



DELAY FACTORS IN NATIONAL HIGHWAY PROJECTS: IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT

This research aims to evaluate delay factors in Highway projects and analyse their implications on achieving the Sustainable Development. The study was conducted on National Highway Projects in rugged terrain, extreme weather conditions, and socio-economic dynamics of Himachal Pradesh, that pose unique challenges leading to project delays, potentially affecting Sustainable Development Goals (SDGs) related to economic growth, infrastructure, and environmental sustainability. The research utilised a qualitative methods approach using NVivo-14 software and data collected from recorded interviews with various stakeholders, media interviews, and document analysis of projects, reports, images, and official documents. The study identified critical delay factors specific to National Highway projects in Himachal Pradesh, including challenging terrain, landslides, weather conditions, and limited working seasons due to rainfall and snowfall. Delays were found to have significant economic and social implications, leading to cost overruns, hindering essential service provision, and impacting community development. Extended construction duration exacerbates environmental degradation, and affecting biodiversity. Delays hinder progress towards achieving SDGs related to economic growth, industry, sustainable infrastructure, and climate action. These findings highlight the necessity for sustainable and resilient infrastructure development capable of addressing the challenges posed by climate change and extreme weather events. Integrating sustainability into the planning, design, and construction of highways is crucial for minimising environmental impact, ensuring the safety and well-being of communities, and achieving the Sustainable Development Goals. The recommendations put forth in this study include enhancements in project management practices, active engagement with stakeholders, and the incorporation of modern construction technologies. In addition to that, strategies proposed for promoting sustainable development involve the utilisation of environmentally friendly materials, construction methodologies that are safe for the environment and ecology, and ensuring that infrastructure development adheres to objectives concerning economic, social, and environmental sustainability. Highway projects can impact SDGs such as Industry, Innovation, and Infrastructure (SDG-9) by hindering economic development, which can prolong delays, and contribute to environmental degradation affecting Climate Action (SDG-13) and Life on Land (SDG-15). Understanding these factors is crucial for developing strategies to mitigate delays and support SDG achievement, providing valuable insights for policymakers and practitioners involved in infrastructure development particularly highway infrastructure in hilly terrain.

Keywords: Highway projects; Hilly Road Projects; Delay factors; Sustainable Development Goals (SDGs); Infrastructure development

INTRODUCTION

Sustainable development is a critical goal for the global community, that aims to meet the needs of the present without compromising the ability of future generations. In the context of highway projects, delays can significantly undermine these efforts, impacting economic, social, and environmental dimensions of sustainability (El-Kholy and Akal, 2020; Hussain *et al.*, 2023). The economic, social, and environmental implications of delays in highway projects include cost overruns, hindered access to services, and extended environmental disruption (Karimi and Piroozfar, 2022; Hussain *et al.*, 2023; Shukla *et al.*, 2023). This highlights the need for strategic planning and sustainability in infrastructure projects. The linkages between sustainable development and infrastructure projects are multifaceted, involving economic, social, and environmental dimensions. Sustainable infrastructure projects aim to be economically viable, socially equitable, and environmentally sound, thereby contributing to the achievement of sustainable development goals (SDGs) (Thacker *et al.*, 2019; Hasan and Ghosh, 2021; Khurshid *et al.*, 2023). Similarly, sustainable highway projects aim to deliver long-term benefits, including enhanced transportation efficiency, reduced emissions, environment protection and an improved quality of life for communities (Scharlemann *et al.*, 2020; Gupta and Singh, 2024).

Delays in highway infrastructure projects are a major issue in developing countries (Mbala, Aigbavboa and Aliu, 2019; Rivera, Baguec and Yeom, 2020), especially in the challenging terrains of the Himalayas (Shri Puri, 2022; Modish Kumar, 2023). To study these delays in reference to sustainability is crucial due to their significant impact on environmental, community, and economic aspects of sustainable development. Moreover, there is a research gap in studying the comprehensive effects of such delays and their implications on sustainable development (Hasan and Ghosh, 2021; Hussain *et al.*, 2023).

LITERATURE REVIEW AND OBJECTIVE

The major causes of delay in construction projects include poor site management, shortage of skilled labour, unrealistic project scheduling, labour absenteeism, design changes/rework due to construction errors, and accidents resulting from poor site safety, all contributing to delays in project delivery (Mbala, Aigbavboa and Aliu, 2019). The primary causes of delay in highway projects include lack of experienced construction management, inadequate planning/scheduling, land acquisition issues, poor communication and frequent design changes, equipment shortages, force majeure, contract modifications, delays in progress billing, material shortages, delayed payments, and poor labour productivity (Rivera, Baguec and Yeom, 2020). Abonassrya, Alam and Saifullah, (2023) identified 14 critical categories derived from top delay factors, with orders and requirements, experience and productivity, financial problems, planning, and both external and management factors being the highest-ranking categories, affecting both developed and developing countries with a 28% and 72% impact respectively.

El-Kholy and Akal, (2020) introduces the Composite Highway Sustainability Index (CHSI) for assessing highway infrastructure projects, using fuzzy set theory and analytic hierarchy process (AHP). Authors extract 11 criteria from 43 factors, discussing their significance for sustainable development and demonstrating CHSI's applicability through a case study. Hussain *et al.*, (2023) concluded that infrastructure is crucial for economic development, and public project delays are a major explanatory factor affecting sustainable development and quality of life in neighbourhoods. The research concludes that social welfare is impacted by these delays. Their study quantitatively modelled the impact of public project delays on sustainable community development, finding significant effects on quality of life. Using PLS-SEM analysis, it identified key delay factors and emphasised their importance to avoid them for community well-being. Delays in highway projects can result in cost overruns, which strain public budgets and redirecting funds from other development projects, leading to increased operational costs and missed opportunities for economic growth due to prolonged project completion (Liu, Zhang and Cao, 2021; Youssefi and Celik, 2024). Project delays can hinder access to essential services, impacting sustainable development; for instance, delays in highway construction can disrupt mobility, affecting jobs, potentially causing displacement of people, and limiting access to healthcare and education (Tummalapudi *et al.*, 2022; Hussain *et al.*, 2023). From an environmental perspective, delays in construction projects can prolong pollution and habitat disruption, while the associated uncertainty and inefficiency can impede the adoption of environmentally friendly technologies and practices (Antoniou, 2021).

The review conducted by Hasan and Ghosh, (2021) highlights key research themes in sustainability, and found that there is a lack of research into project management in sustainable infrastructure projects in developing countries. Despite growing trends in global research themes in sustainability, such as sustainability metrics, processes, and community impact, previous studies fail to address sustainability in project management in infrastructure projects within developing countries. The primary objective of this study is to investigate the multifaceted effects of delays in Himalayan highway projects on sustainable development, focusing on economic repercussions, environmental consequences, and social impacts on local communities. Therefore, this study is an attempt to address the research gap in understanding the implications of project delays on sustainable development. The primary objective is to investigate the multifaceted effects of delays in Himalayan highway projects on sustainable development, focusing on economic repercussions, environmental consequences, and social impacts on local communities. The study is conducted on National Highway projects in Himachal Pradesh, a Himalayan state of India; however, the findings are important lessons for highway projects across the globe.

MATERIAL AND METHODS

In this study, for identification of delay factors we conducted a well-established method called systematic literature review followed by qualitative data analysis of interviews and discussion with project participants. A similar approach was adopted by Shash & AbuAlnaja (2021), Rachid et al. (2019), Wang et al., (2018) and Bajjou & Chafi (2020) to find out the causes of project delays in their respective study. After analysing the results from studies in the systematic literature review, a total of 158 delay factors in construction projects worldwide were identified and listed. To filter out the appropriate causes of delays on National Highway (HPPWD project participants were involved, and detailed discussions with eleven project participants having work experience more than 20 years and holding key positions in Highway Projects were conducted. Participants were given a checklist of identified delay factors from the systematic literature review to select those relevant to this study. Through this process, 45 delay factors were identified as the most relevant to National Highway Projects in Himachal Pradesh. To explore the impact of delays in National Highway projects in Himachal Pradesh on sustainable development, a Qualitative research method approach was employed. Data collection involved 17 semi-structured interviews with project participants, providing in-depth insights into their experiences and perspectives. In this study, professionals such as engineers, consultants, contractors, and managers from projects implemented by to agencies Himachal Pradesh Public Works Department (HPPWD) and the National Highway Authority of India (NHAI) participated in the interviews and discussion process. Additionally, 240 project documents, including contracts, reports, images and communication records pertaining to National Highway projects in Himachal Pradesh, were analysed. The data collection from multiple sources was an iterative process, following theoretical sampling until information gain reached saturation (Flick, 2014).

Table I: Matrix for delay factors, their implications and best practices

Delay Factors	Economic Repercussions	Environmental Consequences	Social Impacts	Best Practices to Mitigate Delays
Poor planning and scheduling by the contractor	Cost overruns, budget reallocation	Increased resource consumption and increased pollution due to longer periods of machinery	May have ripple effect on economic and social well being leading to Community dissatisfaction	Robust project management and scheduling tools and techniques
Inappropriate construction methods and rework	Additional expenses for rework	Waste generation, increased carbon footprint	Dissatisfaction due to prolonged construction	Adoption of modern construction methods and technologies
Contractor's financial difficulties	Project stalling, financial losses	Stalled sites can lead to environmental degradation	Job insecurity for workers	Financial planning and risk assessment
Poor site management and supervision	Inefficiencies leading to economic loss	Potential for environmental harm due to mismanagement	Disrupted communities, damaged landscape, noise, dust, health issues, traffic congestion	Employ competent site managers and effective supervision practices
Design error, lack of design work and information	Increased costs due to redesign	Design errors increase rework, waste, pollution, vulnerability, and potentially unnecessary destruction.	Infrastructure that fails to meet the needs of the community	Comprehensive design review and validation processes
Inaccurate survey of the site	Unplanned expenses to address issues	Disturbance to unanticipated ecological areas	Disruption to community due to changes	Accurate and thorough site surveys prior to construction
Land acquisition	Prolonged project timelines, increased costs	Extended construction period due to Habitat destruction, soil erosion, landslides, and water resource degradation.	Social unrest among affected communities, Community displacement, economic disruption, cultural loss, and health concerns.	Transparent and fair land acquisition processes
Inadequate supervision, inspection, and testing	Risk of substandard infrastructure	Potential long-term environmental damage	Safety concerns for the community	Regular monitoring and quality control measures
Utility shifting work	Delays can lead to cost overruns	Disruption to existing services	Inconvenience and service disruption for locals	Early coordination with utility providers

Forest clearances	Financial penalties and project delays	Loss of biodiversity, deforestation	Impact on local ecosystems relied upon by communities	Environmental impact assessments and sustainable practices
Damaged or poor quality of materials	Need for replacement leading to additional costs	Waste generation, resource depletion	Compromised infrastructure quality	Quality control systems and reliable supply chains
Weather conditions (heavy rains and floods)	Project delays, increased protection costs	Soil erosion, water pollution, landslides, drainage issues, road damage.	Loss of lives, displacement, infrastructure damage, and health risks.	Weather-adaptive planning and construction methods, creating proper drainage system
Changes in government regulations & laws	Compliance costs, project rescheduling	Uncertainty in environmental standards	Legal disputes affecting communities	Staying updated with regulations and proactive compliance
Force majeure (natural disasters)	Unpredictable financial impacts	Severe environmental damage	Loss of life, property, and livelihoods	Disaster preparedness and resilient infrastructure design
Landslides	Repair costs, project delays	Soil degradation, loss of biodiversity	Blocked access routes, isolation	Geotechnical surveys and slope stabilization techniques
Poor contract management	Increased litigation and arbitration costs, delayed project completion	Prolonged delays cause pollution, inefficiency, resource wastage due to extended construction period	Strained stakeholders' relationships	Effective contract management and dispute resolution
Difficulty due to rugged topography	Specialized construction increases costs; frequent maintenance strains economic resources.	Landslides and construction disrupt ecosystems, causing biodiversity loss and pollution.	Possibility of community displacement, prolonged construction impact access to services.	Advanced engineering solutions and terrain analysis
Unfavourable site conditions	Costly adaptations, project delays	Increased environmental impact	Delays in community benefits, interruption in basic public service	Detailed site condition assessments
Space constraints	Use of more expensive construction techniques Increased costs and higher maintenance due to space constraints, Logistical challenges,	Concentrated pollution and waste, Habitat disruption and soil erosion from confined space construction.	Community displacement and interrupt access to services and opportunities.	Efficient space management and logistics planning
Land issues (demarcation, encroachment)	Legal disputes, financial implications	Potential for unplanned environmental impact	Community conflicts, and local land owners	Clear land titles and community engagement

Thematic content analysis was conducted on interviews, news articles, and reports related to the highway projects to understand public perception and media portrayal. For data analysis, NVivo-14 was used to perform thematic content analysis, coding the data into nodes representing themes and sub-themes. Thematic content analysis identified patterns and discrepancies within the project documents and media materials. In this process, 20 critical delay factors in National Highway projects were identified, each directly or indirectly impacting sustainable development. Comparative analysis was used to combine findings from different data sources, to support the findings. Validation and verification were done by sharing summarised findings with participants for their feedback and cross-checking the data from multiple sources. To understand project delays' effects on sustainable development in Himachal Pradesh's National Highway Projects, we used NVivo software and a Framework Matrix to organise and summarize qualitative data. This helped identify and compare economic, environmental, and social impacts. NVivo-14 facilitated thematic analysis, coding data into themes and sub-themes, while content analysis of documents and media identified patterns and correlations. Comparative analysis triangulated data from various sources, enhancing robustness. Validation and verification through member checking and triangulation ensured accurate participant perspectives. The Framework Matrix highlighted significant delays' impacts, emphasizing the need for strategic planning and efficient project management to improve infrastructure project outcomes in Himachal Pradesh. Key themes included cost overruns, budget issues, hindered economic growth, prolonged pollution, habitat disruption, resource depletion,

reduced access to services, economic hardships for local community, dissatisfaction and negative public perception.

RESULTS AND DISCUSSION

The summary of the entire matrix Table 1, is given below, highlight the multifaceted challenges and solutions associated with delay factors in highway construction projects, emphasising the need for integrate strategic planning, environmental consideration, and community engagement.

- Effective Project Management is crucial to prevent cost overruns and community dissatisfaction caused by poor planning and scheduling.
- Adoption of Modern Construction Methods can reduce rework expenses and environmental impact while addressing prolonged construction dissatisfaction.
- Financial Planning is critical for contractors to avoid project stalling, job insecurity, and environmental degradation.
- Competent Site Management is necessary to prevent economic loss, environmental harm, and community disruption.
- Comprehensive Design Review helps prevent increased costs and unnecessary destruction due to design errors or lack of information.
- Accurate Site Surveys are important to avoid unplanned expenses and ecological disturbances, ensuring infrastructure meets community needs.
- Transparent Land Acquisition can mitigate prolonged timelines and social unrest due to habitat destruction and other issues.
- Quality Control Measures are required to prevent substandard infrastructure and long-term environmental damage.
- Early Utility Coordination helps avoid delays and service disruptions during construction.
- Efficient Space Management is critical to prevent increased costs, pollution, and community displacement.

In Himachal Pradesh's challenging Himalayan terrain, effective project management aligns with SDG-9 by enhancing industry, innovation, and infrastructure through cost-efficient and timely highway projects. Advanced construction methods such as lean construction support SDG 11 and SDG-13 by reducing environmental impact and promoting sustainability (Peiris *et al.*, 2023). These practices contribute to SDGs by promoting efficient resource use, environmental protection, and community well-being (*THE 17 GOALS | Sustainable Development*). This emphasises the need for strategic planning, environmental consideration, and community engagement to achieve sustainable development goals in highway construction projects, aligning with SDG targets for infrastructure and responsible consumption in the construction process (Gyadu-Asiedu, Ampadu-Asiamah and Fokuo-Kusi, 123AD; Rageh *et al.*, 2023).

Financial planning and competent site management contribute to SDG-8, ensuring economic growth and decent work. Comprehensive design reviews and accurate site surveys uphold SDG-15, by special focus on protecting life on land through ecological conservation. Transparent land acquisition, fair compensation, and equitable distribution of infrastructure benefits support SDGs by maintaining individuals' standards of living, preventing poverty, building resilient and inclusive infrastructure, and promoting justice and transparent systems (Mahalingam and Vyas, 2011; Jyoti Rao, 2017; Mohmad Shariff *et al.*, 2023). Quality control measures promote the infrastructure is built to last, reducing the need for frequent repairs and rebuilds, which in turn conserves resources and minimises environmental impact (Peiris *et al.*, 2023). Stakeholder engagements and early utility coordination minimises disruptions, reduces the need for relocations and utility alterations, and leads to more efficient resource use, minimising impacts on urban services during construction (Bal *et al.*, 2013; Francis and Almony, 2015; Adhi and Muslim, 2023).

CONCLUSION

In Himachal Pradesh, highway projects are pivotal for regional development but face challenges in execution, leading to delays with economic, social, and environmental repercussions. In this study systematic literature review and qualitative analysis, involving experienced project participants, identified 20 most critical delay factors. Using NVivo-14 for thematic analysis and a Framework Matrix, the research highlights the need for careful planning, community engagement, and sustainable practices. These practices are important to reduce delays and meet the Sustainable Development Goals (SDGs), ensuring that infrastructure projects are economically viable, social equitable and good for the environment. The findings emphasised on effective project management, modern construction methods, and comprehensive planning to enhance transportation efficiency, reduce emissions, and improve community well-being.

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