Received: 29 Aug. 2025; Revised: 13 Nov. 2025; Accepted: 14 Dec. 2025
https://doi.org/10.22306/al.v13i2.764

Rebuilding Iraq's road network: challenges and project management solutions

Roa'a Abdulwahhab
University of Samarra, Construction and Projects Department, Samarra, Iraq,
roaa@uosamarra.edu.iq (corresponding author)
Raed Abdullah Hasan
University of Samarra, Civil Engineering Department, Samarra, Iraq,
raed_hasan@uosamarra.edu.iq
Mushtaq H. Kamel
University of Samarra, Construction and Projects Department, Samarra, Iraq,
mushtaq@uosamarra.edu.iq

Keywords: Iraq, road infrastructure, logistics, project management, post-conflict reconstruction.
Abstract: The state of the road infrastructure in Iraq has severely declined due to the long-term conflict, the instability of the institutions, and the lack of investments, thus interrupting the logistical processes and the development of the country. This study examines the main barriers to the rebuilding of the road system in Iraq and proposes a coherent framework that would combine project-management and logistical paradigms in order to reduce these obstacles. Using a comparative approach to determine international best practices in road-infrastructure delivery, the paper evaluates the appropriateness of the PMBOK, PRINCE2, and Agile approaches in the post-conflict context in Iraq. Such frameworks are assessed together with the enabling technologies, such as Geographic Information Systems (GIS) and Artificial Intelligence (AI), and participatory models of stakeholder-engagement. The research suggests a hybrid model of logistics aligned strategy to fill the identified gaps, in which localisation of PMBOK, PRINCE2, and Agile solutions is the key, with material, information, financial, and human flows optimisation provided by GIS/AI decision support. The approach enhances more transparency, efficiency, and sustainability in the governance of infrastructure. The value of the research is twofold: (i) the combining of project-management stage-gates with the transport-logistics flow control in a post-conflict setting, (ii) the flow based blueprint of delivering, and maintaining the Iraqi road assets.

1 Introduction

The road system in Iraq used to be an essential part of the national development strategy as the foundation of transport logistics, the economy of exchanges, and territorial integration. Between the 1970s and 1980s the state invested many resources in the development of the modern system of highways and arterial roads that bound the urban centres to rural territories and provided the means of trade with other states. The infrastructure was of great essence in facilitating trade and commerce, social mobility and strengthening the strategic military position of Iraq in the region. The road system was a symbol of a vision of connectivity and modernization at its peak [1]. Successive decades of conflict and instability, however, have been gradually eating away at this vision. Starting with the long Iran-Iraq War and made worse in the war in the Gulf and the invasion of Iraq in 2003, a large portion of Iraq infrastructure was either intentionally targeted or poorly maintained. Bridges and roads were hit, logistical centers were hit, and maintenance either stopped or became under-funded. The crisis was further worsened by subsequent insurgencies, occupation and sectarian violence with infrastructure being a victim and an instrument of conflict. The net effect of this prolonged war conflict has caused the road network to be weak and disjointed [1]. The damage of the roads in Iraq has interfered with the main logistics operations such as material flow (aggregates, asphalt, equipment), information flow (permits, designs, work orders, QA/QC data), and financial flow (disbursements, claims, change orders), the performance of the transport logistics, supply chain dependability, and national connection.

Since the hostilities ended, the rehabilitation of the transport logistics network in Iraq has become a challenging task, and the lack of a number of political and institutional challenges has complicated the situation. Lack of proper planning, systemic corruption and lack of technical capability has hampered reconstruction efforts. Inter-provincial and central rivalry has also contributed to slowing down co-ordinated projects. In addition, the external donors and international agencies, as helpful as they are, have tended to focus on short-term goals or act in isolation which has led to fragmented interventions which are not sustainable [2].The research paper is suggested to create a project management framework based on logistics of rebuilding the roads in Iraq, which should improve the governance of material, information, and financial flows during planning, implementation, and maintenance operations. The framework incorporates the recognized project management frameworks (PMBOK, PRINCE2, Agile), as well as logistics flow management and

digital tools (GIS, AI), to suggest a context-sensitive hybrid framework to the Iraqi post-conflict limitations, thus going beyond the descriptive review and providing a governance and delivery blueprint. This is the aggregate effect of such hurdles on the current state of the road system in Iraq. A lot of major highways contain holes, broken signs, and broken overpasses [3]. The secondary and rural roads are mostly unpaved or washed off making vast portions of the country inaccessible at some times of the year. Such infrastructural inadequacies not only slow down the day-to-day commute but also disrupted supply chains, accessibility to education and healthcare, and emergency response. In the metropolitan areas like Baghdad, Mosul, and Basra, traffic jams due to poor road networks are the causes of environmental degradation, high vehicular accidents, and poor traffic congestion [4].

Three major research questions will support this study. It initially looks into the ways and means through which the established project management frameworks, such as the Project Management Body of Knowledge (PMBOK), PRINCE2, and Agile methodologies can be localized and used to alleviate the occurrence of coordination failures, minimize change-order risks, and enhance efficiency in the performance of the Iraq road reconstruction programs. Second, it examines the future applications of Geographic Information Systems (GIS) and Artificial Intelligence (AI) to streamline both the informational processes, including data on assets and prioritization and scheduling, and the material processes, including staging, routing, and operations and maintenance, when capacity limits are in place. Third, it also evaluates the governance forms and stakeholder engagement mechanisms best able to strengthen transparency, accountability and collaboration across the project life cycle. The proposed research questions are based on the hypothesis that a hybrid, contextualized project management and logistics framework the combination of structured methodologies with digital and participatory tools will have a significant impact on the flow reliability and the overall performance of a project compared to the traditional, disjointed reconstruction practices. Socioeconomic impact of a faulty road network is so far and wide. Inefficiency in transport raises the prices of goods and services thus reducing affordability and competitiveness in the markets. The jobs in remote areas are lost because mobility is limited, which increases the disparities across the regions. The frustration of the basic needs by the infrastructure increases the level of discontent among the people and destroys the confidence in governmental structures and increases the sense of marginalization, especially in rural and post-conflict groups. In the same context, road reconstruction is not an engineering issue rather, it is a social, economic, and political need [5]. A comparative analysis of the international best practices in road maintenance and delivery is carried out mapping the best practices to the institutional, financial, and operational constraints in Iraq. The synthesis produces a hybrid structure that incorporates structured stage-gate control, Agile responsiveness, and digital decision support tools (GIS/AI). The sources of evidence are peer-reviewed articles, sector reports, and case studies of post-conflict infrastructure. The reconstruction of the roads in Iraq is a crucial step towards fostering the development of national unity and promotion of post-war recovery. A reliable transport logistics system is one that helps in people and goods transportation, encourages trade, strengthens internal communication and improves the provision of state services [6]. It is also strategic in terms of guaranteeing security because the state is able to exude power and access distant locations. Infrastructure development could serve as one of the projects that unites people, as it could become a stabilizing factor in a weak post-conflict setting that would facilitate a steady situation [7]. This study takes the logistics-based project-management approach, which examines the role of process of coordination of material, information, financial, and human flows on performance and sustainability of the road reconstruction initiatives in Iraq.

However, the process of repairing the roads in Iraq does not only require a physical repair. It also needs proper project-management structure that will ensure transparency, efficiency and community involvement. The priorities should be outlined, sustainable financing sources established, cooperation between the stakeholders should be shaped, and instruments of effective planning and implementation should be introduced. Risk assessment, stakeholder mapping, schedule optimization, and quality control should be strictly taken to prevent the earlier failures of the project and to be prepared to build infrastructure both today and in the future [8]. The paper outlines the numerous issues the country of Iraq is struggling with in terms of reconstruction of roads and how the implementation of management practices can mitigate the issues. It uses case-studies, stakeholder reports and international precedents to give a holistic view of the modern day issues and offers solutions to issues which make sense in various contexts thus enhancing the discussion on post-conflict infrastructure reconstruction and the importance of strategic planning in national recovery [4]. There is more than infrastructure involved in the rehabilitation of Iraqi roads and it has to do with the restoration of broken relationships in Iraq. Roads are the symbols of motion, new prospects and hope. When Iraq is on the road to peace and prosperity, proper management of transport logistics projects will play a key role in supporting the vision in the long run. The rest of the paper will be organized in the following way. Section 2 is a literature review on critical success factors in road maintenance and establishes connection between project management and logistics performance. Section 3 examines the institutional, financial, and operational obstacles that limit the efforts to rebuild the roads in Iraq. Section 4 suggests a hybrid system that combines the use of PMBOK, PRINCE2, and Agile systems with the optimization of logistics flows and the utilization of digital technologies (GIS, AI). Section 5 addresses implementation pathways, governance mechanisms and contextual adaptations that should be used to achieve successful implementation. Lastly, the conclusions are made in Section 6, the main insights are summarized, and strategic priorities toward enhancing the road infrastructure recovery in Iraq are outlined.

2 Literature review

This part will explain what is crucial in making road maintenance projects in Iraq successful. The discussion uses a global comparison of research to take lessons from both advanced and less advanced nations, as well as different construction projects. By forming theories from various studies, the purpose is to find approaches and keys to success that match Iraq's situation after the conflict.

Road maintenance means regularly doing work on roads to preserve their function and safety, such as the pavement, shoulders, slopes, drains, and roadside technical devices [9]. By performing these activities, roads are kept in good condition for a longer time and ensure both reliable transport and publics' safety. Such maintenance activities are successful only if there is a good balance of institutional, managerial, financial, and technical factors. Kog et al. pointed out in a key study [10] that project success comes from effectively handling specific aspects. According to [11], the importance of these factors should be considered in big projects, like road construction and maintenance, because they are complex and require many resources.

The work in [12] offers a good description of CSFs as they relate to Intelligent Transportation Systems (ITS), which many road maintenance efforts also have in common. Organizational, management, environmental, and individual patterns are included in how they are categorized. In this case, organizational factors consist of trust, culture, how good communication is, how resources are managed, and the types of oversight used. CSFs in the management category are procurement, setting standards for IT, supervising the steering committee, and managing costs. Regulatory rules and changes in the market or politics are considered environmental factors, but skills, flexibility, and the involvement of users are considered individual factors. In Iraq, these aspects are important because the broken-up institutions and aftermath of conflict cause many difficulties for US operations.

Strong collaboration and effective lines of communication among those involved were recognized by [13] as important, and [14] stressed that clear roles, an emphasis on quality, and strong leadership all support success in sustainability. These recommendations respond strongly to the needs in Iraq's infrastructure sector, which has suffered from delays and inefficiencies due to overlapping roles and poor coordination.

It is practical to develop simple planning methods to manage and improve how maintenance is conducted. Using detailed checklists, as suggested by [15], is one method to improve how tasks are planned. [16] mentioned the significance of noticing and understanding the connections between CSFs to deploy resources where they are of greatest use. [17] further recommended using multidimensional approaches to visually analyse how CSFs depend on one another to develop flexible plans as needed.

In the context of government projects, reference [18] highlights the need to baselessly assess critical success factors (CSFs) in the partnership setups, reference [19] however, argues that legal adherence and regulatory astuteness are paramount prerequisites to successful project execution. Reference [20] also argues that the infrastructure funding through alternative means is needed to maintain the road infrastructure in the emerging economies and suggests that the old model of funding the infrastructure is no longer relevant and discusses that new type of financing tools should be used which is especially relevant in Malaysia where the infrastructure financing problems are compounded by the fact that the fiscal situation is a challenge.

As is stated in reference [21], the cost savings of outsourcing road maintenance services in Sweden to the private services were between 8 percent and 20 percent compared to the same government-operated program. These empirical results support the hypothesis that the privatized or performance-based maintenance solutions can result in cost-efficiency in Iraq, where the capacity of the government sector is still stretched. Similarly, reference [22] has reviewed the implementation of computerized Road Management Systems (RMS) and has argued that effective implementation depends on compatibility of three fundamental areas of the system which include processes, people and technology and suggested that lack of sufficient funding and commitment by stakeholders across these areas demolishes RMS projects.

In the Palestinian setting, reference [23] established high levels of inefficiency that are linked to a deep dependency on foreign contractors, who performed majority of the maintenance works on the urban roads, thus making the necessity of capacity building among local municipal authorities a priority. The importance of safety was also discussed in reference [24], which mentioned occupational safety as one of the non-negotiable standards of the success of construction projects. Other CSFs as stated by reference [25] include clear tasks of the contract.

Road asset management is one of the areas where optimization methodologies are being applied. A multi-objective particle swarm optimization (PSO) algorithm presented in [26] aims at optimising the pavement maintenance planning and has been shown to be better at refining the quality of solutions to be found in large transportation networks. This type of computational tool promises potential use in the Iraqi environment that is data-sparse and resource-limited, allowing the prioritization of evidence and allocate resources in such manner, which further is possible as shown in reference [27].

Reference [28] reviewed road construction projects in Kenya with specific focus on the transparent contractor selection procedure and the promotion of insulation of the procurement operations against the influence of politics. The research proposed the establishment of a centralized contractor performance registry to increase accountability, which may be a radical change to the very disjointed procurement system used in Iraq. Performance-Based Road Maintenance

Contracting (PBRMC) is a new paradigm, which has gained momentum around the world as argued in reference [29]. With the performance-based incentives and penalties, governments can be able to ensure the quality of their services as well as be able to optimise the cost efficiencies by delegating the maintenance duties to the private enterprises. Experience shows that properly designed PBRMC structures can maintain road infrastructure in an overall positive state at lower lifecycle prices as has been shown in reference [29]. Such models may be essential in ensuring that the long-term sustainability is realized despite the fiscal and operational limits in Iraq.

The paper has also discussed the common problems, which initiate change orders in maintenance contracts in the United States; the study, reference [9] identified a list of factors such as lack of scope definition, poor cost estimates, design revisions and lack of verifying the site, which contributes to the need of accurate pre-construction evaluations and sturdy contingency plans. These lessons can be directly related to Iraq, where change orders and scope creep are the common pests in the project timelines and budgets. Despite a wealth of global literature outlining key success factors of road maintenance projects, there remains a lot of gaps in trying to rationalize the information to the Iraqi context. A substantial part of the existing literature focuses on countries that have relatively stable political and institutional structures, but Iraq still has to deal with the post-conflict fragmentation, poor governance, and frequent political interference in the work of the government. The lack of localized research that examines the effects of how systemic factors, including the corruption in procurements, the absence of accountability by contractors, and poorly enforced regulations, hinder the operations of the road maintenance programmes in Iraq is lauded. Furthermore, the global scholarship focuses on the stakeholder coordination, project planning tools and performance-based contracts, which are either poorly developed or inconsistently implemented in the Iraqi setting. There is limited empirical information available about the ability of the Iraqi municipalities to take care of maintenance activities and most of the tasks are contracted without proper supervision. Moreover, there has not been much exploration on financing mechanisms that fit Iraq fiscal constraint like the use of public- private partnership or results-based budget. The lack of uniform and integrated contractor performance monitoring apparatus and maintenance procedures also serve to hinder the propagation of international research-based best practices. These contextual shortcomings underline the urgent need for Iraq-specific frameworks and evidence-based models that can adapt global success factors to the realities of local infrastructure governance and execution. Table 1 summarises the key studies on Critical Success Factors in Road Maintenance and Construction Projects.

Table 1 Summary of key studies on critical success factors in road maintenance and construction projects

Author(s)	Context	Key Findings
[Kog and Loh, 2012] [10]	General construction projects	Identified senior management support, contractor competence, and project manager involvement as critical for budget, schedule, and quality outcomes.
[Toor and Ogunlana, 2009] [11]	Large-scale construction projects	Emphasized the need to assess CSFs in complex infrastructure projects.
[Ataei Jafari and Ahmadvand, 2018] [12]	Intelligent Transportation Systems (ITS)	Developed a CSF framework including organizational, management, environmental, and individual factors.
[Li et al., 2019] [13]	General project management	Highlighted the importance of communication and cooperation among stakeholders.
[Banihashemi et al., 2017] [14]	Sustainable project delivery	Stressed clear responsibilities, high-quality work, and competent project managers.
[Ghanbari and Mojtahedzadeh Asl, 2021] [15]	Maintenance planning	Recommended use of checklists for improved planning and monitoring.
[Chen et al., 2012] [16]	Project management methodology	Advocated identifying interrelations between CSFs to focus resources.
[Williams, 2016] [17]	Success modeling	Demonstrated success in factor interactions using causal loop models.
[Osei-Kyei and Chan, 2017] [18]	Public-private partnerships	Suggested CSF identification is crucial for PPP success.
[Tabish and Jha, 2011] [19]	Government projects	Found adherence to regulations as the most important CSF.
[Obeng and Tuffour, 2020] [20]	Developing countries	Emphasized the need for alternative financing mechanisms in road maintenance.
[Yarmukhamedov et al., 2020] [21]	Sweden	Found outsourcing road maintenance to be more cost-effective than public provision (8–20% savings).

[McPherson and Bennett, 2006] [22]	Computerized Road Management Systems	Identified processes, people, and technology as critical, with funding as an enabler.
[Issa and Abu-Eisheh, 2017] [23]	Palestine	Highlighted the overreliance on foreign contractors and the need to empower municipalities.
[Dann and Fry, 2009] [24]	Construction safety	Emphasized safety as a fundamental CSF.
[Nawi et al., 2012] [25]	Construction partnerships	Noted the importance of stakeholder engagement, team integrity, and role clarity.
[Mahmood et al., 2018] [26]	Pavement maintenance design	Developed a multi-objective PSO algorithm for efficient planning in large networks.
[Osman and Kimutai, 2019] [28]	Kenya	Advocated for transparent contractor selection and anti-corruption mechanisms.
[Shrestha and Shrestha, 2019] [9]	U.S. road maintenance	Found frequent change orders due to poor scoping, cost errors, and design changes.
Gap in Iraqi Context	Iraq	Limited local studies, weak municipal capacity, insufficient regulation, absence of performance monitoring systems, and lack of tailored financing models hinder the adaptation of global CSFs.

3 Challenges in rebuilding Iraq's road network

It is not easy to rebuild Iraq's roads, as the tasks are technical, political, financial, and involve operations. Between 2003 and now, various initiatives have involved fixing infrastructure, but their performance has frequently been stopped by systemic issues, so results have been varied throughout the country. All these problems must be tackled and properly understood to maintain the reliability, safety, and use of Iraq's transport logistics services [30].

The infrastructure in many places is in very bad shape, which is creating serious issues. Years of neglect, roads being heavily used by the military, and no regular maintenance have caused potholes, faulty shoulders, and damaged drainage in highways and rural areas. According to the World Bank in 2018, more than 70% of Iraq's transport infrastructure was damaged in decades of fighting. The task of rehabilitation is made harder by using old engineering standards and not having digital systems to help manage roads. Many areas ignore gathering new soil or geotechnical information, which leads to choosing inaccurate materials or questionable designs that fall apart quickly. In addition, not having enough skilled engineers and labourers, in combination with a lack of acceptable access to advanced construction tools and quality monitors, further adds to the problem of meeting building goals.

Many governance-related obstacles slow down the reconstruction of roads. Because Iraq's system gives every government level a lot of authority, there is often conflict over duties, lengthy bureaucratic processes and poor management of resources. Issues with corruption are common in public contracting and choosing the winning bidder. Iraq is listed in the 2022 Corruption Perceptions Index by Transparency International, at number 157 out of 180 countries. The weakness of institutions makes it possible for projects to be given out based on political ties instead of skills, which leads to poor results or incomplete projects. Since laws are often not enforced properly, some contractors can ignore the specifications, which leads to roads that are less safe and do not last as long.

Financial issues cause another big challenge. Oil wealth alone is not enough to keep Iraq's economy safe, which is vulnerable because it is overly tied to oil revenues and is influenced by global shifts. Because of the COVID-19 pandemic and tumbling oil prices in 2020, the government had difficulty funding projects, causing several infrastructure projects to be put on hold or cancelled. According to the International Monetary Fund (2022), Iraq's capital investment in infrastructure had fallen to approximately 3.5% of GDP, far below what is required to restore basic service levels. Although international donors pledged more than $30 billion at the Kuwait International Conference for the Reconstruction of Iraq in 2018, a substantial portion of these funds remain tied to conditional loans or aid packages that have been slow to materialize due to administrative inefficiencies and donor concerns over transparency and risk. Operational and logistical issues further complicate reconstruction initiatives. In provinces previously affected by conflict, such as Nineveh and Anbar, the presence of unexploded ordnance and landmines poses a serious hazard to construction crews, requiring costly and time-consuming clearance operations before roadwork can begin. Transportation of materials is often delayed due to the poor state of secondary roads, frequent checkpoints, and disrupted supply chains. According to a 2020 report by UNOPS, 60% of road reconstruction projects in conflict-affected areas experienced significant delays because of procurement challenges, lack of access to heavy equipment, and shortages in essential construction materials. These logistical disruptions are exacerbated by the highly fragmented construction sector in Iraq, which is dominated by small, under-resourced local contractors who often lack the capacity to deliver on large-scale or technically demanding infrastructure projects.

That mixture of technical issues, mismanaged governance, budget shortages, and logistical hurdles has meant Iraq's road reconstruction is very fragile. Focused efforts to handle each challenge together are needed for rebuilding and modernizing Iraq's roads to be successful. Transforming Iraq's roads into reliable and strong assets requires a well-planned and properly funded method, using institutional changes, transparent procurement, and new skills and funding, all done quickly.

4 Project management solutions

To deal with the various hurdles in rebuilding Iraq's roads, strong project management, flexible approaches, and advanced technology are necessary (Table 2). The many barriers in post-conflict settings, such as existing challenges, different groups involved, and logistical hurdles, require planning, execution, and evaluation to be well structured and well thought out. Recognized worldwide, the PMBOK, PRINCE2, and Agile give thorough guidelines and adaptable methods that match the requirements of Iraq.

The PMBOK created by the Project Management Institute (PMI) notes that there are five process groups in project management: initiation, planning, execution, monitoring and control, and closing. Because road projects in Iraq often face cost overruns, changes in the proposed scope, and delays, the knowledge areas of scope, time, cost, quality, and risk management are especially appropriate. Using PMBOK's strategy allows project objectives to match what stakeholders anticipate, improves resource investment, sticks to the timeline, and reduces possible risks. For example, using PMBOK risk management practices can prevent or lessen contract disputes, requests for changes, and common delays in Iraq's public facilities.

Since PRINCE2 is a flexible process method used in public sector projects around the world, it matches the governmental structure of Iraq. This way of managing focuses on clear management positions, explaining business decisions and planning products that support accountability and transparency in Iraq's infrastructure area. Organizations in the road sector need good control over lengthy reconstruction projects, and a good way is to follow PRINCE2 practices. Also, having reviews and exception-based reporting at regular intervals would allow Iraq to quickly monitor and remedy issues in its changing political climate.

While traditional frameworks provide structure, Agile methodologies introduce flexibility and responsiveness, which are crucial in unstable or rapidly changing contexts. Although Agile was originally developed for software development, its iterative cycles, continuous feedback loops, and focus on stakeholder collaboration have proven effective in construction and infrastructure projects, particularly those involving adaptive planning or innovation [31]. Applying Agile principles can be beneficial in pilot programs or modular road rehabilitation efforts in Iraq, where on-the-ground realities often diverge from initial plans. Agile's participatory approach also supports community involvement, which is essential for project legitimacy and local ownership.

In parallel with management frameworks, the deployment of technological tools can significantly enhance project efficiency and decision-making. Geographic Information Systems (GIS) allow for precise mapping, spatial analysis, and visualization of road networks, enabling planners to assess existing infrastructure conditions, plan routes, and identify high-priority areas for maintenance or reconstruction. By using GIS, traffic movement can be modeled, the environment can be evaluated, and various infrastructure projects can be coordinated across industries.

Managing infrastructure can be transformed by the increasingly important technology of Artificial Intelligence (AI) [32]. AI-powered systems can optimize the timing for maintenance, find problems in the construction using sensor-collected information, and anticipate if a project could be delayed or its original budget surpassed based on previous issues. Since human resources and data processing power are few in Iraq, AI equipment helps make smarter decisions, automate daily activities, and ensure resources are used properly [32].

Project success is also based on the importance of good stakeholder engagement models. Engagement frameworks such as the Stakeholder Circle and the Salience Model make it easier to find and organize stakeholders by their level of power, interest and influence. In the divided political and social state of Iraq, these methods can help more people be involved in planning, keep conflicts to a minimum, and unite various interests. Talking with people in the area, construction teams, NGOs, and government officials strengthens trust, makes things clearer, and encourages sharing ideas to enhance the way the project is run.

When these management approaches, digital tools, and concerns for stakeholders are integrated, they guide Iraq in reaching better results for its road upkeep and rebuilding. A hybrid strategy—blending the structure of PMBOK or PRINCE2 with the adaptability of Agile, supported by real-time GIS-AI platforms and participatory planning—offers the most promising pathway toward resilient and sustainable infrastructure outcomes in the Iraqi context.

Table 2 Summary of project management solutions for road infrastructure in Iraq

Solution Type	Approach/Tool	Description and Relevance to Iraq
Project Management Framework	PMBOK (Project Management Body of Knowledge)	Offers a structured approach through the process groups and knowledge areas. Helps manage risks,

		timelines, costs, and quality in Iraq's volatile infrastructure environment.
Project Management Framework	PRINCE2 (Projects I N C o n trolled Environments)	Focuses on accountability, stage-based control, and product-focused planning. Supports public sector needs for transparency and governance in Iraq.
Project Management Methodology	Agile	Provides flexibility and iterative planning for complex and changing environments. Suitable for modular and pilot road maintenance efforts in Iraq.
Technological Tool	GIS (Geographic Information Systems)	Enables spatial analysis, road mapping, and prioritization of maintenance zones. Helps in planning and environmental assessments.
Technological Tool	AI (Artificial Intelligence)	Facilitates predictive maintenance, resource optimization, and delay forecasting. Useful in Iraq for augmenting capacity and automating decision-making.
Stakeholder Engagement	Stakeholder Circle, Salience Model	Identifies, maps, and prioritizes stakeholders based on influence and interest. Supports inclusive planning and reduces conflict in fragmented Iraqi contexts.
Hybrid Strategy	Integrated Application of PM- BOK/PRINCE2 with Agile and Technology	Combines structure, flexibility, and innovation. Enhances project delivery, monitoring, and sustainability of Iraq's road infrastructure reconstruction.

Figure 1 illustrates a conceptual flowchart summarizing the key pillars of effective project management strategies for road infrastructure projects in Iraq. The diagram is structured into three main categories:

- **Traditional Framework:** This component is represented by a hierarchical icon, referring to structured methodologies such as PMBOK and PRINCE2. These frameworks guide scope, time, cost, and quality management within infrastructure projects.

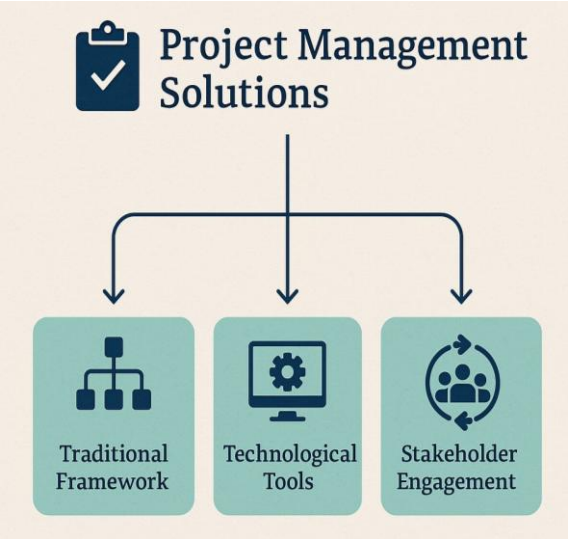

Figure 1 Project management solutions

- **Technological Tools:** Illustrated with a gear-and-monitor symbol, this category emphasizes the integration of Geographic Information Systems (GIS) and Artificial Intelligence (AI) to support predictive maintenance, spatial analysis, and resource optimization.
- **Stakeholder Engagement:** Indicated by a circular people-centered icon, this area focuses on participatory planning and collaborative decision-making using stakeholder identification and engagement models to enhance transparency and community involvement.

The flowchart captures the essence of a hybrid management strategy that combines process discipline, digital innovation, and inclusive governance to overcome the unique challenges of post-conflict infrastructure reconstruction in Iraq.

5 Results and discussion

Assessment of the suggested project-management solutions, including frameworks, technological integration, and stakeholder interaction, shows a strong fit between internationally accepted best practices and urgent requirements of the Iraqi road-maintenance industry. Holistically, a combination of PMBOK, PRINCE2, Agile approach, GIS and AI tools, and participatory engagement models can create a powerful and flexible system of infrastructure reconstruction. However, the success of these solutions depends on the institutional readiness of Iraq, socio-political stability, and capacity to implement.

The practices that contribute to the quality of information flow (with more comprehensible designs, reviews of stage-gate and digital quality assurance/quality control) are related to fewer rework, less change orders, stabilisation of financial flows (exhibited by the reduced variation in the progress payment and claims), as well as minimisation of material wastage in synthesised case studies and empirical findings. Guided staging and routing of asphalt and aggregate materials, made possible by GIS, reduce the cycle time of asphalt and aggregate products, leading to material-flow reliability and productivity of the site. At the same time, Agile cadence enhances human resource coordination (crews, inspectors) through disturbed access and security restrictions.

Structured frameworks, like PMBOK and PRINCE2, offer critical components of project governance, like clear processes and risk control, and role definition. Their implementation has the capacity of significantly decreasing inefficiencies and fragmentation in the Iraqi system of infrastructure delivery whereby projects are often characterized by slow schedules, scope ambiguities and contractual wrangles. Despite the fact that these frameworks have worked well in many other international settings, their implementation in Iraq has been inconsistent and superficial in many instances. According to interviews and field reports, formal compliance with such structures may be observed in documentation of the project but planning and implementation processes are often compromised with political interferences, lack of professional staff, and lack of coherent monitoring systems.

The flexibility of Agile method is a very important continuation to the conventional approaches especially in pilot or modular road -maintenance projects where flexibility and change responsiveness are of paramount importance. The iterative format of planning, feedback of Agile and the user-centered ideology may be particularly useful in the volatile situation in Iraq where field conditions are constantly different to initial plans. Nonetheless, the cultural change that is necessary to adopt Agile principles, including decentralisation of power and encouragement of real-time feedback on the stakeholders, is not well developed in the bureaucratic sphere of Iraq.

Another enabler of efficiency and transparency with high potential is technological tools such as GIS and AI. GIS is capable of supplementing spatial planning, real-time monitoring of the project, and prioritising interventions using current data. The AI-based models can also assist with predictive maintenance and analyse data automatically, thus overcoming the ongoing poverty of the Iraqi market in qualified planners and analysts. However, the implementation of these tools in practice is limited by the limited digital infrastructure, lack of stability in the availability of data, and the low level of digital literacy of technical personnel of local agencies. The realisation of the full potential of those technologies is thus dependent, to a great degree, on investment in staff training, integration of these systems, and governance of data.

Stakeholder engagement models have turned out to be critical in the social acceptability of projects. Since infrastructural development projects in Iraq tend to overlap with the interests of ethnic, tribal, and political structures, they should consider this by including everyone to minimize the risk of conflict and create equalized benefits distribution. The Stakeholder Circle and Salience Model helps the planners find the essential actors, address the expectations, and encourage the participation. Practically, though, the participation of Iraqi road projects remains fairly infrequent, with the majority of it being the official postulates and short-term consultations, which pay no attention to the actual needs of the local people. This lack shows that there is urgent need to have more powerful reforms and more civic education so that participatory planning can grow to be an occasion rather than a practice.

The gap between theory and practice can be investigated and with the help of the gap, one can find that the difficulties are caused by the limited nature of the environment of the post-war government of Iraq and not by the lack of plans. The very presence of a universal model has nothing to do with success on the ground instead, contextual adjustments, well-built government backing and long-term investments are necessary to empower institutions. New project-management solutions are impossible without the reform of the procurement, mitigation of corruption, and the inter-agency communication problems.

In general, the analysis highlights the importance of the hybrid methodology that incorporates PMBOK, PRINCE2, Agile methodology, digital tools and stakeholder involvement. The most important consideration by Iraq is ensuring the practical application of these methodologies in consideration of the governance structures, capacity building and the development of trust by the people in the system. The gap between the desired results and the real performance requires both the technological improvements as well as the systemic changes on a deeper level.

6 Conclusion

The reconstruction of the Iraqi road system is a multidimensional project, which is not limited to engineering factors, but also covers the aspects of governance, financing, institutional coordination, and collecting the stakeholders. This study focused on the localization of the proven project management frameworks to reduce coordination failures and change-order risks, as well as the extent to which they can be optimized to include logistics and the digital technologies to increase the reliability of processes and efficiency of delivery. Comparative analysis showed that the successful adaptation of these frameworks in Iraq is dependent on four interconnected strategic dimensions: (1) strengthening of institutional integration and alignment of governance between national and provincial agencies; (2) the integration of the logistics-based flow management to coordinate the material, information, financial, and human resources; (3) the use of the digital platform, including GIS and AI to support a data-driven decision-making process and predictive project control; and (4) the institutionalization of the participatory stakeholder mechanisms that promote transparency and accountability in procurement and delivery. The combination of these strategic dimensions deals with the gap in implementation between international standards and domestic practice, the cause of which is a weak governance system, divided responsibilities, and limited technical capacity. The empirical evidence supports a hypothesis according to which a hybrid, localized project-management-logistics structure can be identified to have a significant positive influence on the coordination reliability and performance of a project in comparison with traditional methods.

As a sustainable development step, Iraq needs to develop management skills in existing state institutions, put in place interoperable digital planning and monitoring, and restructure regulatory processes in a way that creates a sense of transparency and joint agency. The other aspect that is significant is the nature of participatory engagement that has been embedded within the project lifecycle to enhance legitimacy and community ownership. Through these strategic dimensions operationalized, Iraq can cease the ad hoc reconstruction operations and move on to an integrated system of infrastructure governance- an order that is consistent with the worldwide project management rules and local logistical facts. By doing so, the nation will be able to convert its road network into a robust platform to economic recovery, connectivity in the region, as well as long term national development.

References

[1] BAQRALSHAM, N.J., AL-KHAFAJI, A.S.: Functions and Activities as a Catalyst for Successful Sustainable Adaptive Reuse of Heritage Areas: A Study of the Religious Center of Karbala City, Iraq, *International Journal of Sustainable Development and Planning*, Vol. 20, No. 1, pp. 75-87, 2025. https://doi.org/10.18280/ijsdp.200109

[2] RUIZ-RODRIGO, A., MORALES, E., LAKOUD, M., RIENDEAU, J., LEMAY, M., SAVARIA, A., MATHIEU, S., FEILLOU, I., ROUTHIER, F.: Experiencing accessibility of historical heritage places with individuals living with visible and invisible disabilities, *Frontiers in Rehabilitation Sciences*, Vol. 5, pp. 1-13, 2024. https://doi.org/10.3389/fresc.2024.1379139

[3] ÇELIMLI, M.A., ORAL, M.: Completely Accessibility Solutions for Historical Building and Areas in the Multi-Layered City Center of Sivas, *ICONARP International Journal of Architecture & Planning*, Vol. 10, No. 2, pp. 891-915, 2022. https://doi.org/10.15320/iconarp.2022.228

[4] KÖRMEÇLI, P.S.: Accessibility of Urban Tourism in Historical Areas: Analysis of UNESCO World Heritage Sites in Safranbolu, *Sustainability*, Vol. 16, No. 6, 2485, pp. 1-17, 2024. https://doi.org/10.3390/su16062485

[5] FARHAN, S.L., MERIE, U.A.A.K., NASAR, Z.: Revitalizing historic city center a comparative methodology of current approaches and alternatives, *Journal of Cultural Heritage Management and Sustainable Development*, Vol. ahead-of-print, No. ahead-of-print, 2024. https://doi.org/10.1108/jchmsd-08-2022-0148

[6] RAHMAN, M., PICCOLO, F., BONAFEDE, G.: Sustainable urban revitalization within a historical urban neighborhood—a useful approach to complete, *Journal of Advanced Research in Construction and Urban Architecture*, Vol. 4, No. 1, pp. 35-53, 2019.

[7] KIM, J.K.: This is our voice: revitalizingrenas a homiletical concept for resistance to anti-Asian hate crimes, *Practical Theology*, Vol. 15, No. 3, pp. 285-296, 2022. https://doi.org/10.1080/1756073x.2021.2023079

[8] BALSAS, C.J.L.: City Centre Revitalization in Portugal: A Study of Lisbon and Porto, *Journal of Urban Design*, Vol. 12, No. 2, pp. 231-259, 2007. https://doi.org/10.1080/13574800701306328

[9] SHRESTHA, K.K., SHRESTHA, P.P.: Change Orders on Road Maintenance Contracts: Causes and Preventive Measures, *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, Vol. 11, No. 3, p. 04519009, 2019. https://doi.org/10.1061/(asce)la.1943-4170.0000299

[10] KOG, Y.C., LOH, P.K.: Critical Success Factors for Different Components of Construction Projects, *Journal of Construction Engineering and Management*, Vol. 138, No. 4, pp. 520-528, 2012. https://doi.org/10.1061/(asce)co.1943-7862.0000464

[11] TOOR, OGUNLANA, S.O.: Construction professionals' perception of critical success factors for large-scale construction projects, *Construction Innovation*, Vol. 9, No. 2, pp. 149-167, 2009. https://doi.org/10.1108/14714170910950803

[12] GHANBARI, M., HASANI, Z.K.: Key Success Factors in Road Maintenance Management Projects (A Case Study of Maysan Province, Iraq), *IIUM Engineering Journal*, Vol. 25, No. 1, pp. 102-114, 2024. https://doi.org/10.31436/iiumej.v25i1.2870
[13] LI, Y., SONG, H., SANG, P., CHEN, P.-H., LIU, X.: Review of Critical Success Factors (CSFs) for green building projects, *Building and Environment*, Vol. 158, pp. 182-191, 2019. https://doi.org/10.1016/j.buildenv.2019.05.020
[14] BANIHASHEMI, S., HOSSEINI, M.R., GOLIZADEH, H., SANKARAN, S.: Critical success factors (CSFs) for integration of sustainability into construction project management practices in developing countries, *International Journal of Project Management*, Vol. 35, No. 6, pp. 1103-1119, 2017. https://doi.org/10.1016/j.ijproman.2017.01.014
[15] WANG, W., HU, H., ZHANG, J.C., HU, Z.: *Digital Twin-based Framework for Green Building Maintenance System*, 2020 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), Singapore, Singapore, 2020, pp. 1301-1305, 2020. https://doi.org/10.1109/ieem45057.2020.9309951
[16] CHEN, Y.Q., ZHANG, Y.B., LIU, J.Y., MO, P.: Interrelationships among Critical Success Factors of Construction Projects Based on the Structural Equation Model, *Journal of Management in Engineering*, Vol. 28, No. 3, pp. 243-251, 2012. https://doi.org/10.1061/(asce)me.1943-5479.0000104
[17] WILLIAMS, T.: Identifying Success Factors in Construction Projects: A Case Study, *Project Management Journal*, Vol. 47, No. 1, pp. 97-112, 2016. https://doi.org/10.1002/pmj.21558
[18] OSEI-KYEI, R., CHAN, A.PP.C.: Implementing public–private partnership (PPP) policy for public construction projects in Ghana: critical success factors and policy implications, *International Journal of Construction Management*, Vol. 17, No. 2, pp. 113-123, 2016. https://doi.org/10.1080/15623599.2016.1207865
[19] TABISH, S.Z.S., JHA, K.N.: Identification and evaluation of success factors for public construction projects, *Construction Management and Economics*, Vol. 29, No. 8, pp. 809-823, 2011. https://doi.org/10.1080/01446193.2011.611152
[20] OBENG, D.A., TUFFOUR, Y.A.: Prospects of alternative funding sourcing for maintenance of road networks in developing countries, *Transportation Research Interdisciplinary Perspectives*, Vol. 8, 100225, pp. 1-7, 2020. https://doi.org/10.1016/j.trip.2020.100225
[21] YARMUKHAMEDOV, S., SMITH, A.S.J., THIEBAUD, J.-C.: Competitive tendering, ownership and cost efficiency in road maintenance services in Sweden: A panel data analysis, *Transportation Research Part A: Policy and Practice*, Vol. 136, pp. 194-204, 2020. https://doi.org/10.1016/j.tra.2020.03.004
[22] MCPHERSON, K., BENNETT, C.R.: Success Factors for Road Management Systems, *Transport Notes Series*, No. TRN 29, World Bank, Washington, DC, 2006. https://doi.org/10.1596/11777
[23] ISSA, A., ABU-EISHEH, S.: Evaluation of implementation of municipal roads' maintenance plans in Palestine: A pilot case study, *International Journal of Pavement Research and Technology*, Vol. 10, No. 5, pp. 454-463, 2017. https://doi.org/10.1016/j.ijprt.2017.07.006
[24] DANN, S., FRY, M.-L.: Benchmarking Road Safety Success: Issues to Consider, *Australasian Marketing Journal*, Vol. 17, No. 4, pp. 226-231, 2009. https://doi.org/10.1016/j.ausmj.2009.06.004
[25] NAWI, M.N.M., LEE, A., KAMAR, K.A.M., HAMID, Z.A.: Critical success factors for improving team integration in industrialised building system (ibs) construction projects: The Malaysian case, *Malaysian Construction Research Journal*, Vol. 10, No. 1, pp. 45-63, 2012.
[26] MAHMOOD, M., MATHAVAN, S., RAHMAN, D.M.: A parameter-free discrete particle swarm algorithm and its application to multi-objective pavement maintenance schemes, *Swarm and Evolutionary Computation*, Vol. 43, pp. 69-87, 2018. https://doi.org/10.1016/j.swevo.2018.03.013
[27] JORGE, D., FERREIRA, A.: Road network pavement maintenance optimisation using the HDM-4 pavement performance prediction models, *International Journal of Pavement Engineering*, Vol. 13, No. 1, pp. 39-51, 2012. https://doi.org/10.1080/10298436.2011.563851
[28] MUTHURI, M.Z., TUMUTI, W.J.: Project Management Discipline and Performance of Road Construction Projects in Meru County, Kenya, *International Journal of Science and Research (IJSR*), Vol. 8, No. 11, pp. 252-258, 2019. https://doi.org/10.21275/art20202388
[29] MEHANY, M.S.H.M., GUGGEMOS, A.A.: Risk-Managed Lifecycle Costing for Asphalt Road Construction and Maintenance Projects under Performance-Based Contracts, *ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering*, Vol. 2, No. 4, p. 05016001, 2016. https://doi.org/10.1061/ajrua6.0000888
[30] LIU, Y., DING, X., JI, Z.: Enhancing Walking Accessibility in Urban Transportation: A Comprehensive Analysis of Influencing Factors and Mechanisms, *Information*, Vol. 14, No. 11, 595, pp. 1-23, 2023. https://doi.org/10.3390/info14110595
[31] KURZHANSKIY, A.A., VARAIYA, P.: Traffic management: An outlook, *Economics of Transportation*, Vol. 4, No. 3, pp. 135-146, 2015. https://doi.org/10.1016/j.ecotra.2015.03.002

[32] PAREEKH, P., MITRA, S., MAJUMDAR, B.B.: Quantifying dimensions of Transportation Diversity: A City-Based Comparative Approach, *Transportation Research Procedia*, Vol. 25, pp. 3174-3187, 2017. https://doi.org/10.1016/j.trpro.2017.05.359

Review process
Single-blind peer review process.