them effectively. The sustainability level of highway projects must be assessed using sustainability assessment techniques. It is necessary to take into account two factors: first, sustainability measures are sensitive to the socioeconomic context of the project. Second, planning, running, maintaining, and recycling/reusing are all legitimate components of sustainable highway projects [20].

Highway construction generates significant waste, energy, and material consumption due to its dynamic nature. Sustainable infrastructure is crucial for economic stability. Electricity consumption is the primary fuel causing carbon emissions. Concrete and dump trucks are the biggest sources. Equipment selection impacts project expenses and emissions. Sustainable materials can reduce costs and emissions [21].

In contrast to the traditional traffic-oriented approach, which focuses on increasing network capacity, traffic volumes, and travel speed, a sustainable transport planning approach aims to provide accessibility as well as improve the quality of life through the regeneration of public space. Specifically, the choice of construction methods that may reduce environmental consequences and enhance social and economic conditions for both current and future generations can characterize the sustainable development of highways and transportation infrastructure [1].

The highway infrastructure projects are crucial for economic growth and sustainability, addressing negative externalities and environmental impacts. Environmental sustainability focuses on reducing energy use and emissions, while social sustainability emphasizes safety, fairness, and quality of life. Economic sustainability involves efficient movement and continuous financial gains [22].

Sustainable transportation systems ensure environmental, social, and economic sustainability by providing safe, accessible transportation. They promote social equality and environmental conservation and reduce travel times, expenses, and life cycle impacts, improving the economy and generating new employment opportunities [20].

In building company operations, sustainable construction has recently gained recognition as a critical issue. Promoting sustainable construction depends extensively on creating and applying multicriteria evaluation models to rank different construction projects according to sustainability metrics. Because the evaluation involves several variables with intricate interdependencies, assessing construction projects following sustainable development principles is a challenging task [23].

The construction business, a rapidly growing sector in both established and developing nations, is gaining attention due to the improving social, economic, and environmental indicators of sustainable development [24]. A report that called for a strategy that combined development and the environment and declared that sustainable development is meeting present needs without compromising the ability of future generations to meet their own needs was published. Sustainable development has garnered a lot of attention in all countries. Energy planning has grown more complicated in the contemporary period of sustainable development since it involves several criteria, including technical, social, economic, and environmental ones. Energy from sustainable development is very dependable and reasonably priced, but it is also susceptible to many environmental problems caused by enterprises. Green energy resources can be extremely important in addressing the environmental problems that stand in the way of sustainable development. To meet the growing demand for energy while maintaining a vision of

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sustainable development, a sufficient planning system that takes into account relevant political, social, economic, and environmental factors is crucial [25].

3. Methodology

This study conducted an in-depth analysis of the sustainability of the Mugling-Pokhara highway project, particularly focusing on the Damauli section from Ghasikuwa to Bholetarchowk in Tanahun district, Gandaki Province, Nepal. The research aimed to gather insights from residents, consultants, and contractor personnel directly impacted by or involved in the project. Both qualitative and quantitative methods were used, with data collected through questionnaires, field observations, and secondary sources like reports and journals.

A total of 28 questionnaire items were developed 10 focused on socio-economic aspects, 6 on environmental issues, and 12 on challenges and opportunities. These were distributed to 61 local residents living along the highway's right of way (ROW) and 24 consultants and contractor staff. Households were selected using a systematic method every fifth house from a total of 305 within the project section was surveyed. This structured approach allowed for a balanced collection of data representing both community and technical perspectives [24].

The responses were analyzed using statistical tools such as SPSS and Excel. The process began with a review of existing literature, which informed the research design, objectives, and questions. Findings were then interpreted to assess the project's sustainability and draw conclusions to guide future improvements.

Table 1 presents the sample size distribution of respondents. Out of 85 participants, 61 (71.76%) were local people, while 24 (28.23%) belonged to the consultant and contractor category.

Table 1.
Sample Size.

S.N.	Respondent Category	Number	Percentages%
1	Local people	61	71.76%
2	Consultant and Contractor	24	28.23%
	Total	85	100%

The questionnaire, structured using a Likert scale, was developed based on interest, course syllabus, current events, and government focus. It aimed to identify and rate factors related to the ongoing highway extension project. Literature review and consultations with locals, consultants, and contractors helped refine the questions. The questionnaire is categorized around three core pillars—social, economic, and environmental—each addressing associated opportunities and challenges relevant to the highway project and its impact on the surrounding communities.

The socio-economic indicators used in the study encompass key aspects such as household income and expenses, opportunities for local employment and business, the ability to save money, and improved access to markets for selling goods. Additionally, they include access to education and training, enhanced property valuation, and healthcare services and costs.

Environmental indicators focus on air and noise quality, availability of clean drinking water, traffic density and its impact on the environment, service lanes during construction, and eco-renovation efforts aimed at preserving natural resources. Sustainability-related challenges and opportunities include the relocation and migration of affected populations, compensation and resettlement processes, provision of alternate routes, community participation, and stakeholder coordination. Other factors include construction waste management, road safety, and the management of electric poles, water supply systems, sewage pipelines, and internet infrastructure.

3.1. Key Informants Interview (KII)

A Key Informant Interview (KII) is a qualitative method involving interviews with individuals who possess specialized knowledge not commonly known by the general population. In this study, KIIs were conducted to validate and cross-reference the survey data. Participants included the project manager,

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engineering department head, environmental and social experts, and the assistant resident engineer from selected highway construction projects. These experts have extensive experience in both rural and urban highway developments. The insights gained from the KIIs help assess the community's situation related to the highway, compare conditions across different localities, and guide more detailed evaluations to support targeted development activities.

3.2. Field Observation

Field observation is an effective method for collecting data, and site visits were conducted to assess the impacts, challenges, opportunities, and sustainability aspects of highway construction projects. A pilot study was carried out on 10% of the sample population to test the questionnaire, aiming to identify unclear items and potential biases. Participants were encouraged to provide feedback, suggest additional questions, and share comments. This process ensured the questionnaire was well-designed and comprehensive. For data analysis, statistical tools such as SPSS and Excel were used to process and interpret the collected survey data accurately.

3.3. Validity and Reliability

To ensure the study's validity and integrity, a comprehensive literature review and consultations with subject experts guided the research approach. A detailed research instrument was developed and pre-evaluated, incorporating expert feedback and similar prior studies. Respondents were carefully selected based on the study's focus. Cronbach's alpha was calculated to assess the questionnaire's reliability and internal consistency, measuring how closely related the items are as a group. This statistic evaluates the reliability of the survey's five-point rating scale. A Cronbach's alpha value of 0.7 or above is generally considered the minimum acceptable threshold for scale reliability.

4. Result and Discussion

This study included responses from individuals of different genders and age groups. Among the 85 respondents, 54 were male (63.52%) and 31 were female (36.48%), indicating higher male participation. In terms of age distribution, participants were categorized into four age ranges: 25–35, 35–45, 45–55, and 55–65 years. The largest group comprised individuals aged 25–35, with 28 respondents (32.94%), followed closely by the 35–45 age group with 27 respondents (31.76%). The 45–55 age group included 23 participants (27.05%), while the smallest group was those aged 55–65, with only 7 respondents (8.25%).

4.1. Reliability of Results

Cronbach's alpha is a measure to determine internal consistency, that is, how closely it is related to a set of items as a group. It is considered to be a measure of scale reliability. Table 2 displays the Cronbach's alpha values for items under socio-economic aspects, indicating internal consistency. The overall Cronbach's alpha for the socioeconomic construct is 0.782, considered acceptable. Individual items range from 0.729 to 0.824, with most falling under the "acceptable" category. Notably, the item "Decrease the cost of health care services" shows the highest reliability ($\alpha = 0.824$), classified as "good." These results suggest that the items reliably measure socio-economic impacts, supporting the internal consistency of the construct and justifying its use in further statistical analysis.

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Table 2.
Socio-economic aspects.

S. N	Descriptions	Cronbach alpha	Remarks
A.	**Socio-economic**	**0.782**	**Acceptable**
1	Increase your household income.	0.729	Acceptable
2	Decrease your household expenses.	0.768	Acceptable
3	Increases job and business opportunities for local people	0.743	Acceptable
4	Increase in wages or salary of local people	0.747	Acceptable
5	Increases your ability to save money	0.729	Acceptable
6	Improve your access to markets and ability to sell your goods.	0.751	Acceptable
7	Increases access to education and training	0.781	Acceptable
8	Reduce the transportation time and fair.	0.783	Acceptable
9	Increases the value of property (land, houses)	0.757	Acceptable
10	Decrease the cost of health care services	0.824	Good

Table 3 presents Cronbach's alpha values for environmental aspect items, assessing their internal consistency. The overall Cronbach's alpha for the environmental construct is 0.777, which is considered acceptable. Individual items show alpha values ranging from 0.714 to 0.772, indicating a reliable level of consistency across the statements. These items address key environmental concerns such as air quality, noise and water pollution, traffic congestion, road service provision during construction, and eco-renovation efforts like plantation and resource conservation. All items received an "acceptable" remark, confirming that the environmental dimension of the questionnaire is both coherent and dependable. This supports its suitability for further analysis in evaluating the environmental impacts of infrastructure development.

Table 3.
Environmental aspects.

S. N	Descriptions	Cronbach alpha	Remarks
B	**Environment**	**0.777**	**Acceptable**
1	Increase air quality and visual aspect of local	0.714	Acceptable
2	Increases noise pollution	0.735	Acceptable
3	Increases pollution of water sources and affects access to clean drinking water	0.727	Acceptable
4	Increases the frequency of traffic congestion, density, and its environment (noise by horns, plastics, and open defection)	0.772	Acceptable
5	Provide a service (lane, traffic signs) road to vehicles, and pedestrians during the construction period	0.749	Acceptable
6	Increase eco-renovation to cut, fill, water resources, etc. by plantation and resource conservation.	0.763	Acceptable

Table 4 presents Cronbach's alpha values for items related to challenges and opportunities, with an overall alpha of 0.779, indicating acceptable internal consistency. The items cover a wide range of issues, including disputes over property boundaries, household relocation, compensation, alternative routes, community participation, waste management, road safety, and infrastructure challenges related to electricity, water, sewage, and internet services. Individual alpha values range from 0.734 to 0.795, all falling within the acceptable range. Notably, the highest reliability is observed for items related to sewage and construction waste management. The consistency across items confirms the reliability of this construct for assessing both the challenges and opportunities associated with infrastructure development projects.

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Table 4.
Challenges and Opportunities.

S. N	Descriptions	Cronbach alpha	Remarks
C.	**Challenges and opportunities**	**0.779**	**Acceptable**
1	Increase a dispute over property boundaries or right of way.	0.748	Acceptable
2	Increase relocation and migration of affected households.	0.734	Acceptable
3	Provide compensation for your property of claim due to road right of way.	0.740	Acceptable
4	Suggest an effective alternate route during some natural destruction(landslide) and construction periods.	0.757	Acceptable
5	Increases participation and communication between the community, local people, stakeholders, and project team	0.754	Acceptable
6	Manage construction material waste and reuse	0.793	Acceptable
7	Maintain safety and reduce road accident	0.757	Acceptable
8	Increase difficulties and disputes in the removal and placement of electric poles	0.737	Acceptable
9	Increase difficulties and disputes in the removal and placement of electric poles	0.764	Acceptable
10	Increase difficulties and disputes in the distribution and management of water supply pipes.	0.771	Acceptable
11	Increase difficulties and disputes in the management of disposal of sewerage pipes.	0.795	Acceptable
12	Increase difficulties in the distribution and management of internet wires and service in the poles to the public.	0.790	Acceptable

Table 5 illustrates the Relative Importance Index (RII) ranking of various socio-economic aspects as perceived by the respondents. The highest-ranked item is "Decrease the cost of health care services" with an RII of 0.753, indicating it is the most valued socio-economic benefit. This is followed by "Increases in the value of property (land, houses)" (RII = 0.729) and "Increases in wages or salary of local people" (RII = 0.673), highlighting the importance of financial and asset-related improvements. Other notable aspects include increased access to education and training (RII = 0.671) and enhanced job and business opportunities (RII = 0.668). Conversely, "Reduce the transportation time and fare" (RII = 0.515) and "Decrease your household expense" (RII = 0.544) received the lowest rankings, indicating a relatively lower perceived impact. Overall, the table emphasizes that respondents prioritize improvements in healthcare, property value, and income-related factors when evaluating socioeconomic outcomes of development projects.

Table 5.
RII rank of Socio-economic aspects.

S. N	Description	RII	Rank
1	Increase your household income.	0.572	8
2	Decrease your household expense	0.544	9
3	Increases job and business opportunities for local people	0.668	5
4	Increase in wages or salary of local people	0.673	3
5	Increases your ability to save money	0.574	7
6	Improve your access to markets and ability to sell your goods	0.649	6
7	Increases access to education and training	0.671	4
8	Reduce the transportation time and fair	0.515	10
9	Increases the value of property (land, houses)	0.729	2
10	Decrease the cost of health care services	0.753	1

Table 6 presents the Relative Importance Index (RII) rankings of environmental aspects based on respondent feedback. The highest-ranked concern is "Increases noise pollution" with an RII of 0.899, indicating it is the most significant environmental issue identified. This is followed by "Increase eco-renovation through plantation and resource conservation" (RII = 0.854) and "Provide a service (lane, traffic signs) road to vehicles and pedestrians during the construction period" (RII = 0.852). These reflect both environmental concerns and mitigation efforts. "Increase in traffic congestion and environmental disturbance" ranks fourth (RII = 0.802), while water pollution and access to clean

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drinking water (RII = 0.704) is fifth. The lowest-ranked item is "Increase air quality and visual aspect of the local area" (RII = 0.487), suggesting it is perceived as the least impactful. Overall, the table highlights noise pollution and eco-renovation as key environmental issues in the development context.

Table 6.
RII rank of environmental aspects.

S. N	Description	RII	Rank
1	Increase air quality and visual aspect of local	0.487	6
2	Increases noise pollution	0.899	1
3	Increases pollution of water sources and affects access to clean drinking water	0.704	5
4	Increases the frequency of traffic congestion, density, and its environment (noise by horns, plastics, and open defection)	0.802	4
5	Provide a service (lane, traffic signs) road to vehicles, and pedestrians during the construction period	0.852	3
6	Increase eco-renovation to cut, fill, water resources, etc. by plantation and resource conservation.	0.854	2

Table 7 displays the Relative Importance Index (RII) rankings of various challenges and opportunities related to infrastructure development. The most significant concern identified is "Manage construction material waste and reuse" with the highest RII of 0.791, reflecting a strong emphasis on sustainable construction practices. This is followed by issues related to the "distribution and management of water supply pipes" (RII = 0.758) and the need to "suggest effective alternate routes during natural disasters or construction" (RII = 0.746). Concerns such as sewerage management (RII = 0.739) and internet service disruptions (RII = 0.725) also ranked high. Lower-ranked issues include "Increase a dispute over property boundaries or right of way" (RII = 0.574) and "Provide compensation for affected property" (RII = 0.591). The least important challenge identified was "Maintaining safety and reducing road accidents" with an RII of 0.416. Overall, respondents prioritized technical and logistical infrastructure issues over social and compensation-related concerns.

Table 7.
RII rank of Challenges and Opportunities aspects.

S. N	Description	RII	Rank
1	Increase a dispute over property boundaries or right of way.	0.574	11
2	Increase relocation and migration of affected households	0.598	9
3	Provide compensation for your property of claim due to road right of way.	0.591	10
4	Suggest an effective alternate route during some natural destruction(landslide) and construction periods.	0.746	3
5	Increases participation and communication between the community, local people, stakeholders, and project team	0.722	6
6	Manage construction material waste and reuse	0.791	1
7	Maintain safety and reduce road accident	0.416	12
8	Increase difficulties and disputes in the removal and placement of electric poles	0.645	8
9	Increase difficulties and disputes in the removal and placement of electric poles	0.689	7
10	Increase difficulties and disputes in the distribution and management of water supply pipes.	0.758	2
11	Increase difficulties and disputes in the management of disposal of sewerage pipes.	0.739	4
12	Increase difficulties in the distribution and management of internet wires and service in the poles to the public.	0.725	5

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4.2. Key Informants Interview (KII) Response

After conducting Key Informant Interviews (KII) with various stakeholders involved in the Mugling-Pokhara Highway (Damauli Section) project, valuable insights were gained to confirm and validate the information collected through the questionnaire survey. Before the interviews, I introduced myself, explained the purpose of my visit, and requested the cooperation of the interviewees. We emphasized that their perspectives were crucial for verifying the data and ensuring the accuracy and credibility of my master's thesis research, which focuses on the socio-economic, environmental, and infrastructural impacts of highway development.

According to the project manager from the contractor's side, the initiative has significantly increased employment opportunities for both residents and individuals from other regions. While the road is still under construction and less congested, minor accidents have become more frequent due to potholes and slippery surfaces. Increased air and noise pollution were also acknowledged, although mitigation measures such as spraying water on the road surface have been implemented to minimize dust and air quality issues. The manager also confirmed that compensation for property affected by the Right of Way (ROW) has been provided, based on compliance with project specifications. Coordination with the Nepal Electricity Authority (NEA) is ongoing for the removal and replacement of electric poles. He emphasized that sustainability in highway construction includes various small but impactful actions affecting socio-economic and environmental well-being.

The Assistant Resident Engineer echoed many of these points, noting a rise in job opportunities due to the project. However, he observed that air pollution has negatively impacted the hospitality and retail sectors. Despite this, some reduction in travel time was noted. He acknowledged an increase in minor traffic accidents during the construction phase and confirmed that the preservation of water resources is addressed through user committees responsible for pipe repairs. Compensation has been paid as per established guidelines, and electric poles are being managed in coordination with NEA. He also affirmed the essential nature of sustainable highway development.

Similarly, the Head of the Engineering Department highlighted the project's role in creating employment and boosting business opportunities. However, challenges such as poor visibility, slippery road surfaces, and prolonged travel times during construction were cited as causes of increased minor traffic accidents. He noted efforts to reduce pollution, including watering road surfaces, and emphasized environmental protection through the construction of retaining walls and slope stabilization structures. Sustainability, he stated, is a fundamental principle due to the high investment required for highway development.

Lastly, another department head reinforced the importance of sustainable and green construction practices. He pointed out that while the project has generated job opportunities, pollution has led to the closure of some small businesses. He confirmed rising pollution levels and increased traffic incidents. Environmental conservation efforts, including bioengineering and water resource preservation, were discussed. The role of NEA and the Ministry of Forests in managing electric poles and tree cutting along the ROW was also confirmed. These KIIs collectively validate the data from the questionnaire survey and enrich the research with nuanced, field-based insights.

4.3. IEE report analysis of Mugling-Pokhara Highway

The IEE report analysis of the Mugling-Pokhara Highway highlights significant socio-economic and environmental impacts. Socio-economically, the project offers substantial employment opportunities, with approximately 1.3 million unskilled and 300,000 skilled workers expected to benefit during construction, alongside gaining technical expertise. It also expands business prospects and facilitates the faster, safer, and more affordable transport of goods and services from rural to urban areas. However, the construction may affect laborers' and locals' health and disrupt essential services due to the relocation of electric poles, telephone lines, water pipes, and sewerage systems. Notably, numerous community taps, transformers, and poles will be impacted. Compensation and relocation

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assistance will be provided to affected households. Additionally, changes in local markets and population behaviors are anticipated.

Environmentally, the project may cause terrain alterations, increasing risks of landslides, soil erosion, pollution, and climate change effects. The inclusion of paved shoulders aims to reduce dust-related air pollution, especially in populated areas, mitigating some environmental concerns.

5. Conclusion

This study aimed to evaluate the sustainability of the ongoing Mugling-Pokhara highway expansion project, with a focus on the Damauli section, by examining the socio-economic and environmental impacts, as well as the associated opportunities and challenges during the construction phase. Through field surveys and questionnaire responses from residents, contractors, and consultants, the study effectively captured diverse perspectives and experiences related to the project. Findings indicate that while highway construction significantly affects local socio-economic dynamics including disruptions to businesses, employment opportunities, market access, public health, and traffic flow these challenges are generally short-term, temporary, and reversible. If addressed through timely mitigation strategies, these impacts can be managed effectively, contributing to the project's long-term sustainability. On the environmental aspect, issues such as poor visibility, slippery road conditions, and increased risk of accidents were highlighted, emphasizing the need for proper site management and sustainable solutions like bioengineering and eco-renovation.

One of the major challenges identified relates to poor inter-agency coordination, particularly between the Nepal Electricity Authority (NEA) and the Khanipani Karyalaya (Water Supply Office). This lack of collaboration has delayed the relocation of utilities like electric poles and water pipelines, further complicated by inadequate compensation mechanisms for affected property owners.

The study's specific objectives were achieved by calculating the Relative Importance Index (RII) and using Cronbach's alpha to assess the internal consistency of the survey responses. This statistical analysis helped validate the significance of each sustainability factor as perceived by stakeholders. In conclusion, while the construction phase presents several short-term challenges, it also opens avenues for economic growth and infrastructure improvement. Effective planning, coordination, and stakeholder engagement are essential to ensure that such highway projects contribute positively to the nation's sustainable development goals.

6. Recommendation

Based on the study's conclusions, several recommendations are proposed to improve the Mugling-Pokhara Highway project's outcomes. Establishing clear economic, social, and environmental indicators such as pollution, income, healthcare, safety, and waste management will help monitor impacts effectively. Encouraging community and female participation in the design and implementation stages can enhance acceptance and reduce social disruptions. Long-term evaluation of environmental and economic impacts from construction to operation is essential for sustainability. Safety measures should include clear warning signs, limited water use, and road watering during low-traffic periods to prevent accidents. Planting trees and stabilizing slopes will reduce erosion, noise, and dust pollution. Enhancing coordination between NEA and local authorities will ensure efficient management of electric poles and water pipes with minimal disturbance. A transparent, timely compensation process with audits is necessary for affected households. Finally, dust control, quicker pothole repairs, and temporary access routes will maintain traffic flow and improve air quality during construction.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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References
[1] A. Shishegaran, A. Shishegaran, G. Mazzulla, and C. Forciniti, "A novel approach for a sustainability evaluation of developing system interchange: The case study of the sheikhfazolah-yadegar Interchange, Tehran, Iran," *International Journal of Environmental Research and Public Health*, vol. 17, no. 2, p. 435, 2020. https://doi.org/10.3390/ijerph17020435

[2] P. Rosasco and L. Sdino, "Infrastructures and sustainability: An estimation model for a new highway near Genoa," *Sustainability*, vol. 12, no. 12, p. 5051, 2020. https://doi.org/10.3390/su12125051

[3] H. Yao, L. Shen, Y. Tan, and J. Hao, "Simulating the impacts of policy scenarios on the sustainability performance of infrastructure projects," *Automation in Construction*, vol. 20, no. 8, pp. 1060-1069, 2011. https://doi.org/10.1016/j.autcon.2011.04.007

[4] H. Naganathan and W. K. Chong, "Evaluation of state sustainable transportation performances (SSTP) using sustainable indicators," *Sustainable Cities and Society*, vol. 35, pp. 799-815, 2017. https://doi.org/10.1016/j.scs.2017.06.011

[5] Government of Nepal, "Environment protection act, 2076 Kathmandu: Government of Nepal," Ministry of Forests and Environment, 2019. https://www.lawcommission.gov.np

[6] G. B. Suprayoga, M. Bakker, P. Witte, and T. Spit, "A systematic review of indicators to assess the sustainability of road infrastructure projects," *European Transport Research Review*, vol. 12, no. 1, p. 19, 2020. https://doi.org/10.3390/su12125051

[7] S. Alam, A. Kumar, and L. Dawes, "Sustainability assessment of road infrastructure using sustainability index," *Infrastructure Asset Management*, vol. 5, no. 1, pp. 3-13, 2017. https://doi.org/10.1680/jinam.17.00005

[8] A. Umer, K. Hewage, H. Haider, and R. Sadiq, "Sustainability assessment of roadway projects under uncertainty using Green Proforma: An index-based approach," *International Journal of Sustainable Built Environment*, vol. 5, no. 2, pp. 604-619, 2016. https://doi.org/10.1016/j.ijsbe.2016.06.002

[9] S. Sala, B. Ciuffo, and P. Nijkamp, "A systemic framework for sustainability assessment," *Ecological Economics*, vol. 119, pp. 314-325, 2015. https://doi.org/10.1016/j.ecolecon.2015.09.015

[10] F. Rodríguez López and G. Fernández Sánchez, "Challenges for sustainability assessment by indicators," *Leadership and Management in Engineering*, vol. 11, no. 4, pp. 321-325, 2011.

[11] O. Mills Leslie and N. Attoh-Okine, "Sustainability of civil infrastructure systems: The past, the present, and the way forward," in Sustainable Development of Critical Infrastructure, 2014, pp. 79-90. https://doi.org/10.1061/9780784413470.005

[12] S. Shivakumar, T. Pedersen, S. Wilkins, and S. Schuster, "Envision: A measure of infrastructure sustainability." Portland, Oregon: American Society of Civil Engineers, 2014, pp. 2249-2256. https://doi.org/10.1061/9780784413692.205

[13] P. Verma and A. S. Raghubanshi, "Urban sustainability indicators: Challenges and opportunities," *Ecological Indicators*, vol. 93, pp. 282-291, 2018. https://doi.org/10.1016/j.ecolind.2018.05.007

[14] B. Moldan, S. Janoušková, and T. Hák, "How to understand and measure environmental sustainability: Indicators and targets," *Ecological Indicators*, vol. 17, pp. 4-13, 2012. https://doi.org/10.1016/j.ecolind.2011.04.033

[15] J. M. Bryce, "Developing sustainable transportation infrastructure: Exploring the development and implementation of a green highway rating system (WISE internship project report)," Washington Internships for Students of Engineering Program, University of Missouri, 2008.

[16] A. Dawadi, S. K. Shrestha, and O. P. Giri, "Road maintenance practices in nepal: A case study of malekhu–mugling road section," *Advances in Engineering and Technology: An International Journal*, vol. 2, no. 01, pp. 59-67, 2022.

[17] K. P. Dhakal and J. S. Oh, "Integrating sustainability into highway projects: Sustainability indicators and assessment tool for Michigan roads," presented at the Transportation and Development Institute Congress 2011: Integrated Transportation and Development for a Better Tomorrow (pp. 987-996), 2011.

[18] A. H. Ibrahim and M. A. Shaker, "Sustainability index for highway construction projects," *Alexandria Engineering Journal*, vol. 58, no. 4, pp. 1399-1411, 2019. https://doi.org/10.1016/j.aej.2019.11.011

[19] A. J. Kadhim, Q. S. Banyhussan, and A. K. Jameel, "Cost-effectiveness analysis of a road improvement proposal based on sustainability Indicators: Case study Al-Nebai-Baghdad highway," *Periodicals of Engineering and Natural Sciences*, vol. 8, no. 2, pp. 916-932, 2020.

[20] A. Aljboor, R. Imam, and R. Alawneh, "Barriers to achieving sustainability in highway construction projects: The case of Jordan," *Sustainability*, vol. 15, no. 13, p. 10081, 2023. https://doi.org/10.3390/su151310081

[21] W. Luo, M. Sandanayake, G. Zhang, and Y. Tan, "Construction cost and carbon emission assessment of a highway construction—a case towards sustainable transportation," *Sustainability*, vol. 13, no. 14, p. 7854, 2021. https://doi.org/10.3390/su13147854

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 8: 1762-1775, 2025
DOI: 10.55214/2576-8484.v9i8.9706

[22] I. Henke, A. Cartenì, C. Molitierno, and A. Errico, "Decision-making in the transport sector: A sustainable evaluation method for road infrastructure," *Sustainability*, vol. 12, no. 3, p. 764, 2020. https://doi.org/10.3390/su12030764

[23] P. Ghoddousi, F. Nasirzadeh, and H. Hashemi, "Evaluating highway construction projects' sustainability using a multicriteria group decision-making model based on bootstrap simulation," *Journal of Construction Engineering and Management*, vol. 144, no. 9, p. 04018092, 2018. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001514

[24] O. P. Giri, "Choosing sampling techniques and calculating sample size," *Indonesian Journal of Teaching in Science*, vol. 4, no. 2, pp. 165-176, 2024.

[25] A. Kumar *et al.*, "A review of multi criteria decision making (MCDM) towards sustainable renewable energy development," *Renewable and Sustainable Energy Reviews*, vol. 69, pp. 596-609, 2017. https://doi.org/10.1016/j.rser.2016.11.191

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