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THE IMPACT OF POOR PLANNING AND LOGISTICS MANAGEMENT ON ROAD CONSTRUCTION AND MAINTENANCE: A CASE STUDY OF AIRPORT HIGHWAY, TRIPOLI

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ABSTRACT
This study examines how poor planning and logistics management affect road construction and maintenance, using Airport Highway in Tripoli, Libya, as a case study. A quantitative case-study approach was adopted, based on a structured questionnaire completed by road users. Fifty-nine valid responses out of 60 were analysed in SPSS using descriptive statistics, Cronbach's alpha, Spearman correlation, and one-way ANOVA. The questionnaire demonstrated acceptable internal consistency, with a Cronbach's alpha value of 0.748. Significant relationships were found among traffic congestion, travel-time impact, poor project planning, inadequate alternative routes, insufficient safety measures, and weak coordination. The findings highlight the need for integrated activity sequencing, logistics preparation, traffic management, and stakeholder coordination in road-maintenance projects.
Keywords: road maintenance; logistics management; project planning; traffic congestion; Libya.

I. INTRODUCTION

Airport Highway is one of Tripoli's principal transport corridors, extending approximately 22 km from Bab Ben Gashir near the city centre toward Tripoli International Airport. It passes through densely populated residential and commercial areas and carries substantial daily traffic, making the quality and timing of maintenance works particularly important.

The highway underwent maintenance, while service roads were constructed on both sides. Although these projects are intended to improve capacity and road condition, simultaneous implementation has created serious operational difficulties. Traffic diversions have not always been clearly prepared, road signs and safety arrangements have been insufficient, and some road sections have been reopened before all work was fully completed. These conditions have contributed to congestion, longer travel time, vehicle damage, and concern about pavement durability.

The central problem is not maintenance alone, but the sequencing and logistical coordination of activities. Closing or restricting the main road before service roads and alternative routes are ready transfers construction risk directly to road users. Weak coordination among contractors, responsible authorities, traffic police, and material suppliers can also extend project duration and reduce the effectiveness of available resources.

Accordingly, this study investigates the influence of poor planning and logistics management on road construction and maintenance outcomes on Airport Highway. It focuses on congestion, travel-time effects, simultaneous works, service-road conditions, materials and equipment, safety measures, and coordination. The study also evaluates whether road users from different categories perceive these problems differently.

Research Objectives

1. To assess road users' perceptions of how poor planning and logistics management affect road construction and maintenance outcomes on Airport Highway.
2. To examine the relationships among traffic congestion, travel-time impact, alternative routes, safety measures, and coordination.
3. To determine whether perceptions of congestion, travel-time impact, and project-duration problems differ across road-use and age groups.
4. To propose practical recommendations for improving activity sequencing, logistics preparation, traffic management, and stakeholder coordination on Airport Highway.

Research Questions

1. How do road users perceive the effects of poor planning and logistics management on road construction and maintenance outcomes on Airport Highway?
2. What relationships exist among traffic congestion, travel-time impact, alternative routes, safety measures, and coordination?
3. Do perceptions of congestion, travel-time impact, and project-duration problems differ across road-use and age groups?
4. What practical measures can improve activity sequencing, logistics preparation, traffic management, and stakeholder coordination on Airport Highway?

Scientific Contribution

This study contributes to existing knowledge by integrating project planning, logistics management, traffic management, safety, and stakeholder coordination within a single Libyan road-maintenance case study based on road users' perceptions.

II. LITERATURE REVIEW

Previous research shows that project planning, construction logistics, traffic management, resource availability, safety, and stakeholder coordination are closely connected and can collectively influence the performance of road construction and maintenance projects.

Gann and Salter (2000) examined project-based engineering and construction firms. They found that effective project delivery depends on integrating technical knowledge, project activities, and wider organisational processes rather than managing each activity separately.

Alfakhri et al. (2018) investigated the effects of road-construction delays in Tripoli. The study associated schedule overruns with increased costs, time extensions, disputes, reduced profits, contractual problems, and poor construction quality.

Mashwama et al. (2018) examined stakeholder challenges in road projects in Gauteng, South Africa. The main challenges included design problems, shortages of skilled labour, equipment and materials, cost overruns, and extended project duration.

Rivera et al. (2020) analysed road-construction delays across 25 developing countries. They identified recurring causes related to weak planning, poor management, financial constraints, material shortages, equipment problems, and difficult external conditions.

Sezer and Fredriksson (2021) studied construction-logistics practices and found that fragmented logistics, uncoordinated deliveries, and weak communication between project actors reduce operational efficiency. They recommended integrating logistics into project planning before construction begins.

Consilvio et al. (2023) developed a digital-twin decision-support tool for road maintenance. The system integrated pavement-condition data with technical and human-resource constraints to support inspection, predictive maintenance, and the selection of suitable interventions.

Kušić et al. (2023) created a digital twin of the Geneva motorway by combining real-time traffic data with microscopic simulation. The system supported continuous traffic monitoring, predictive analysis, and improved traffic-management decisions.

Onyia et al. (2024) surveyed 171 construction professionals about digital technology in construction supply chains. They identified insufficient skills, weak institutional support, implementation complexity, and limited technical expertise as important adoption barriers.

Fredriksson et al. (2024) examined the organisational position of logistics in complex construction projects. They found that logistics functions require sufficient authority and central coordination to manage material flows, shared resources, stakeholders, and operational conflicts effectively.

Wang et al. (2024) reviewed digital-twin applications in highway infrastructure. They proposed a five-dimensional model connecting physical roads, digital models, data, services, and communication to support planning, construction, operation, and maintenance.

Talaghat et al. (2024) reviewed digital-twin technology for road pavements. They concluded that it can improve condition monitoring, maintenance decisions, simulation, and asset management, although practical road-pavement applications remain relatively limited.

Jiang et al. (2024) integrated digital twins, multi-criteria decision-making, and GIS for sustainable urban-road planning. Their framework considered traffic, cost, engineering, environmental, social, and development factors when evaluating road alternatives.

Yin et al. (2025) investigated the value of digital twins in highway maintenance through expert interviews and 183 questionnaire responses. Participants highlighted deterioration prediction, routine-maintenance planning, and repair-scenario evaluation as important applications.

Buuveibaatar et al. (2025) proposed a five-layer framework for planning road digital twins. The framework connects data acquisition, processing, modelling, analysis, control, services, and users to support early road-planning decisions.

Long et al. (2025) developed an AI-enabled digital-twin framework for intelligent transportation. The platform combined traffic, camera, infrastructure, and telematics data to forecast congestion, identify safety risks, and support real-time decisions.

Studies from technologically advanced contexts increasingly emphasise digital twins, real-time monitoring, predictive maintenance, artificial intelligence, and integrated data systems. In contrast, studies from developing countries continue to highlight basic problems involving planning, financing, materials, equipment, logistics, and institutional coordination.

Despite these differences, the reviewed studies agree that effective road-project performance requires coordinated planning of activities, resources, traffic arrangements, safety measures, information flows, and stakeholder responsibilities.

Research gap

Although previous studies have examined construction delays, logistics management, digital technologies, and road-maintenance systems, limited research has integrated these factors within a single Libyan road-maintenance case study.

Existing Libyan studies have mainly examined the general causes or effects of construction delays from the perspective of contractors, consultants, and project owners. Less attention has been given to road users who directly experience congestion, travel-time disruption, inadequate alternative routes, service-road problems, and safety risks.

This study addresses this gap by quantitatively examining the relationships among project planning, construction logistics, congestion, travel time, alternative routes, safety measures, resource availability, service-road conditions, and stakeholder coordination on Airport Highway in Tripoli from the perspective of road users.

III. MATERIALS AND METHODS

Research design and study area

A quantitative case-study design was adopted to examine how road users perceived planning and logistics problems during construction and maintenance on Airport Highway in Tripoli. The quantitative approach enabled questionnaire responses to be coded numerically and analysed in SPSS. The highway was selected because it is a strategically important route used by commuters, residents, workers, and businesses and has been directly affected by overlapping maintenance and service-road works.

Population, sample, and instrument

The target population consisted of people who use Airport Highway or are directly affected by works on the route. Participants were recruited using non-probability convenience sampling. The questionnaire link was distributed to acquaintances who regularly use Airport Highway and shared in academic and other online groups, with respondents asked to participate only if they used or were directly affected by the road. A structured questionnaire collected 60 responses. Following data screening, one mostly empty response was removed, leaving 59 valid cases. Given the exploratory nature of this single-road case study and the practical limitations of reaching eligible road users, the 59 valid responses were considered sufficient for descriptive and preliminary association analysis, although they do not support broad generalisation to all road users in Libya. The questionnaire contained background questions and Likert-scale items covering congestion, traffic planning, vehicle damage, simultaneous works, alternative routes, travel-time impact, project duration, safety measures, materials and equipment, coordination, the main perceived problem, and service-road conditions.

Questionnaire validation

Before distribution, the questionnaire was reviewed by the academic supervisor at the Libyan Academy for Postgraduate Studies to assess the clarity, relevance, and alignment of its items with the research objectives.

Data preparation and analysis

Missing responses were treated as missing values in SPSS, with the value 99 excluded from calculations where applicable. Response_ID was removed from reliability testing because it was an identifier rather than a scale item. Negatively worded items concerning traffic planning, alternative roads, safety measures, and coordination were reverse-coded so that higher values consistently represented more serious planning or logistics deficiencies.

Frequencies, percentages, means, and standard deviations were used for description. Cronbach's alpha assessed internal consistency, Spearman's rho examined relationships among ordinal variables, and one-way ANOVA compared respondent groups.

Table 1. Summary of the research design and analytical procedures

Component	Description
Design	Quantitative case study of Airport Highway, Tripoli
Respondents	Road users and persons directly affected by construction and maintenance works
Sample	60 Non-probability convenience sampling; 60 responses collected and 59 valid after screening
Instrument	Structured questionnaire with background and Likert-scale items
Validation	Reviewed by the academic supervisor at the Libyan Academy for Postgraduate Studies
Software	SPSS
Analyses	Frequencies, descriptive statistics, Cronbach's alpha, Spearman correlation, and one-way ANOVA

The use of a road-user questionnaire captures the practical consequences of project decisions; however, the results represent perceptions rather than direct engineering measurements. Accordingly, statistical relationships are interpreted as associations and not as proof of causation.

IV. RESULTS AND DISCUSSION

Sample and descriptive findings

The final dataset contained 59 cases. Age had 58 valid responses and one missing value, while road-use frequency, purpose, and the main-problem variable had 59 valid responses. Because category labels were not preserved in the SPSS output, coded background categories were not assigned descriptive names. The analysis therefore emphasised the scale items, for which the response direction was known.

Table 2 shows that the highest mean was recorded for the perceived effect of poor planning on project duration (M = 4.49). Congestion (M = 4.38), service-road problems (M = 4.36), materials and equipment (M = 4.22), and simultaneous works (M = 4.19) also received high scores. These results indicate that respondents experienced the project primarily as a combined planning, logistics, and traffic-management problem rather than as a single isolated construction defect.

Table 2. Descriptive statistics for the principal questionnaire variables

Variable	N	Mean	Std. deviation
Congestion	58	4.38	0.768
Traffic planning	59	2.42	1.054
Vehicle damage/road impact	59	3.44	1.087
Simultaneous works	59	4.19	0.798
Alternative roads	59	2.36	1.156
Travel-time impact	58	3.55	1.259
Poor planning and project duration	59	4.49	0.917
Safety measures	58	2.83	1.110
Materials and equipment	59	4.22	0.966
Coordination	59	2.42	0.986
Service-road problems	59	4.36	0.804

Interpretation of the descriptive pattern

The lower raw means for traffic planning, alternative roads, safety measures, and coordination should not be interpreted as evidence that these matters were unimportant. These questions assessed the adequacy of arrangements, so low scores indicate dissatisfaction with the arrangements provided. They were reverse-coded before reliability and correlation analysis to ensure that higher corrected values consistently represented more severe planning and logistics weaknesses.

Vehicle damage and travel-time impact received moderate-to-high scores, showing that the consequences of the project extended beyond inconvenience. Rough road surfaces, incomplete diversions, and repeated changes in traffic movement can increase operating costs for drivers and create uncertainty in daily journeys. The descriptive pattern therefore supports a management response that combines construction scheduling with route readiness, traffic information, safety control, and resource availability rather than treating each issue separately.

As illustrated in Fig. 1, all five highest-rated issues exceeded a mean score of 4.0. The close clustering of these values supports the interpretation that project duration, congestion, service-road readiness, resource logistics, and overlapping activities were experienced as mutually reinforcing weaknesses.

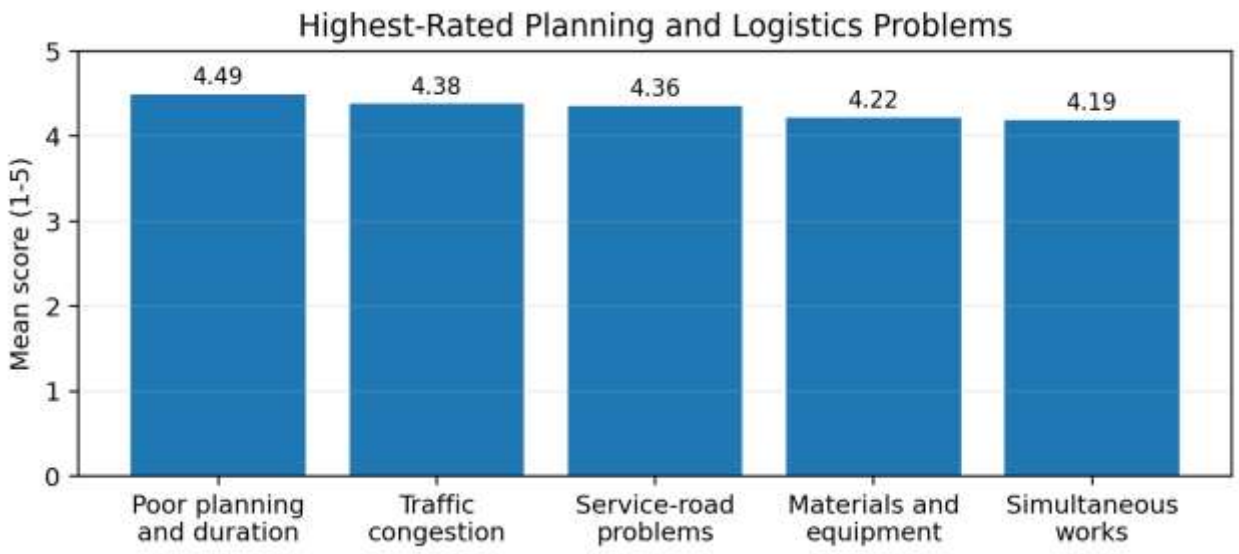


Fig. 1. Highest-rated planning and logistics problems reported by respondents.

Reliability and interrelationships among project problems

The initial reliability analysis was invalid because it included Response_ID and combined items with opposing response directions. After removing the identifier and reverse-coding the relevant items, Cronbach's alpha increased to 0.748 for 11 items. This value indicates acceptable internal consistency and supports use of the corrected scale for exploratory analysis.

Spearman analysis showed that the reported problems were interconnected. Congestion was positively associated with travel-time impact (rho = 0.391, p = 0.003), perceived project-duration problems (rho = 0.283, p = 0.031), and service-road problems (rho = 0.379, p = 0.003). Travel-time impact was related to weak traffic planning, inadequate alternative roads, insufficient safety measures, and weak coordination. The strongest selected relationship was between weak safety measures and weak coordination (rho = 0.556, $p < 0.001$).

Meaning of the reliability and correlation results

The corrected reliability result is important because it shows that the questionnaire items, once coded in a common direction, measured a reasonably coherent set of planning and logistics difficulties. It does not mean that every item represents the same operational problem; rather, the items collectively describe different visible consequences of a shared management environment. The value is adequate for an exploratory case study and supports cautious interpretation of the combined evidence.

Coordination emerged as a central variable in the correlation pattern. Its links with traffic planning, alternative routes, safety measures, service roads, and travel time suggest that weak coordination can transmit problems across organisational boundaries. A contractor may complete a physical activity, but users can still face disruption when traffic police, utilities, inspection teams, and communication units are not aligned with the same schedule.

Table 3. Selected statistically significant Spearman correlations

Variables	rho	p value	Interpretation
Congestion - travel time	0.391	0.003	Positive association
Congestion - project duration	0.283	0.031	Positive association
Congestion - service roads	0.379	0.003	Positive association
Travel time - traffic planning	0.329	0.012	Positive association
Travel time - alternative roads	0.381	0.003	Positive association
Travel time - safety measures	0.355	0.007	Positive association
Travel time - coordination	0.466	<0.001	Positive association
Traffic planning - coordination	0.428	<0.001	Positive association
Alternative roads - coordination	0.527	<0.001	Positive association
Safety measures - coordination	0.556	<0.001	Strongest selected link

Fig. 2 highlights the strongest selected relationships. Coordination appears repeatedly, suggesting that traffic planning, alternative-route provision, safety, and travel-time performance are not independent functions. A weakness in institutional or site coordination can therefore spread across several visible aspects of project performance.

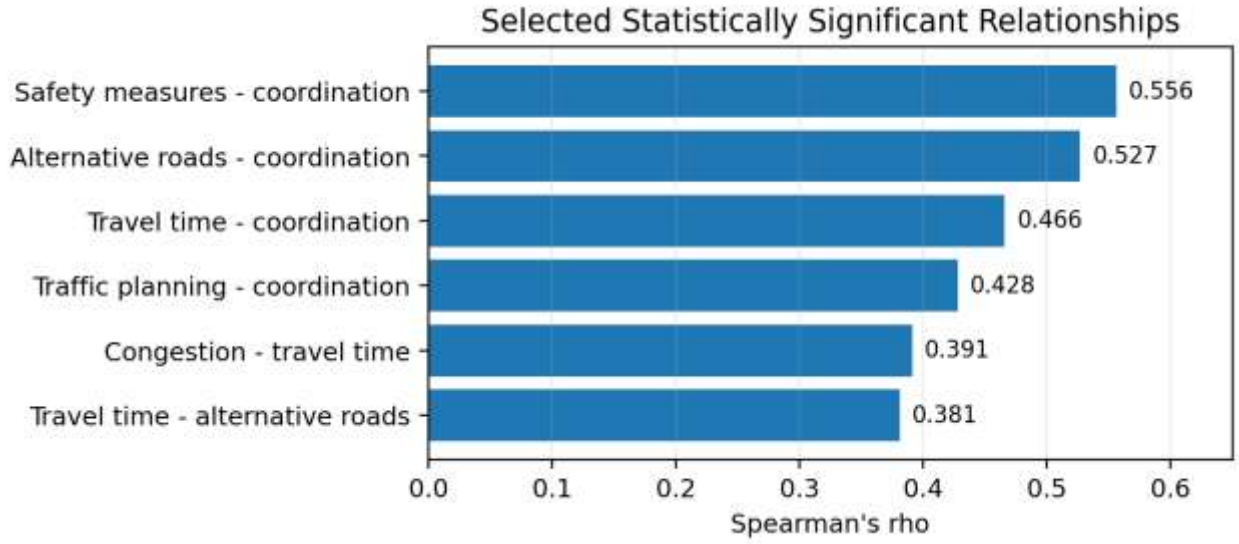


Fig. 2. Selected statistically significant relationships among planning and logistics variables.

Interpretation of the association network

The strongest coefficients involved coordination, but the correlations remained moderate rather than perfect. This indicates that no single management variable explains all disruption on the highway. Site conditions, traffic demand, construction methods, public behaviour, and the readiness of service roads may also influence outcomes. The results therefore support a portfolio of coordinated interventions instead of reliance on one corrective measure.

Statistical significance should also be distinguished from practical importance. Even moderate relationships can have substantial consequences on a heavily used urban

corridor because small failures are repeated across thousands of daily journeys. Conversely, the correlations do not prove causality. They identify patterns that should guide field investigation, engineering assessment, and management review.

Group comparisons

One-way ANOVA found no statistically significant difference in congestion perceptions across road-use groups ($p = 0.515$), indicating that congestion was experienced as a general problem. The standard ANOVA for travel-time impact was significant ($p = 0.043$), but Levene's test indicated unequal variances and the Welch and Brown-Forsythe tests were not significant. This result should therefore be treated cautiously. Poor-planning duration did not differ significantly across age groups ($p = 0.081$).

Table 4. Summary of one-way ANOVA results

Dependent variable	Grouping variable	p value	Interpretation
Congestion	Road-use frequency	0.515	No significant group difference
Travel-time impact	Road-use frequency	0.043	Standard ANOVA significant; robust tests not significant
Poor planning and duration	Age category	0.081	No significant age-group difference

Discussion

The results support the central argument of the study: weak planning and logistics management can transform road improvement into prolonged disruption. The very high score for project-duration effects is consistent with Alfakhri et al. (2018) and Rivera et al. (2020), who linked weak planning, resource constraints, and management deficiencies with delays and cost escalation in road-construction projects.. The high ratings for simultaneous works and service-road problems are consistent with Sezer and Fredriksson (2021), who emphasised the importance of integrating logistics and activity sequencing into project planning before construction begins.

The correlation findings also support the systems perspective highlighted by Fredriksson et al. (2024) and Kušić et al. (2023), in which logistics, traffic management, information, and stakeholder coordination operate as interconnected functions. Congestion, travel time, safety, traffic planning, alternative roads, and coordination were statistically linked, meaning that an improvement in only one element may be insufficient. For example, a diversion route provides limited benefit if it is incomplete, unsafe, poorly signed, or not coordinated with the timing of main-road closures. Similarly, the findings support Rivera et al. (2020) and Fredriksson et al. (2024), who emphasised that materials, equipment, and logistical resources should be coordinated and available before each construction phase begins.

Practical recommendations

The project should be implemented in clearly defined phases. Service roads and temporary diversions should be completed and inspected before major restrictions are imposed on the main highway. A joint traffic-management plan should specify diversion routes, signs, barriers, lighting, speed controls, and public notifications. Responsible authorities,

contractors, traffic police, and utility providers should hold regular coordination meetings, while materials, equipment, and labour should be confirmed before each phase starts. Continuous monitoring and a formal risk-management plan should address congestion, safety, weather, resource shortages, and public complaints.

Proposed implementation sequence

A practical sequence would begin with a readiness audit and public traffic plan, followed by completion of service roads and temporary diversions. The third stage would mobilise materials, equipment, labour, safety devices, and inspection teams before closing any main-road section. Maintenance should then proceed in short, controlled segments with daily monitoring of traffic and work progress. Each segment should be inspected and formally accepted before reopening, after which lessons from that phase should be incorporated into the next section of work.

V. CONCLUSIONS

Airport Highway users perceived poor planning, congestion, service-road conditions, simultaneous works, and resource availability as serious and interconnected problems. The corrected questionnaire demonstrated acceptable reliability, and the correlation analysis showed that weak coordination was closely associated with traffic planning, alternative routes, safety measures, and travel time. Most group comparisons were not significant, suggesting that the disruption was broadly experienced rather than limited to one category of users.

This study contributes to the literature by providing quantitative evidence from a Libyan road-user perspective that project planning, construction logistics, traffic management, safety, service-road readiness, and stakeholder coordination operate as an interconnected system during road-maintenance projects.

The study concludes that successful road maintenance requires sequencing, logistics preparation, traffic control, and stakeholder coordination to be planned as one integrated system. Completing service roads and temporary routes before restricting the main carriageway would reduce exposure to congestion and safety risks. Likewise, confirming labour, equipment, materials, signage, and traffic arrangements before each phase would limit interruptions and prevent partially completed work from remaining open for long periods.

Managerial and policy implications

From a managerial perspective, the results support a phase-gate approach in which no major closure begins until alternative routes, safety controls, equipment, materials, and responsible personnel have passed a documented readiness review. A single integrated schedule should link construction activities with traffic diversions, deliveries, inspection points, and public communication. Progress should be monitored through a concise dashboard covering planned versus actual completion, road sections open to traffic, resource availability, travel-time disruption, safety incidents, and unresolved coordination issues.

At the policy level, road authorities could require a temporary traffic-management plan as a formal condition for approving maintenance and rehabilitation works. The plan should define responsibilities among contractors, municipalities, traffic police, utility providers,

and emergency services. Independent inspection before reopening lanes would reduce the risk of premature use, while advance public notices and clearly maintained diversions would improve trust and reduce avoidable disruption. These measures are particularly important where several organisations share authority over one transport corridor.

Study limitations

This study is limited by its relatively small sample of 59 valid respondents and its focus on a single road corridor in Tripoli. The use of non-probability convenience sampling may also limit the representativeness of the sample and the generalisation of the findings to all road users or road projects in Libya. In addition, the study relied on respondents' perceptions rather than direct engineering measurements of pavement condition, traffic volume, construction progress, or project cost. The cross-sectional design captured participants' views at one point in time and therefore cannot establish causal relationships between planning and logistics deficiencies and project outcomes. Furthermore, the loss of descriptive labels for some background categories restricted the interpretation of certain group comparisons.

Future research directions

Future research should involve larger and more representative samples and examine additional road construction and maintenance projects in different Libyan cities. Further studies could combine road-user questionnaires with engineering assessments, traffic-volume data, project schedules, cost records, and real-time monitoring technologies. Longitudinal research could also examine how road conditions and user perceptions change across different project phases. With larger datasets, future researchers may apply multiple regression, Structural Equation Modelling, artificial intelligence, and digital-twin technologies to investigate the relationships among planning, logistics, traffic management, safety, and maintenance performance in greater depth.

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