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CONSTRUCTION OF SEWER REHABILITATION AND ITS CONSEQUENCES: A CASE STUDY OF LALITPUR METROPOLITAN CITY, NEPAL

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ABSTRACT

Urban sewerage infrastructure plays a vital role in maintaining public health, environmental sustainability, and the overall quality of urban life. Lalitpur Metropolitan City (LMC), one of the major urban centres in Nepal and home to the UNESCO World Heritage Site of Patan Durbar Square, has been experiencing severe drainage and sewerage-related problems, particularly during the monsoon season. Frequent clogging of stormwater drains, overflow of existing sewer networks, waterlogging, and flooding in areas such as Mahapal and Patan Durbar Square have adversely affected public health, transportation, tourism, and environmental conditions. This study investigates the construction of sewer rehabilitation works and their consequences in Lalitpur Metropolitan City. A mixed-method approach was adopted, involving field observations, questionnaire surveys, in-depth interviews with engineers, contractors, consultants, and local stakeholders, focus group discussions, and review of project reports. Data were collected from 205 respondents and analyzed using descriptive statistics and the Relative Importance Index (RII). The study focuses on rehabilitation works along the core sewer network extending from Lagankhel to Sankhamul, including the heritage-sensitive zones of Patan Durbar Square. The findings indicate that inadequate existing sewer infrastructure capacity was ranked as the most severe problem (RII = 0.89), followed closely by lack of proper planning and design integration, weak institutional coordination, and funding and budget constraints (RII = 0.88 each). Insufficient drain capacity, aging sewer infrastructure, improper road gradients, solid waste disposal into drains, inadequate maintenance, and rapid urbanization were identified as the primary causes of sewer blockage and flooding, while consequences include traffic disruption, damage to infrastructure, environmental pollution, public health risks, and negative impacts on tourism and local economic activities. The study identifies preparation of a comprehensive sewer master plan as the highest-ranked mitigation measure (RII = 0.90), followed by strengthening institutional coordination and securing adequate and sustainable funding mechanisms. The findings underscore the need for combined sewer and stormwater planning, regular maintenance, public awareness, and heritage-sensitive construction practices to reduce flooding and improve urban sanitation in Lalitpur Metropolitan City.

Keywords: *Sewer rehabilitation, stormwater drainage, urban flooding, wastewater management, urban infrastructure, sewer network.*

1. INTRODUCTION

The development of sewerage systems and underground utilities has played a crucial role in shaping modern cities and improving public health. Urban sewage systems should not only focus on preventing waterlogging but also on recycling wastewater, using water resources sustainably, and restoring natural water systems, with sewers primarily intended to carry rainwater and wastewater away from the city to nearby water bodies [3]. Sewage is a major source of pollution, especially in cities, and pollution of drinking water by human waste remains one of the leading causes of death worldwide; proper systems for collecting, treating, and safely disposing of sewage are therefore essential to protect public and environmental health [2].

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In urban areas of the Kathmandu Valley, particularly Lalitpur Metropolitan City (population approximately 1.7 million), the lack of proper sanitation has adversely affected local rivers such as the Bagmati and Bishnumati. Many areas of Lalitpur lack adequate systems for collecting and treating wastewater, sufficient toilet facilities, and proper solid waste management. Untreated wastewater from farms and industries further pollutes water resources and harms public and environmental health; poor wastewater management can contaminate drinking water, damage aquatic life, and contribute to long-term health problems and negative economic effects [1].

Lalitpur Metropolitan City is an ancient city and an important tourist destination for both Hindu and Buddhist traditions. Its drainage system, originally constructed by private contractors roughly 35 years ago, has not kept pace with the city's growing population and expanding built-up area, which has reduced natural infiltration and increased wastewater generation. Areas such as Patan Durbar Square, Mahapal, and the Bangalamukhi Temple precinct frequently experience flooding and waterlogging due to poor drainage, particularly during the monsoon season when rainwater collects on low-lying roads faster than the existing sewerage and stormwater systems can convey it [6].

The Patan Durbar Square area floods every monsoon because the stormwater drainage system is inadequate: large volumes of rainwater enter the existing combined sewer during heavy rainfall, mixing with sewage and blocking pipes. Poor drainage from Lagankhel to Patan Durbar and Mahapal is mainly caused by small, low-capacity drains, aging sewer infrastructure, improper road gradients, insufficient rainwater inlets, and the disposal of solid waste into drains. Because the land slopes toward Patan Durbar Square, rainwater mixed with sewage overflows onto the roads, causing traffic congestion, damage to buildings, water pollution, spread of waterborne disease, and harm to aquatic life.

This study therefore examines the construction of sewer rehabilitation works and their consequences in Lalitpur Metropolitan City, with the objectives of: (a) identifying the causes of clogging of stormwater drainage in the World Heritage Site of Patan Durbar and the Mahapal area; (b) identifying the effects caused by the clogging of stormwater and the existing sewerage system in these areas; and (c) identifying probable solutions to the clogging of stormwater in the Patan Durbar and Mahapal areas.

2. MATERIALS AND METHODS

2.1 Study Area

This study was conducted in Lalitpur Metropolitan City, Nepal, focusing on the core sewer rehabilitation network extending approximately 2.81 km. Line 1 runs from the Lagankhel Bus Park area through Tangal, Hagal, Mangalbazar, Patan Durbar Square, and Swotha to Sankhamul; Line 2 originates near Kumaripati Itti Tole and passes through Ikhalukhu, Mahapal Junction, and Kwalkhu to Swotha; and Line 3 connects Line 1 and Line 2 via Thabulan. The network uses circular pipes ranging from 500 mm to 1400 mm in diameter, comprising 1.71 km of Double Wall Corrugated HDPE pipe and 1.078 km of reinforced concrete pipe, and passes directly through the stone- and brick-paved heritage precinct of Patan Durbar Square.

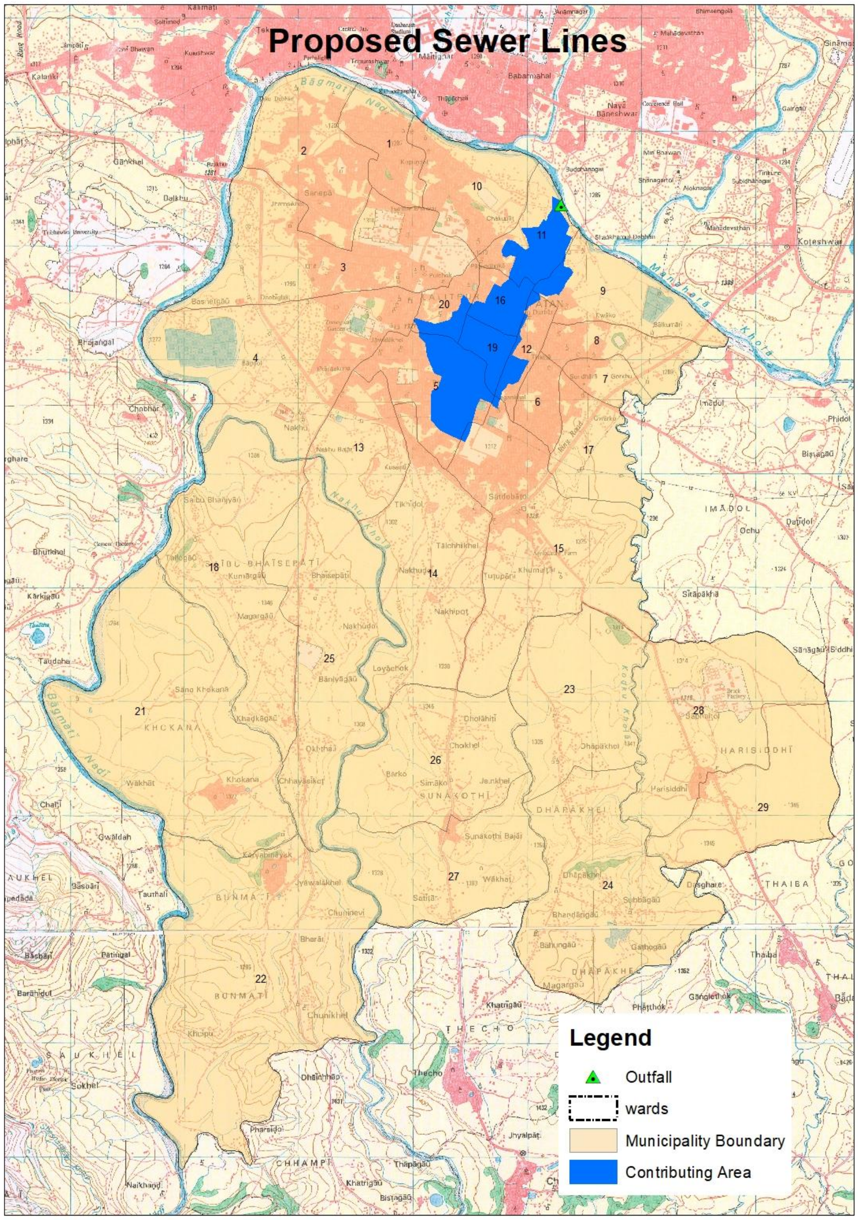

Fig. 2.1. Service area and Lalitpur Metropolitan City (LMC)

2.2 Research Design

A mixed-method research approach combining quantitative and qualitative techniques was adopted, integrating a structured questionnaire survey with field observations, in-depth interviews, and focus group discussions. Primary data were collected over a four-month period from January to June 2024. For the questionnaire survey, the required sample size was determined using Slovin's formula for a known population:

$$n = N / [1 + N(e)^2] \qquad \text{Equation (1)}$$

where N is the population of Lalitpur Metropolitan City (approximately 1.7 million) and e is the desired precision (7%), giving a required sample size of n ≈ 205. Respondents — including municipal and contractor engineers, sub-engineers, consultants, contractors, and members of the public — were selected through purposive sampling.

Data analysis

Data have been analyzed primarily through the Relative Importance Index (RII), used to rank the problems, causes, effects, and mitigation measures associated with the construction of sewer rehabilitation, based on a five-point Likert scale (strongly disagree to strongly agree). RII was computed as:

$$RII = \Sigma W / (A \times N) = (5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1) / 5N \qquad \text{Equation (2)}$$

where W is the weight assigned by each respondent (1–5), A is the highest weight (5), N is the total number of respondents, and n_1–n_5 are the numbers of respondents selecting each rating category. RII values range from 0 to 1, with higher values indicating greater relative importance.

3. RESULTS AND DISCUSSION

3.1 Sewer Network Overview

A hydraulic performance analysis of the rehabilitated sewer network was conducted using Manning's equation to evaluate how well the existing pipes accommodate peak wastewater flows. Line 1 shows conservative design margins, with its largest 1.4 m diameter section utilizing only 84.6% of total capacity and upstream segments operating between 58.5% and 86.8% capacity, indicating a stable infrastructure with a substantial safety buffer. Line 2 operates under tighter hydraulic constraints, with its 1.0 m and 0.8 m pipe sections reaching 91.8% and 95.6% peak utilization respectively — technically adequate for current demand but with minimal margin for future expansion or unexpected stormwater infiltration.

3.2 Characteristics of Respondents

Among the 205 respondents, 66.3% were male and 33.8% were female. By age, 3.2% were below 20 years, 25.8% were between 20–30 years, 30.5% were between 30–40 years, 27.9% were between 40–50 years, and 12.7% were between 50–60 years. By profession, farmers formed the largest group (32%), followed by government officials (25%), consultants (14%), students (10%), engineers, contractors, and businesspersons (6% each), and others (1%) . By education, 49% of respondents held a Bachelor's degree, 34% had completed +2 level, and 17% held a Master's degree.

3.3 Major Problems of Sewer Rehabilitation Construction

Relative Importance Index analysis was applied to twenty problem statements to identify the most significant issues associated with the construction of sewer rehabilitation. “Inadequate existing sewer infrastructure capacity” received the highest rank (RII = 0.89), followed closely by “Lack of proper planning and design integration”, “Weak institutional coordination”, and “Funding and budget constraints” (RII = 0.88 each). “Post-construction maintenance issues” received the lowest rank (RII = 0.77), as shown in Fig. 3.5.

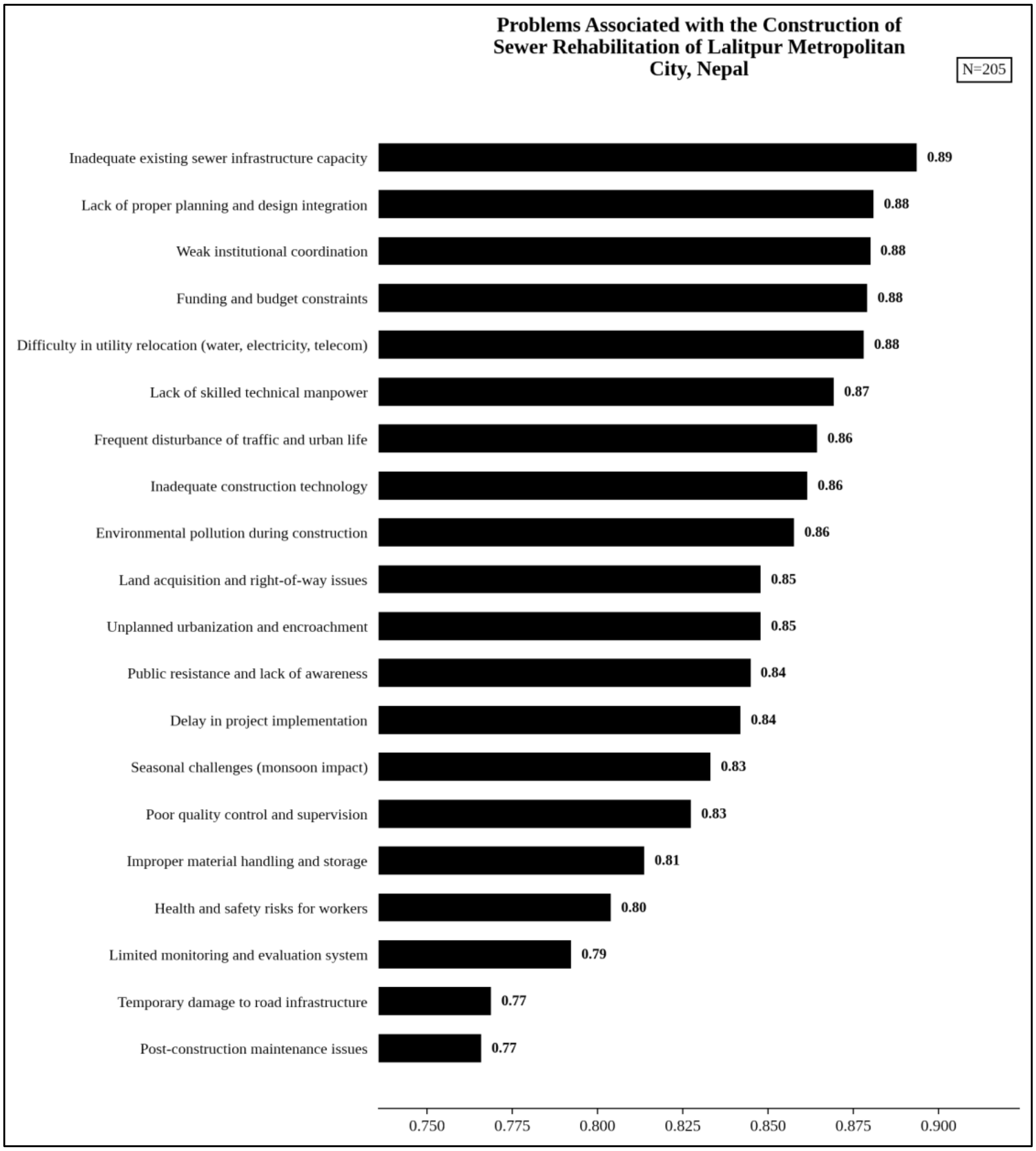

Fig. 3.1. Problems associated with the construction of sewer rehabilitation of Lalitpur Metropolitan City, Nepal (Source: Field Survey, 2024)

3.4 Analysis of Causes and Effects of Sewer Rehabilitation Problems

For each of the twenty problem areas identified in Section 3.3, the underlying causes and resulting effects were separately analyzed using RII, based on the weighted responses of the 205 survey participants. The ranked causes and effects for each issue, from inadequate existing sewer infrastructure capacity through to post-construction maintenance issues, are presented in Fig.s 3.2 through 3.45.

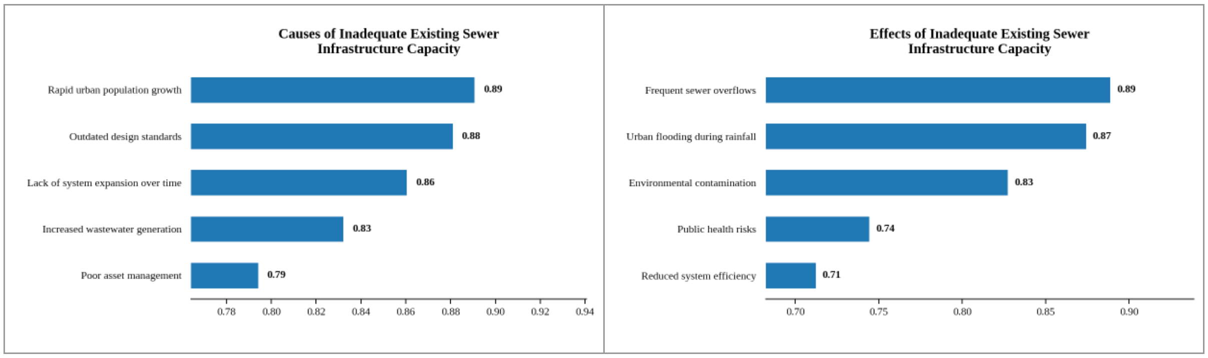

Fig. 3.2(a). Causes and Effects of Inadequate Existing Sewer Infrastructure Capacity

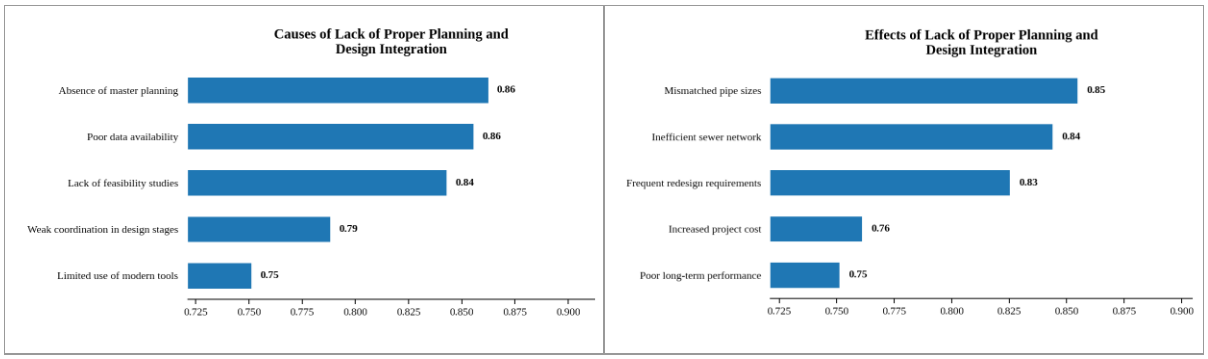

Fig. 3.2(b). Causes and Effects of Lack of Proper Planning and Design Integration

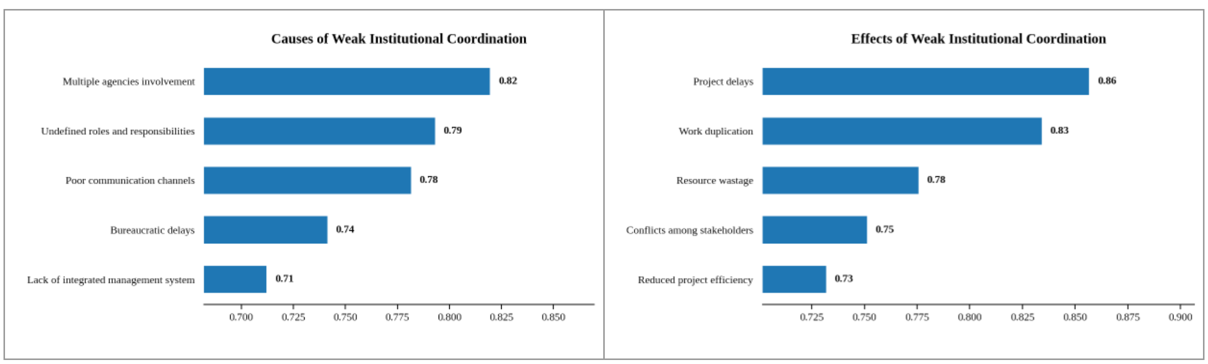

Fig. 3.2(c). Causes and Effects of Weak Institutional Coordination

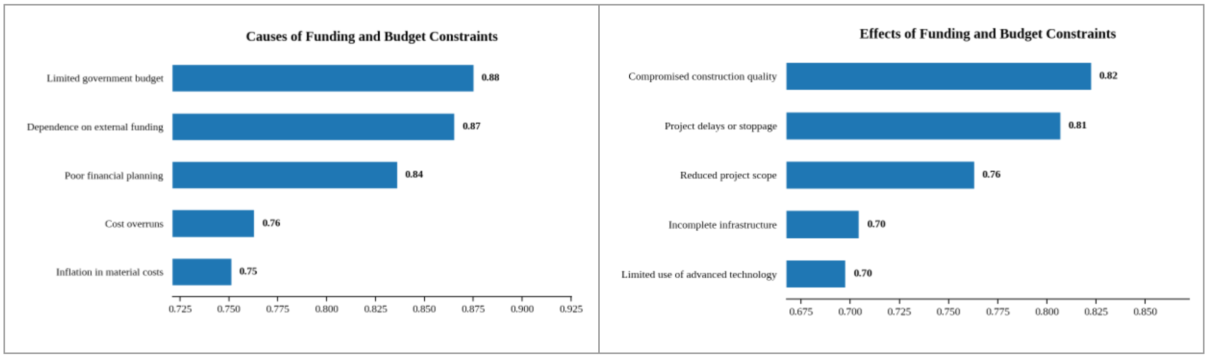

Fig. 3.2(d). Causes and Effects of Funding and Budget Constraints

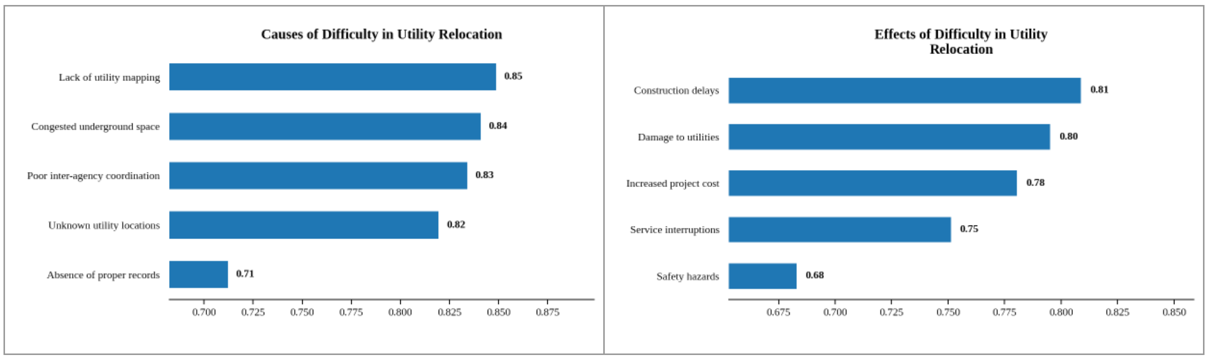

Fig. 3.2(e). Causes and Effects of Difficulty in Utility Relocation

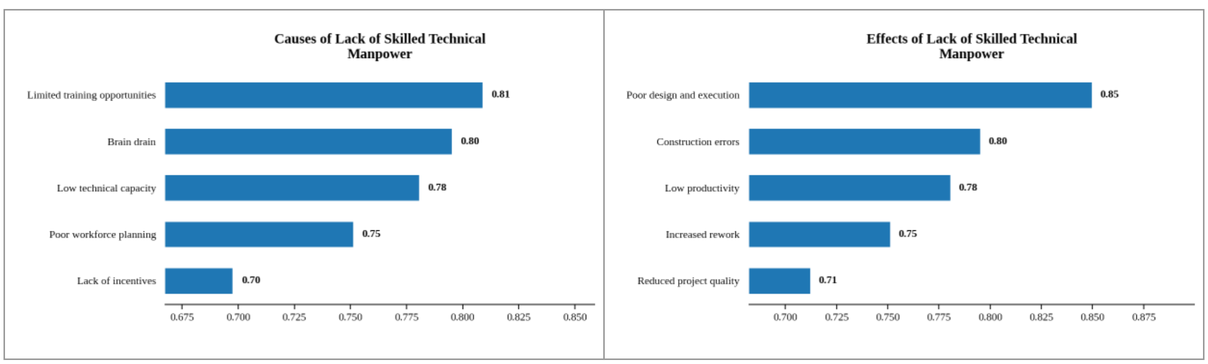

Fig. 3.2(f). Causes and Effects of Lack of Skilled Technical Manpower

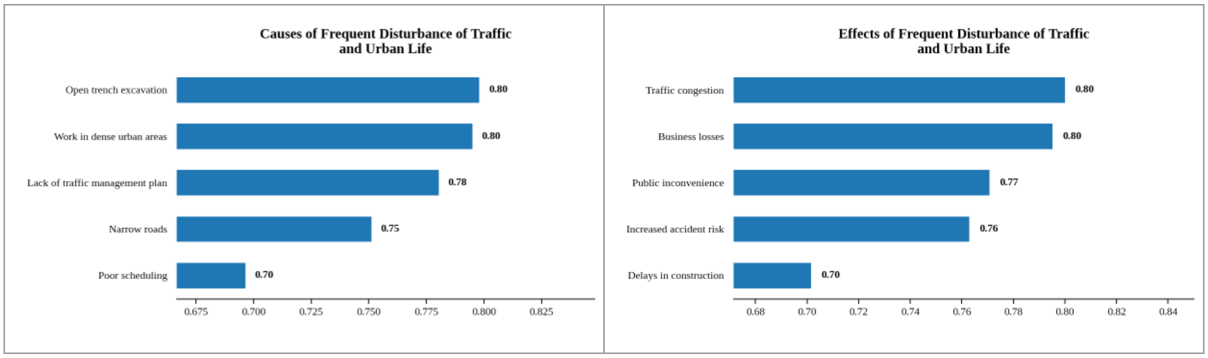

Fig. 3.2(g). Causes and Effects of Frequent Disturbance of Traffic and Urban Life

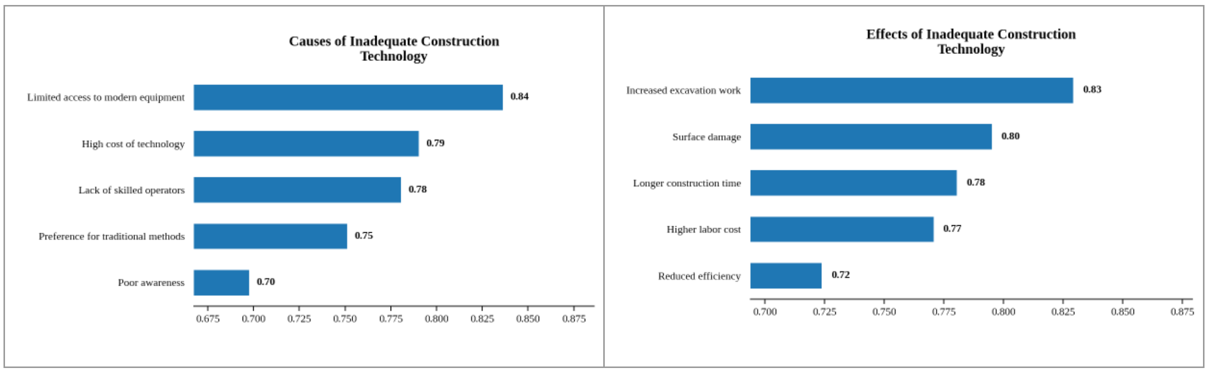

Fig. 3.2(h). Causes and Effects of Inadequate Construction Technology

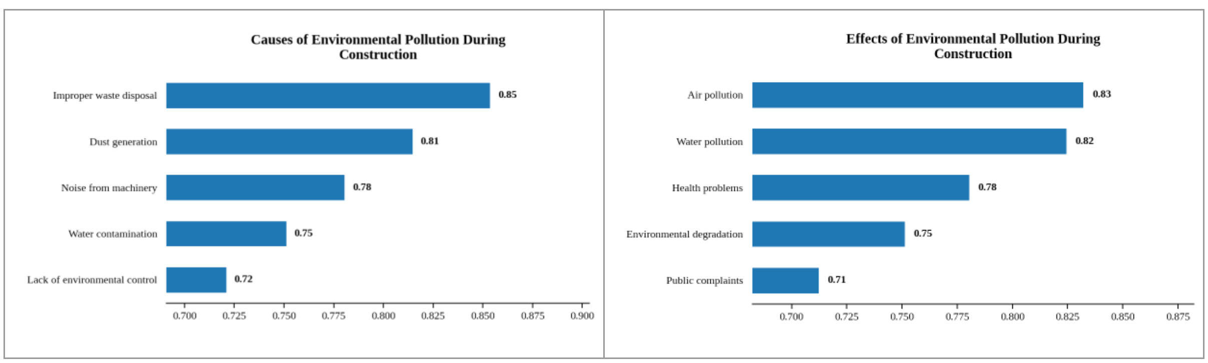

Fig. 3.2(i). Causes and Effects of Environmental Pollution During Construction

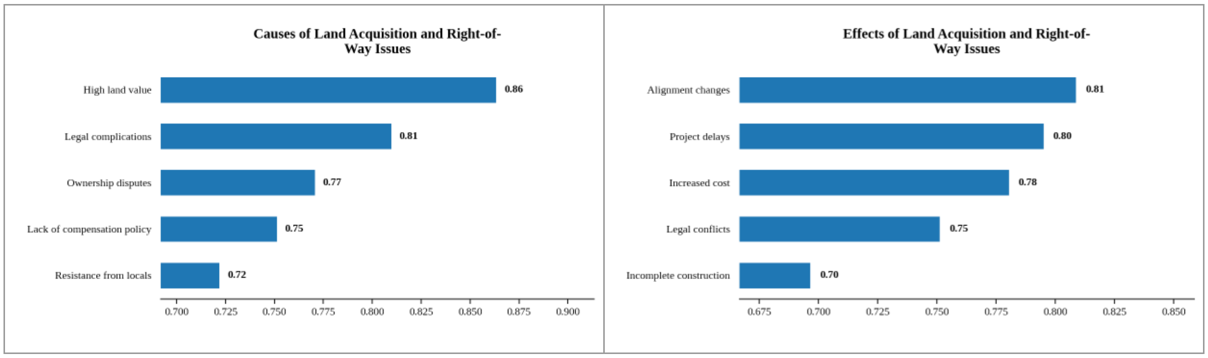

Fig. 3.2(j). Causes and Effects of Land Acquisition and Right-of-Way Issues

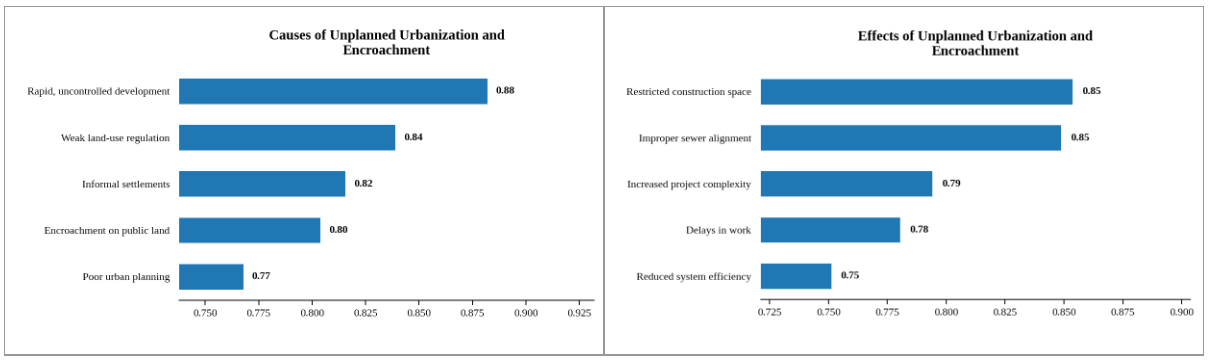

Fig. 3.2(k). Causes and Effects of Unplanned Urbanization and Encroachment

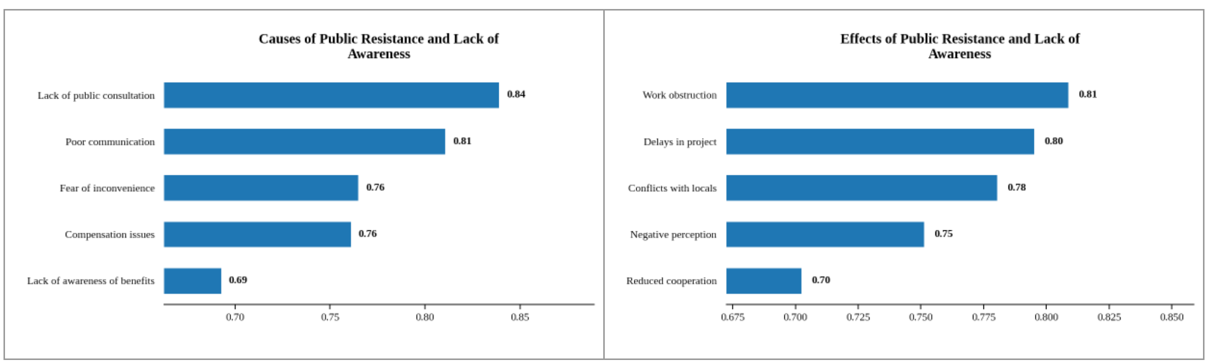

Fig. 3.2(l). Causes and Effects of Public Resistance and Lack of Awareness

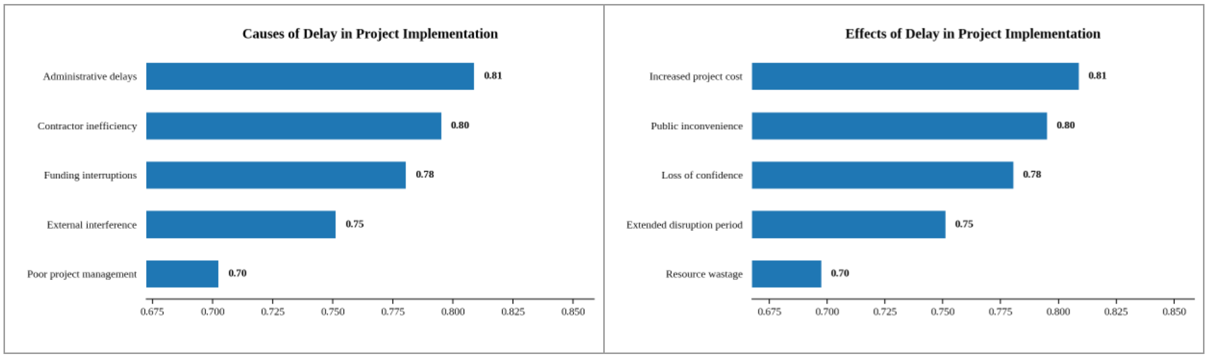

Fig. 3.2(m). Causes and Effects of Delay in Project Implementation

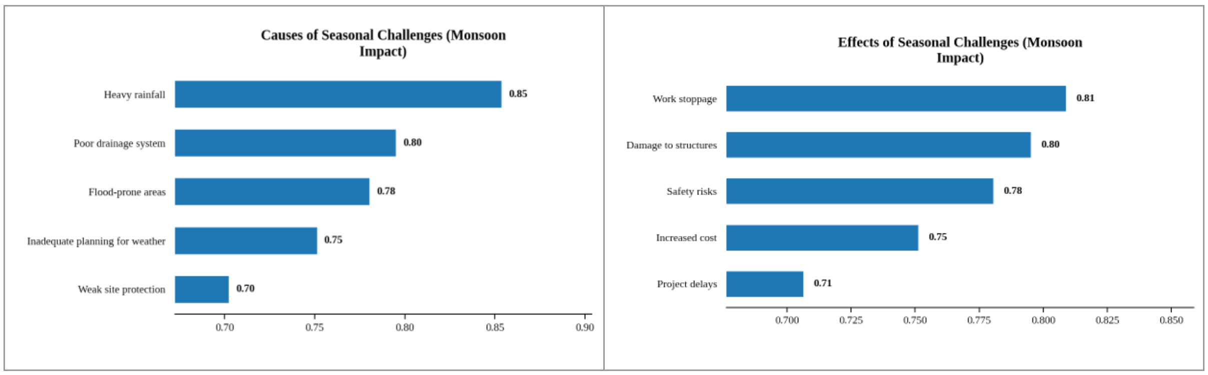

Fig. 3.2(n). Causes and Effects of Seasonal Challenges (Monsoon Impact)

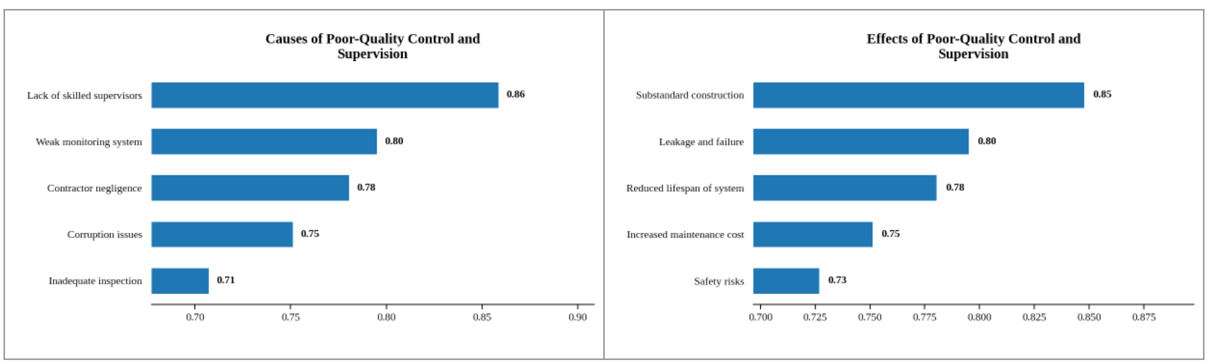

Fig. 3.2(o). Causes and Effects of Poor-Quality Control and Supervision

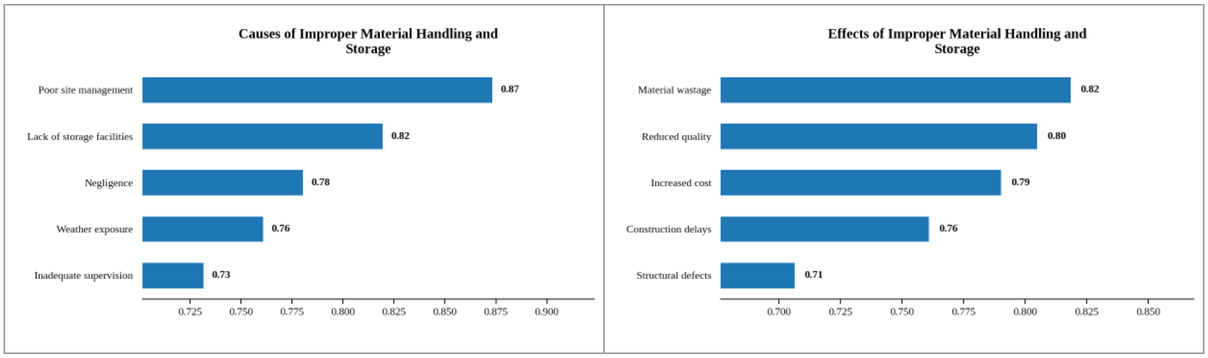

Fig. 3.2(p). Causes and Effects of Improper Material Handling and Storage

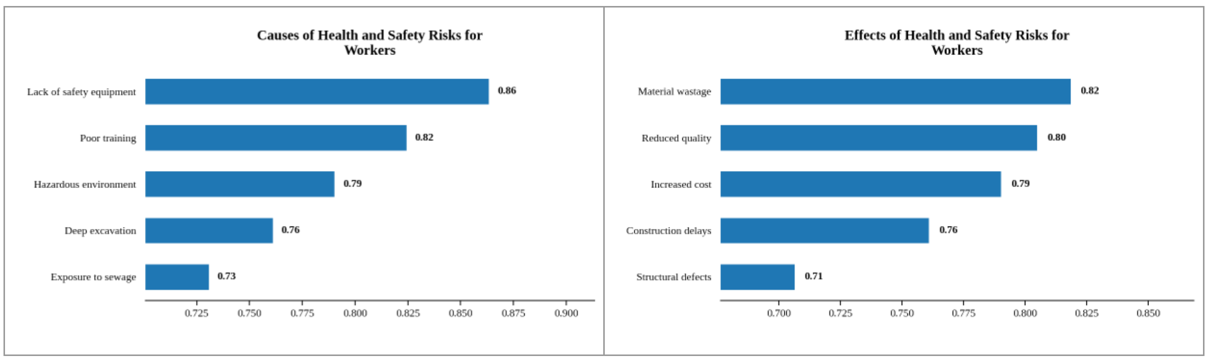

Fig. 3.2(q). Causes and Effects of Health and Safety Risks for Workers

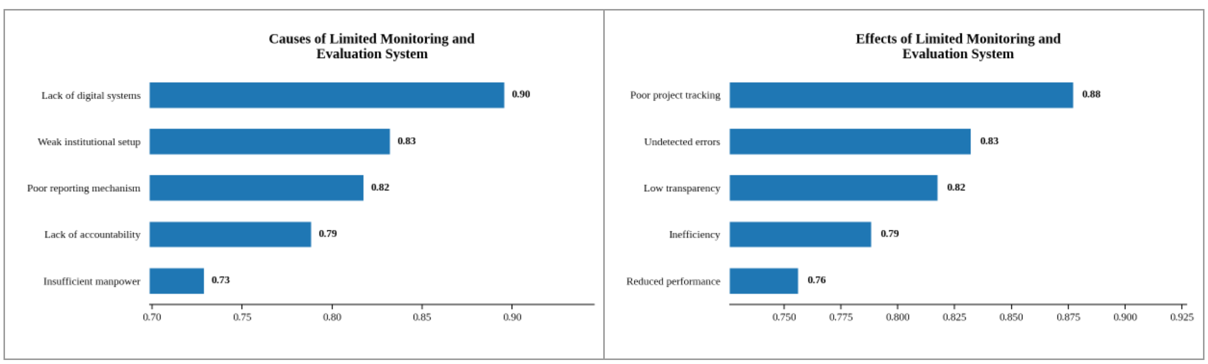

Fig. 3.2(r). Causes and Effects of Limited Monitoring and Evaluation System

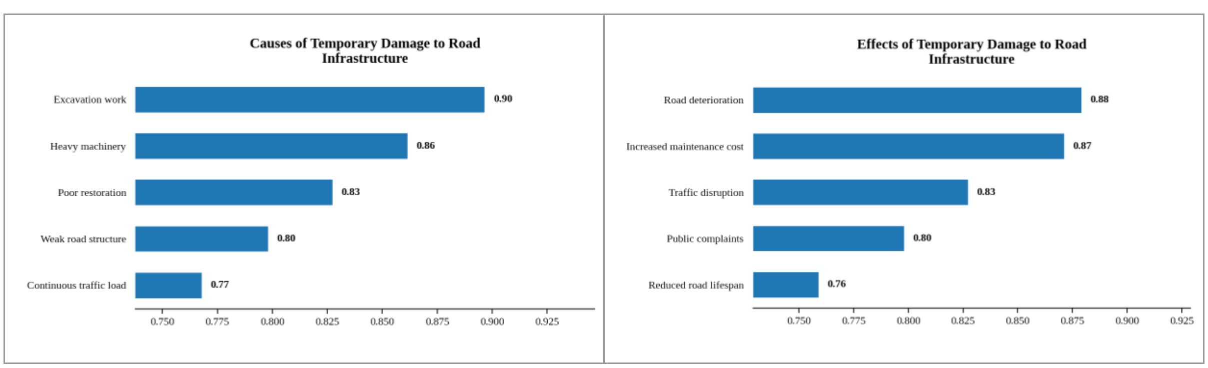

Fig. 3.2(s). Causes and Effects of Temporary Damage to Road Infrastructure

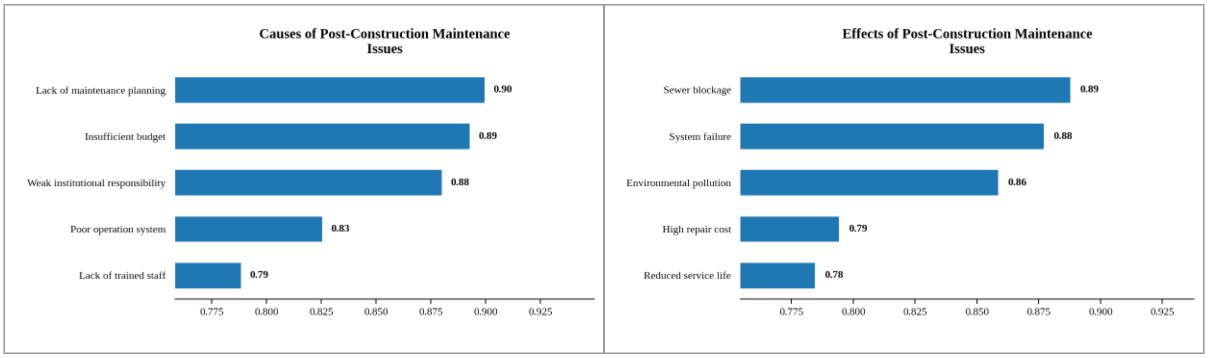

Fig. 3.2(t). Causes and Effects of Post-Construction Maintenance Issues

3.5 Mitigation Measures

An integrated set of twenty mitigation measures was evaluated through RII to identify the most effective strategies for improving the outcomes of sewer rehabilitation construction. “Preparation of a comprehensive sewer master plan” received the highest rank (RII = 0.90), followed by “Strengthening institutional coordination” (RII = 0.87) and “Adequate and sustainable funding mechanisms” (RII = 0.86). “Timely restoration of roads and public infrastructure” and “Proper material management system” tied for the lowest rank (RII = 0.77 each), as shown in Fig. 3.46.

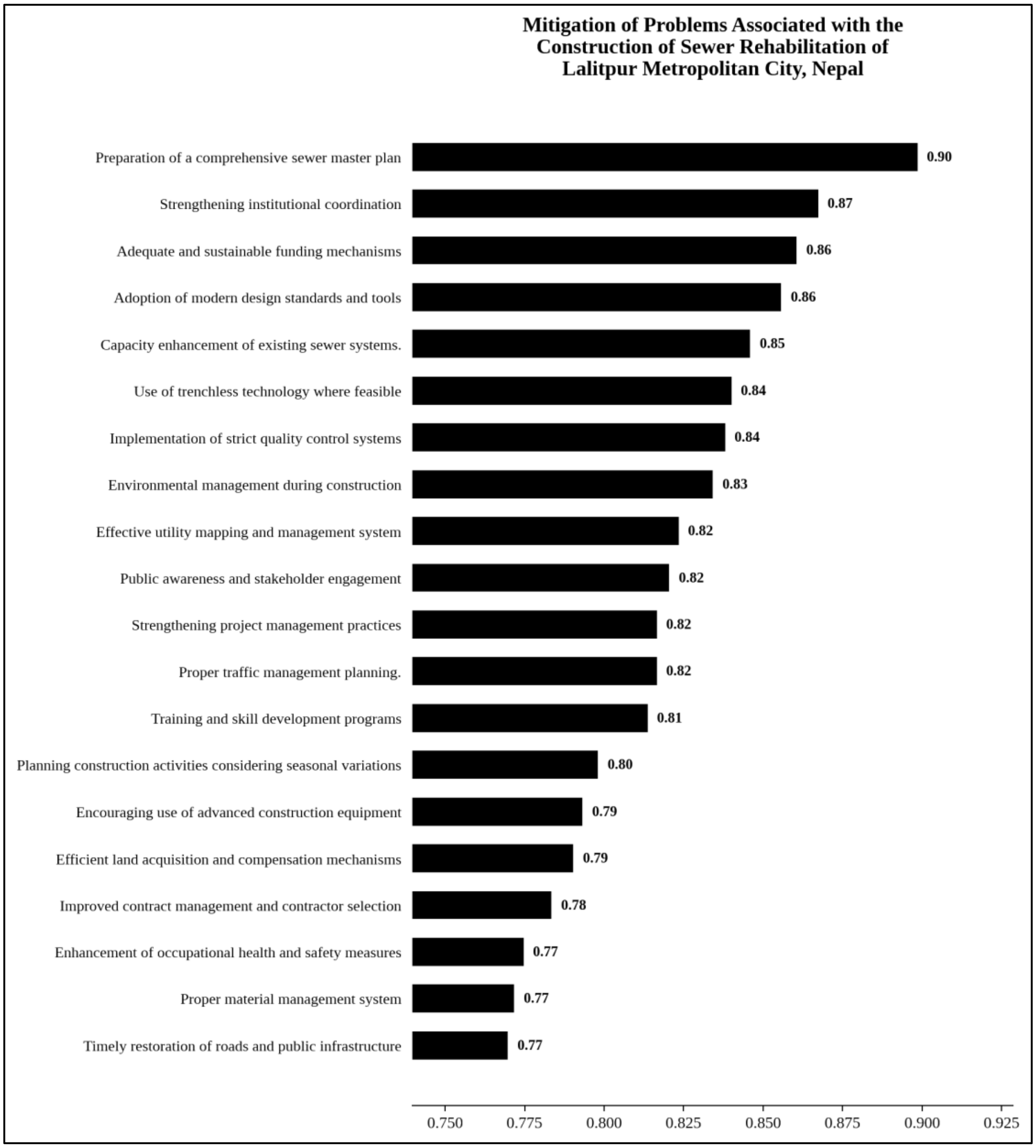

Fig. 3.3 Mitigation of problems associated with the construction of sewer rehabilitation of Lalitpur Metropolitan City, Nepal (Source: Field Survey, 2024)

3.2 Discussion

Field observations conducted within Lalitpur Metropolitan City revealed that most of the existing sewer network, particularly from UN Park to Lagankhel and from Swotha via Itti Chowk, is frequently blocked, resulting in sewer overflows during the monsoon season and disrupting urban activities. The overflow of the combined sewer system was identified as a major cause of recurrent flooding from Lagankhel to Patan Durbar Square during the monsoon, as the existing network is unable to convey the additional stormwater volume entering it during heavy rainfall. Stormwater flowing from the Itti Chowk area and runoff from Pulchowk Road converge and collect at Mahapal, creating a low-lying inundation zone; recurring inundation in historically and culturally significant areas such as Patan Durbar Square, Mahapal, Mangahiti, and the Bangalamukhi Temple precinct poses risks not only to public mobility and sanitation but also to the structural preservation of heritage monuments.

In-depth interviews with technical experts, local residents, shopkeepers, and tourists in the UN Park–Lagankhel and Swotha–Itti Chowk sections consistently expressed dissatisfaction with the current sewer network, particularly during heavy monsoon rainfall. Technical experts noted that the existing sewer system was designed based on historical population Fig.s without accounting for future projections or rapid urbanization, and that increased commercial activity — including footpath businesses in the Lagankhel area — combined with population growth has placed pressure on the system beyond its original design intent. Participants also highlighted weak coordination among utility stakeholders, given the presence of Nepal Telecom cables, underground NEA power lines, and water supply pipelines along the sewer alignment, as a persistent obstacle to effective maintenance.

These findings are consistent with regional and international evidence on urban sewer infrastructure. The identification of inadequate infrastructure capacity and weak institutional coordination as leading problems aligns with evidence that ageing sewer networks in South Asian cities are frequently overwhelmed by populations and development patterns that were not anticipated at the time of original design [8], [10]. The importance of proactive planning and condition assessment as mitigation measures is similarly supported by evidence that systematic, master-plan-driven rehabilitation substantially outperforms reactive, incident-driven repair in extending network service life and reducing overflow frequency [9], [11]. The prominence of funding and coordination constraints identified in this study also mirrors patterns documented in other Kathmandu Valley infrastructure projects, where schedule overruns and implementation delays are frequently traced to inter-agency coordination gaps and constrained municipal budgets rather than technical design deficiencies alone [5], [13].

4. CONCLUSIONS

This study has examined the construction of sewer rehabilitation and its consequences in Lalitpur Metropolitan City, Nepal, using a mixed-method design combining a 205-respondent RII-based questionnaire survey with qualitative field observations, in-depth interviews, and focus group discussions. Lalitpur Metropolitan City faces significant problems due to blockage, overflow, and inundation in low-lying areas caused by the existing sewer network, compounded by improper pipe joint connections, leakage, infiltration, and sub-surface water contamination. Blockage of sewer manholes — driven in large part by solid waste disposal into drains and rainwater inlets — causes sewage to mix with stormwater and overflow during rainfall, while the absence of a systematic periodic maintenance routine by ward offices and the Metropolitan City further affects network performance.

The sewerage system in the Mahapal and Bangalamukhi Temple sections was found to be severely deteriorated, resulting in inadequate hydraulic performance and frequent overflow onto road surfaces during the monsoon, disrupting pedestrian and vehicular movement and posing public health risks. Flooding in the Mahapal area is further aggravated by surface runoff converging from the Itti Chowk and Pulchowk Road catchments into a low-lying inundation zone that the existing infrastructure cannot adequately convey. Analysis of twenty major problem areas confirmed that inadequate infrastructure capacity, poor planning and design integration, weak institutional coordination, and funding constraints are the dominant challenges, while the identification of a comprehensive sewer master plan, strengthened institutional coordination, and sustainable funding mechanisms as the leading mitigation measures shows a clear path toward improved performance.

The study concludes that effective sewer rehabilitation, combined with proper stormwater management, regular maintenance, public awareness, improved planning practices, and stronger coordination among utility stakeholders, can significantly reduce flooding and improve urban sanitation in Lalitpur Metropolitan City. Given the heritage sensitivity of the Patan Durbar Square area, rehabilitation strategies must also account for restricted access, protection of historical monuments, and limited use of heavy machinery. The findings and recommendations of this study can support policymakers, engineers, contractors, and municipal authorities in implementing sustainable sewerage infrastructure projects across similarly constrained urban and heritage environments in Nepal.

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