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Improvement of Social Impact Assessment in Infrastructure Projects using Participatory GIS

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Abstract

Social Impact Assessment (SIA) plays a critical role in ensuring that infrastructure projects are socially sustainable, inclusive, and responsive to the needs of affected communities. However, conventional SIA practices often suffer from inadequate stakeholder engagement, lack of transparency, and data gaps that limit their effectiveness. This study explores the integration of Participatory Geographic Information Systems (PGIS) as a means to enhance the scope and quality of SIA in infrastructure planning.

The research is grounded in a detailed literature review and comparative analysis of five infrastructure case studies, including national examples from India (NH361 Upgradation and Nilambur Bypass) and international projects from Belarus, Sri Lanka, and Malaysia. The findings highlight the limitations of traditional SIAs in addressing community concerns, and demonstrate how PGIS tools—through participatory mapping, spatial data visualization, and real time feedback mechanisms—can improve stakeholder involvement, data accuracy, and social accountability.

A PGIS based framework is proposed, focusing on community centered engagement, digital grievance redressal, mobile based monitoring, and data privacy protocols. The study concludes that integrating PGIS into SIA processes not only enhances transparency and trust but also leads to more inclusive planning and better project outcomes. This approach holds significant potential for policymakers, planners, and project authorities committed to sustainable and socially just infrastructure development.

Keywords: Social Impact Assessment (SIA), Participatory GIS (PGIS), Infrastructure Planning

1. Introduction

The study explores the potential of improving Social Impact Assessment (SIA) in infrastructure projects through the integration of Participatory Geographic Information Systems (PGIS). SIA plays a crucial role in evaluating the social consequences of projects, ensuring that adverse effects on communities are minimized while positive impacts are maximized. In the backdrop of increasing urbanization, infrastructure expansion, and environmental concerns, traditional SIAs often fall short due to limited stakeholder engagement, lack of transparency, and inadequate data accuracy. The study identifies these gaps and proposes that PGIS—a method that combines spatial technologies with community participation—can offer a more inclusive and context sensitive approach to SIA, thereby enhancing the social sustainability of development initiatives.

The research aims to develop a framework for enhancing SIA using PGIS in infrastructure projects. Key objectives include studying the fundamental principles of SIA and PGIS, identifying challenges in conventional SIA practices, analyzing the effectiveness of PGIS, and recommending an integrated framework. The research is guided by questions about the theoretical and methodological foundations of

SIA, the role of PGIS in enhancing impact assessments, and how participatory mapping can mitigate social issues more effectively. The scope of the study includes the examination of infrastructure projects across various geographic contexts, while the limitations lie in the availability of detailed reports, regional disparities in SIA practices, and the subjective nature of social impacts.

2. Aim

To recommend a framework to improve Social Impact Assessment (SIA) in infrastructure projects using Participatory GIS.

3. Objectives

1. To study key concepts of Social Impact Assessment.
2. To study core principles of Participatory GIS.
3. To identify common challenges and best practices in conducting SIAs.
4. To analyse the effectiveness of Participatory GIS in SIA practices in promoting socially sustainable development.
5. To recommend a framework based on Participatory GIS to improve SIA.

4. Research Questions

1. What are the key theoretical foundations and methodologies of Social Impact Assessment?
2. How effective are SIA processes in identifying and mitigating social impacts in selected development projects?
3. How can Participatory GIS enhance SIA?

5. Scope

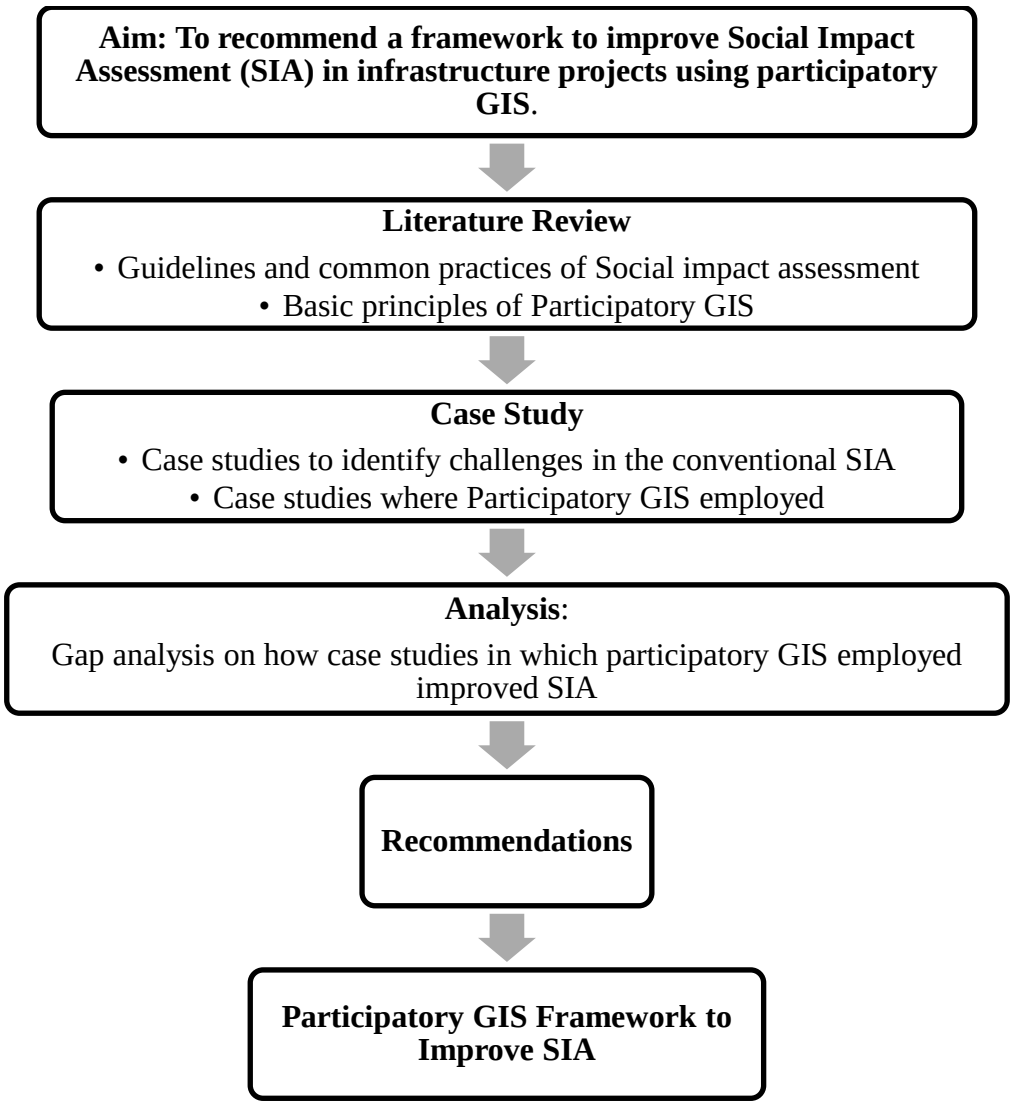
The study focuses on SIA reports conducted in various infrastructure projects. It analyses case studies from different geographic regions to understand diverse applications and outcomes.

6. Limitations

- The study may be constrained by the availability of detailed SIA reports.
- The variability in SIA practices across different sectors and regions may limit the comparability of findings.
- Social impacts are not quantifiable and are multidimensional in nature.

7. Methodology

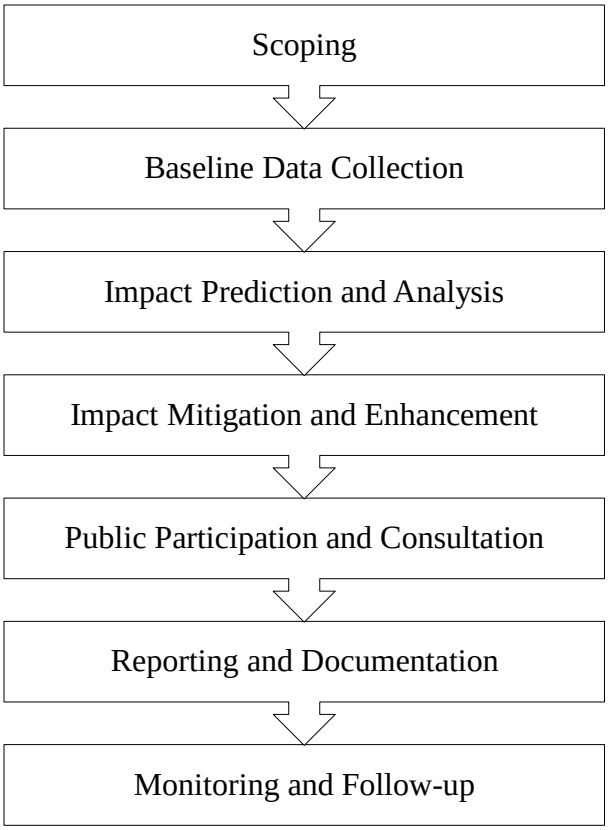
The methodology follows a structured path starting with an extensive literature review to establish a conceptual foundation on both Social Impact Assessment and Participatory GIS. This is followed by a detailed examination of five case studies, selected to represent both national and international projects. These case studies are analyzed to identify challenges in the current SIA framework and evaluate the improvements enabled by PGIS tools. The analysis includes a gap analysis, comparing traditional SIA methods against participatory GIS driven approaches. Finally, based on these insights, a PGIS framework is proposed, including mechanisms for community engagement, real time monitoring, grievance redressal, and data security.



Methodology

8. Literature Review

Social Impact Assessment is a methodology designed to predict and evaluate the potential social consequences of planned projects and policies. It ensures that development activities consider social wellbeing alongside economic and environmental concerns. The evolution of SIA since the 1970s has led to its incorporation into international funding protocols and national legislation such as India's RFCTLARR Act of 2013. SIA methodology typically involves scoping, baseline data collection, stakeholder analysis, impact prediction, mitigation planning, and monitoring. However, traditional approaches often suffer from insufficient community involvement, data generalization, and lack of transparency.



Steps of SIA

Participatory GIS, by contrast, is a tool that blends geospatial technology with local knowledge to create more inclusive decision making processes. It allows communities to contribute their lived experiences directly to spatial data systems, ensuring that planning reflects real world concerns. PGIS emphasizes inclusivity, data transparency, community empowerment, and cultural sensitivity. It supports visual storytelling, enhances data accuracy through localized mapping, and promotes trust through transparent workflows. When applied in SIA, PGIS enables better stakeholder engagement, real time feedback, and the creation of community driven mitigation strategies.

9. Case Studies

NH361 Upgradation Project (India)

This project involved upgrading a 60 km stretch of highway in Maharashtra. It revealed challenges such as inadequate stakeholder consultations, delayed feedback incorporation, economic disruptions for affected populations, and weak mechanisms for health and safety planning. The SIA process highlighted issues in compensation, relocation planning, and monitoring of mitigation measures.

Nilambur Bypass (Kerala)

This regional infrastructure project required the acquisition of 10.66 hectares of land, affecting multiple households and businesses. Key issues identified include preemptive property degradation, inadequate consultation, environmental risks to local water bodies, and unresolved concerns over compensation and relocation. The absence of alternative route planning and skepticism about grievance redressal were significant drawbacks.

P80 Motor Road Sloboda-Papernya (Belarus)

An international case aligning with European Bank for Reconstruction and Development standards, this project faced complex challenges in stakeholder engagement, land acquisition, environmental compliance, and monitoring. While structured consultations were held, lingering dissatisfaction among residents indicated gaps in feedback incorporation and trust building.

Sl. No.	Case Study	Challenges
1.	NH361 Upgradation Project (India)	Stakeholder Engagement and Community Concerns
		Environmental and Health Risks
		Impact on Local Businesses and Agriculture
		Compliance and Monitoring
2.	Nilambur Bypass Project (India)	Land Acquisition and Displacement
		Livelihood and Economic Disruption
		Implementation Delays and Insufficient Consultation
		Health and Safety Concerns
		Monitoring and Capacity Limitations
3.	P80 Motor Road (Belarus)	Land Acquisition and Community Displacement
		Livelihood Disruption
		Environmental and Infrastructure Impacts
		Consultation and Grievance Redressal Issues
		Lack of Alternatives Considered

Challenges in Conventiontional SIA

Kalu Ganga Reservoir Project (Sri Lanka)

This national irrigation development initiative faced initial resistance due to top down decision making. PGIS was employed to enable community mapping of properties and culturally significant sites. It facilitated transparent resettlement planning, ecological corridor mapping, and community driven economic planning. Challenges included institutional resistance and technological barriers, but the overall impact was positive in building trust and reducing conflict.

Darul Hana Redevelopment Project (Malaysia)

The project aimed at urban rejuvenation through active community involvement. PGIS tools were used to enhance stakeholder mapping, identify target groups, and facilitate scenario planning. Despite some initial issues with communication and group representation, the project successfully used spatial visualization to improve participation, trust, and resource allocation.

10. Analysis

The analysis identifies key challenges from the first three case studies, including stakeholder exclusion, environmental risks, inadequate compensation, and weak monitoring mechanisms. In NH361 and Nilambur projects, public consultation was limited and slow, leading to mistrust and planning delays. The SlobodaPapernya project, though aligned with international standards, also suffered from unresolved environmental and compensation issues. These problems span across various stages of SIA—from scoping and impact prediction to mitigation and compliance monitoring.

SIA Challenge	Case Studies 1–3: Challenges Identified	Case Studies 4–5: PGIS Solutions	Effectiveness of PGIS
Stakeholder Engagement	NH361: Limited community input causing opposition	Kalu Ganga: Residents mapped properties, promoting inclusion	PGIS improved engagement by directly involving communities and ensuring balanced representation
	Sloboda–Papernya: Minimal engagement led to misunderstandings	Darul Hana: Targeted engagement via demographic tools	
Data Collection & Accuracy	NH361: Generic data, lacked socioeconomic specifics	Kalu Ganga: Precise household/resource mapping with sociocultural context	PGIS enhanced accuracy by integrating local knowledge, aiding tailored project planning
	Nilambur: Limited baseline data caused planning issues	Darul Hana: Detailed demographic mapping	
Transparency & Trust	Belarus: Lack of transparency eroded stakeholder trust	Kalu Ganga: Open data visualization improved transparency	PGIS built trust through accessible, transparent data and clearer communication of impacts
	Nilambur: Unclear decision making caused skepticism.	Darul Hana: Visualized project impacts.	
Impact Assessment	Belarus: Technical SIA reports hard to interpret	Darul Hana: Scenario based visual assessments	PGIS enabled easy to understand, group specific impact assessments improving mitigation planning
	Nilambur: Poor modeling for specific community groups	Kalu Ganga: Targeted impact modeling	
Compensation & Resettlement	Nilambur: Culturally insensitive planning caused resistance	Kalu Ganga: Mapping included cultural landmarks, improving site appropriateness	PGIS made resettlement planning culturally respectful, reducing opposition
Conflict Resolution	NH361: Conflicts due to poor consultation	Kalu Ganga: Collaborative mapping addressed and validated concerns	PGIS reduced conflicts through inclusive, visual documentation of grievances
Resource Allocation	Nilambur: Poor allocation due to generic data	Darul Hana: PGIS revealed precise community needs and priorities	PGIS optimized resource use by aligning allocation with community specific spatial insights

Improvement of SIA using PGIS

A comparative gap analysis between these traditional SIAs and the PGIS based approaches in the last two case studies reveals clear improvements. PGIS enhanced stakeholder engagement through community mapping, improved data accuracy by integrating sociocultural knowledge, and increased transparency via

visual tools. Compensation planning became more precise, culturally sensitive, and community approved. Impact assessments were more digestible and allowed for scenario modeling, while grievance redressal mechanisms became trackable and efficient. Resource allocation was also better aligned with local needs due to spatially grounded data.

11. Recommendations

Based on the analysis, the study proposes a comprehensive PGISbased framework to improve Social Impact Assessments in infrastructure projects. The framework includes communitycentered stakeholder engagement through mapping workshops and digital input portals. Realtime compliance tracking is facilitated by mobile GIS applications and automated alerts for environmental breaches. A digital grievance redress system is also proposed, enabling users to log complaints directly on GIS platforms with locationspecific tracking.

To ensure privacy and trust, data anonymization protocols and periodic map updates are recommended. A phased implementation strategy is advised—beginning with pilot zones and scaling up based on feedback. Training programs for community liaisons and project teams will support sustained use of the framework. The expected outcomes include improved stakeholder trust, better monitoring of project impacts, efficient grievance redressal, and enhanced social sustainability.

12. Abbreviations and Acronyms

Acronym	Full Form
SIA	Social Impact Assessment
PGIS	Participatory Geographic Information System
GIS	Geographic Information System
PPGIS	Public/Participatory Geographic Information System
RFCTLARR Act	Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act (2013)
EBRD	European Bank for Reconstruction and Development
NHAI	National Highways Authority of India
PAPs	Project Affected Persons
RAP	Resettlement Action Plan

13. Units

Unit	Meaning / Usage
km	Kilometer – used for length and distance
hectare / ha	Land area – used for land acquisition (e.g., 10.66 hectares in Nilambur Bypass)
% (percentage)	Used to describe proportions (e.g., increase in project cost, participation rate, engagement success)
dB (decibels)	Referred indirectly under “noise pollution” – typically used in health/environmental monitoring tools

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