https://doi.org/10.31436/iiumej.v25i1.2870

KEY SUCCESS FACTORS IN ROAD MAINTENANCE MANAGEMENT PROJECTS (A CASE STUDY OF MAYSAN PROVINCE, IRAQ)

MILAD GHANBARI[1*] AND ZAID KHALID HASANI[2]

[1]Department of Civil Engineering, East Tehran Branch, Islamic Azad University, Tehran, Iran
[2]Department of Project Management and Construction, South Tehran Branch, Islamic Azad University, Tehran, Iran

[*]Corresponding author: Milad.ghanbari@srbiau.ac.ir

(Received: 17 May 2023; Accepted: 2 September 2023; Published on-line: 1 January 2024)

ABSTRACT: Developing roads is a crucial and essential activity, but maintaining them regularly is equally important to improve their performance. A well-maintained road network facilitates economic, industrial, cultural, and social growth. Once the construction phase of a road is complete, its operating phase commences, which is subject to wear and tear due to various factors like traffic and weather conditions. Hence, regular and continuous road maintenance activities are essential to increase the useful life of roads and manage national resources effectively. However, road maintenance management in Iraq, particularly in the province of Maysan, is suffering from poor performance due to the absence of an effective maintenance management system. Therefore, this research aims to identify the critical success factors of road maintenance projects, with a focus on the Maysan province as a case study of Iraq. The study identified and analyzed 27 key success factors in road maintenance projects, which were classified into three groups: management, technical, and resources. Based on the analysis of the literature review and field study in Maysan province, the top five key success factors were determined to be: 1. Adequate funds; 2. Timely payment to contractor and employees; 3. Quality of materials; 4. Use of advanced technology to detect or evaluate road defects; and 5. Communication and coordination among parties.

ABSTRAK: Pembangunan jalan adalah sangat penting bagi aktiviti harian, tetapi penyelenggara secara berkala adalah sama penting bagi menambah baik prestasi jalan. Jaringan jalan yang terpelihara membantu dalam ekonomi, industri, budaya, dan perkembangan sosial. Sebaik fasa pembangunan jalan siap, fasa operasi bermula, bergantung pada tahap jalan disebabkan pelbagai faktor seperti trafik dan kondisi jalan. Oleh itu, penyelenggaraan jalan berkala dan berterusan sangat penting kepada jangka hayat jalan dan ianya dapat menyumbang kepada pengurusan sumber negara dengan efektif. Walau bagaimanapun, penyelenggaraan jalan di Iraq, khususnya di daerah Maysan, memiliki kekurangan dalam penyelenggaraan jalan disebabkan oleh ketiadaan sistem pengurusan jalan yang efektif. Oleh itu, kajian ini menumpukan tentang mencari faktor kejayaan penting sesebuah projek penyelenggaraan jalan, sebagai fokus kes kajian ini dipilih di daerah Maysan, di Iraq. Kajian ini merincikan dan menilai 27 kunci kejayaan dalam projek penyelenggaraan jalan di bawah 3 kumpulan: pengurusan, teknikal dan sumber. Berdasarkan analis dapatan kajian terdahulu dan bidang kajian di daerah Maysan, lima kunci faktor kejayaan didapati dari: 1. Sumber yang mencukupi; 2. Pembayaran tepat kepada kontraktor dan pekerja; 3. Material kualiti; 4. Pengunaan teknologi moden bagi mengesan dan menganalisa kerosakan jalan; dan 5. Komunikasi dan koordinasi antara semua yang terlibat.

https://doi.org/10.31436/iiumej.v25i1.2870

KEYWORDS: *success factors; project success; road maintenance; project management; performance assessment*

1. INTRODUCTION

Developing a country's road network is an essential requirement for societal growth and development [1,2]. By enhancing accessibility and reducing poverty, well-maintained roads can contribute to economic and social development [3].

Although the construction of new roads is expensive, it is vital to maintain them properly to prevent quick deterioration. Poor management of road maintenance will lead to the need for replacement or significant repairs in just a few years [4]. However, with proper planning and prioritization, even small maintenance budgets can make a significant improvement in service quality of road transportation. Road maintenance costs that are neglected will eventually be cost the users and the community rather than the country's budget [5].

Constructing roads with a specific quality and standard requires a significant amount of resources, which are typically provided or managed by the government [6]. However, roads, like other infrastructure assets, are subject to depreciation. The extent of the road deterioration process depends on various factors, including traffic volume, weather conditions, and the maintenance activities implemented for that road. For example, areas with high traffic volumes and severe weather conditions require more frequent and focused maintenance activities [7]. Establishing a road management system leads to planning, monitoring, and effective management of roads [8]. Obtaining information about the technical and financial status of road network maintenance is crucial since it impacts the overall economy of the province or country [3].

The neglect of road maintenance in Iraq has resulted in severe deterioration of the existing road network and has transformed low maintenance costs into significant expenses for renovation and reconstruction. Iraq, as a whole, lacks an efficient road management system and a comprehensive database detailing the maintenance measures undertaken on its roads. Sustaining the service level of infrastructure assets, including roads, and preventing their deterioration necessitates ongoing analysis and planning [9]. The regular and consistent execution of road maintenance activities contributes to prolonging the lifespan of roads and effectively managing national resources, indicating the success of the road maintenance program [10,11]. It is evident that enhancing the quality of existing roads must be carried out within the constraints of financial and technological resources [8].

Determining the success of a project and ensuring that it stays on track in terms of quality, cost, and meeting goals is a crucial aspect of project management. It is important to have knowledge of key factors and tools that can be used to measure, monitor progress and to take appropriate action if a project deviates from the expected path [12].

Due to the significant expenses associated with road construction and its key role in a country's development, coupled with the high maintenance costs, it is crucial to identify and investigate the critical success factors for road maintenance projects. Hence, the primary objective of present research is to study the critical success factors in road maintenance projects, with a focus on the Maysan province as a case study in Iraq.

2. LITERATURE REVIEW

The purpose of this section is to identify the elements that play a role in the success of road maintenance projects in Iraq. This entails examining research from different countries,

encompassing both developing and developed nations, along with studies related to various construction project types.

Road maintenance involves a series of regular and periodic activities and techniques that ensure road components (such as pavement, shoulders, slopes, drainage systems, and other technical road facilities) are kept in the in-service condition [4,13].

Kog et al. [14] conducted research on the influence of critical success factors on the budget, schedule, and quality of construction projects. They identified key factors such as senior management support, contractor team competence, and project manager commitment and involvement. Toor and Ogunlana [15] emphasized the importance of studying critical success factors for large-scale projects, which is particularly relevant for road and road maintenance projects as they fall under this category.

Ataei Jafari and Ahmadvand [16] conducted research on the critical success factors of intelligent transportation system (ITS) projects. According to their findings, outsourcing large ITS projects require careful consideration of critical success factors that fall under four categories: organizational, management, environmental, and individual factors. Organizational factors include elements such as organizational trust, adequate resource allocation, supervision, organizational culture, and quality of communications. Management factors include supplier identification and selection, information technology standards, establishing a steering committee, competent project management, human resource management, cost management, and senior management support. Environmental factors encompass laws and regulations, activities of competitors, and government policies. Lastly, individual factors involve technical expertise, flexibility, and user involvement. The successful implementation of ITS requires proper organizational support, efficient project management, and effective communication, which could also be essential for successful road maintenance projects.

According to the research of Li et al. [17] effective communication and cooperation among project participants is a key success factor. Banihashemi et al. [18] emphasized the importance of clear definition of responsibilities, emphasis on high quality work, and the experience and competence of the project manager as crucial success factors for integrating sustainability into projects.

Ghanbari and Mojtahedzadeh Asl [19] state that creating a maintenance checklist can enhance the effectiveness of planning, implementation, and monitoring of maintenance activities. Similarly, according to Chen et al. [20], identifying critical success factors and understanding their interrelationships can assist project managers in focusing on key factors and allocating appropriate resources. Additionally, Williams [21] examined the multidimensionality of success and demonstrated how success factors interact with one another through causal loops.

Osei-Kyei et al. [22] suggest that studying critical success factors is highly beneficial for projects involving public sector participation. Tabish and Jha [23] found that awareness and adherence to laws and regulations are the most important success factors in government projects. Meanwhile, Obeng and Tuffour [24] have researched alternative financing sources for road network maintenance in developing countries. They argue that traditional financing options have become increasingly challenging, and alternative arrangements are necessary since governments are unable to meet their planned expenditure commitments.

Yarmukhamedov et al. [7] examined the effectiveness of competitive bidding and cost efficiency in road maintenance services in Sweden, utilizing econometric methods. The study revealed that the government provider incurred higher costs (8-20%) compared to private

companies. The findings showed that significant savings could be achieved by outsourcing road maintenance services to the private sector through market competition.

A study conducted by McPherson and Bennett [8] explored the critical factors required for the effective implementation of a computerized road management system (RMS). This type of system relies on three fundamental components - processes, people, and technology, which must be supported by adequate funding. The study findings suggested that the absence of any of these components could lead to system failure. The primary objective of an RMS is to assist the road organization in planning and prioritizing road investments.

In a study analyzing urban road maintenance plans in Palestine, Issa and Abu-Eisheh [25] found that 95% of maintenance work was done through foreign contracts, indicating a need for support and equipment for municipalities to carry out basic road maintenance works. Safety is also a crucial success criterion in construction project management, as emphasized in the research of Dann and Fry [26] and Aksorn and Hadikusumo [27]. Additionally, stakeholder management [28] and improving team integrity [29] are also important considerations for project success. Clear definition of responsibilities is also cited as a critical success factor for partnering in construction projects, according to Chan et al. [30].

The utilization of optimization methods enables the identification of the most suitable approach for managing road and pavement maintenance [31,32]. Mahmood et al. [33] introduced a multi-objective particle swarm algorithm for pavement maintenance design. The algorithm can improve maintenance solutions' quality and efficiently analyze large road networks.

Osman and Kimutai [34] conducted a study on the critical success factors in road construction projects in Kenya. They emphasize the importance of officials not only ensuring the availability of guidelines for the contractor selection process but also adhering to them and taking measures to prevent corruption and political influences in contract agreements. The research suggests the establishment of a comprehensive system that maintains and integrates the details and records of road contractors who have previously worked with the government. This system aims to facilitate easy tracking of contractors' performance to minimize the selection of inefficient contractors.

The topic of road management includes the study of performance-based road maintenance contracting (PBRMC) [5,6,35,36]. PBRMC is an effective way to shift the responsibility of road maintenance activities to the private sector. The structure of performance indicators, as well as the penalties and incentives included in the contract, has a significant impact on the overall cost and level of service provided to the public [36]. PBRMCs that are well-designed maintain roads in predefined good conditions at relatively low costs [6].

Shrestha and Shrestha [4] conducted research on change orders in road maintenance contracts in the United States. The study found that there are several reasons for change orders in maintenance projects, such as an incorrect scope of work, errors in estimation, changes in the initial design, changes in material specifications, and failure to confirm the work site conditions before signing the contract.

3. ROAD MAINTENANCE STATUS IN MAYSAN

Maysan province is situated in Iraq and has a network of exit roads in all directions, covering a length of approximately 700 km. The province's road and bridge infrastructure is in critical and difficult conditions due to insufficient budget allocation and financial capacity. The roads are suffering from issues like rutting and creeping in the asphalt layers, which is caused

https://doi.org/10.31436/iiumej.v25i1.2870

by several factors such as the lack of control over truckloads and the use of a weak asphalt mixture. To address this issue, axial weighing stations were installed at the entrance of the governorate to regulate the loads and polymer asphalt used. These corrective measures led to a reduction in maintenance work and costs compared to previous periods.

Several successes and failures have been observed in road maintenance and repair projects in Iraq, which provide valuable experiences. To achieve more success in road maintenance projects, it is necessary to conduct a scientific analysis of the key success factors in Maysan's road maintenance projects. The results of this analysis can be beneficial to Iraq's road infrastructure.

4. RESEARCH METHOD

4.1 Research Conceptual Model

This research is practical in terms of its purpose and descriptive in terms of its research method. Data collection was done through a questionnaire. The study collected 27 key success factors for Iraqi maintenance projects. Section 5 of this article presents the statistical analysis of the model. Figure 1 shows the conceptual model of this research, which identifies the relationship between the key success factors and the success of Iraqi maintenance projects.

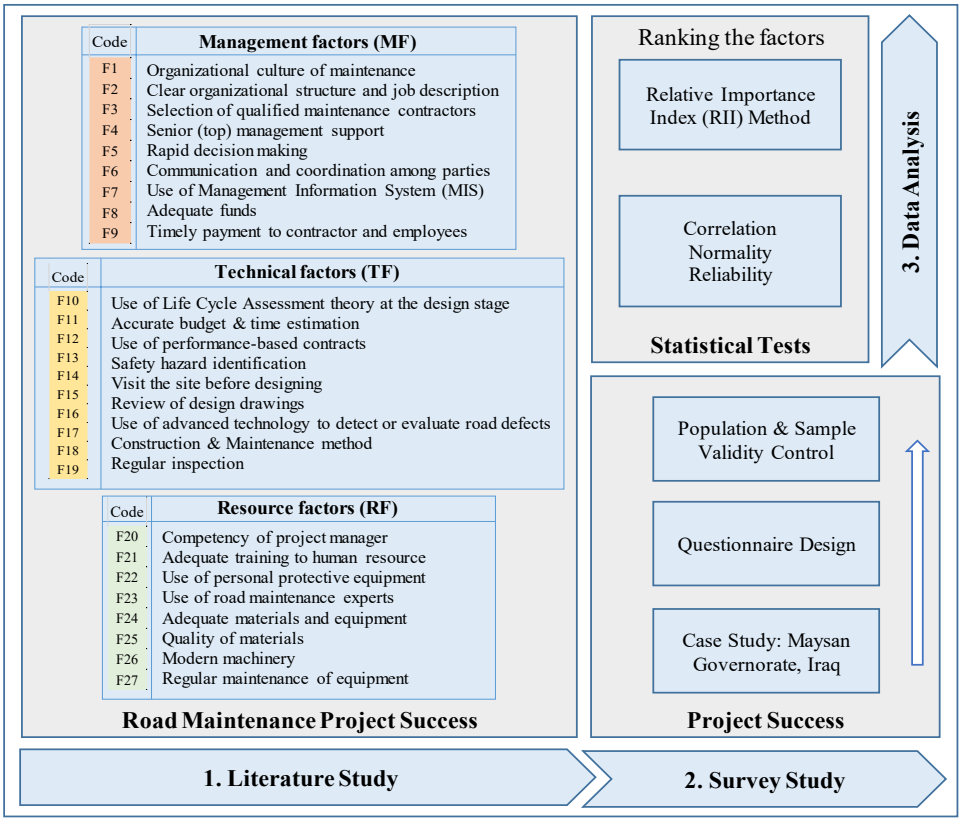

Fig. 1: Conceptual model of the research.

The conceptual model presented in Fig. 1 shows that the classification of key success factors of road maintenance projects is based on three indicators: management factors, technical factors, and resource factors, all of which are independent variables. The dependent variable in this model is the success of road maintenance projects. Then, a questionnaire was created and sent to the road maintenance engineers of Maysan, who were the statistical

population of the research. The questionnaire was developed based on a 5-point Likert scale and 27 factors (which are classified into three groups of managerial, technical, and resource factors). To ensure content validity, the questionnaire was reviewed by two civil engineering university professors, who provided their opinions for the questionnaire.

The data collected from the surveys were analyzed using SPSS 20 software, and then the key success factors were ranked using the Relative Importance Index (RII) method. The sample size of the research is 45, of which 43 road maintenance engineers answered all the questions in the questionnaire, which resulted in a 95% efficiency rate. The demographic characteristics of the respondents are presented in Table 1.

Table 1: Demographic description of respondents

Characteristics	Category	Frequency	Percentage
Age (years)	> 40	12	27.91%
	30-40	27	62.79%
	< 30	4	9.30%
Specialty	Civil engineering	27	62.79%
	Architecture	5	11.63%
	Electricity	4	9.30%
	Mechanics	5	11.63%
	Other	2	4.65%
Experience	> 25	2	4.65%
	15-25	14	32.56%
	10-14	13	30.23%
	6-9	12	27.91%
	3-5	2	4.65%
Education level	PhD	2	4.65%
	Master	12	27.91%
	Bachelor	29	67.44%
Affiliation	Client	28	65.12%
	Consultant	11	25.58%
	Contractor	4	9.30%

4.2 Relative Importance Index Method

Previous studies have provided a formula to calculate the RII based on expert questionnaire data, and this formula has been used in this study as well [4,37,38]. The RII formula, shown in Eq. (1), calculates the weight of each factor based on the expert responses:

$$RII = \frac{\sum_{i=1}^{I} W_i}{A \times N} \quad (1)$$

Table 2: The weighted importance scale of the responses

Option	Not important	Slightly important	Moderately important	Important	Very important
Likert value	1	2	3	4	5
RII value	0 - 0.2	0.2 – 0.4	0.4 – 0.6	0.6 – 0.8	0.8 - 1

https://doi.org/10.31436/iiumej.v25i1.2870

The RII values were calculated for each response using Table 2 and Eq. (1). According to Table 2, if the RII value of a factor is greater than 0.6, it is considered a key success factor.

5. RESULTS AND DISCUSSION

5.1 Statistical Data Screening

The reliability of the questionnaire used in this research was evaluated by computing Cronbach's alpha in SPSS software, which yielded a value of 0.86. As this value is greater than 0.7, it indicates that the measurement tool used in this research is reliable. The normality of the research data was evaluated using the Kolmogorov-Smirnov and Shapiro-Wilk nonparametric tests in SPSS software, and the results showed that the research variables follow a normal distribution, as the deviation from normal distribution was found to be greater than 0.05. Subsequently, Pearson's test was conducted to examine the correlation between variables using SPSS software (see Table 3). A significant correlation was found between the research variables and the success of road maintenance projects, indicating that each group of managerial, technical, and resource factors significantly affects the success of road maintenance projects in Maysan.

Table 3: The result of Pearson's correlation test

		Management	Technical	Resource
Management	Correlation Coefficient	1	0.677	0.605
	Sig. (2-tailed)	.	0	0
	N	43	43	43
Technical	Correlation Coefficient	0.677	1	0.533
	Sig. (2-tailed)	0	.	0
	N	43	43	43
Resource	Correlation Coefficient	0.605	0.533	1
	Sig. (2-tailed)	0	0	.
	N	43	43	43

5.2 Factors Ranking

This study examined 27 essential factors for the success of road maintenance projects in Maysan province, and based on the statistical tests and their RII score, all of the factors were identified as crucial factors for success.

5.2.1 Ranking of the Management Factors

According to the survey responses of 43 road maintenance engineers, the top 5 management factors contributing to the success of road maintenance projects are as follows:

- Adequate funds
- Timely payment to contractor and employees
- Communication and coordination among parties
- Selection of qualified maintenance contractors
- Senior (top) management support

The study identified and ranked 9 management factors that were found to be effective in road maintenance project success. Table 4 displays the prioritized list of these factors. The

analysis indicated that the organizational culture of maintenance was ranked the least effective among these factors.

Table 4: Ranking of management factors affecting the success of road maintenance projects

Code	Key Success Factor	RII	Rank
F8	Adequate funds	0.874	1
F9	Timely payment to contractor and employees	0.871	2
F6	Communication and coordination among parties	0.856	3
F3	Selection of qualified maintenance contractors	0.847	4
F4	Senior (top) management support	0.833	5
F5	Rapid decision making	0.791	6
F7	Use of Management Information System (MIS)	0.767	7
F2	Clear organizational structure and job description	0.749	8
F1	Organizational culture of maintenance	0.740	9

5.2.2 Ranking of the Technical Factors

Based on the collected responses of 43 road maintenance engineers, the top 5 technical factors in the success of road maintenance projects are:

- Use of advanced technology to detect or evaluate road defects
- Accurate budget & time estimation
- Construction & Maintenance method
- Regular inspection
- Visit the site before designing

Table 5 shows a summary of the ranking of technical factors based on the RII score. The Life Cycle Assessment theory used during the design phase was found to have the least priority in the technical group.

Table 5: Ranking of technical factors affecting the success of road maintenance projects

Code	Key Success Factor	RII	Rank
F16	Use of advanced technology to detect or evaluate road defects	0.865	1
F11	Accurate budget & time estimation	0.851	2
F17	Construction & Maintenance method	0.819	3
F18	Regular inspection	0.819	4
F14	Visit the site before designing	0.800	5
F15	Review of design drawings	0.753	6
F19	Flexibility in different weather conditions	0.749	7
F12	Use of performance-based contracts	0.735	8
F13	Safety hazard identification	0.735	9
F10	Use of Life Cycle Assessment theory at the design stage	0.730	10

https://doi.org/10.31436/iiumej.v25i1.2870

5.2.3 Ranking of the Resource Factors

According to the analysis of 43 questionnaires, the top five resource factors that contribute to the success of road maintenance projects are as follows:

- Quality of materials
- Modern machinery
- Adequate materials and equipment
- Use of road maintenance experts
- Regular maintenance of equipment

Table 6 presents the prioritized ranking of resource factors based on the RII score obtained from the data analysis of 43 questionnaires. It was found that the use of personal protective equipment was ranked lowest among the resource factors.

Table 6: Ranking of resource factors affecting the success of road maintenance projects

Code	Key Success Factor	RII	Rank
F25	Quality of materials	0.870	1
F26	Modern machinery	0.846	2
F24	Adequate materials and equipment	0.837	3
F23	Use of road maintenance experts	0.833	4
F27	Regular maintenance of equipment	0.823	5
F20	Competency of project manager	0.800	6
F21	Adequate training to human resource	0.753	7
F22	Use of personal protective equipment	0.721	8

5.2.4 Top Ten Success Factors

The top 10 key factors that influence the success of road maintenance projects are presented in Table 7. The ranking chart of these factors based on their RII scores is illustrated in Fig. 2. According to the findings of the research, incorporating these 10 factors can lead to more successful road maintenance and repair projects.

Table 7: Ranking of resource factors affecting the success of road maintenance projects

Code	Key Success Factor	Category	RII	Rank
F8	Adequate funds	Management factors (MF)	0.874	1
F9	Timely payment to contractor and employees	Management factors (MF)	0.871	2
F25	Quality of materials	Resource factors (RF)	0.870	3
F16	Use of advanced technology to detect or evaluate road defects	Technical factors (TF)	0.865	4
F6	Communication and coordination among parties	Management factors (MF)	0.856	5
F11	Accurate budget & time estimation	Technical factors (TF)	0.851	6
F3	Selection of qualified maintenance contractors	Management factors (MF)	0.847	7
F26	Modern machinery	Resource factors (RF)	0.846	8
F24	Adequate materials and equipment	Resource factors (RF)	0.837	9
F4	Senior (top) management support	Management factors (MF)	0.833	10

https://doi.org/10.31436/iiumej.v25i1.2870

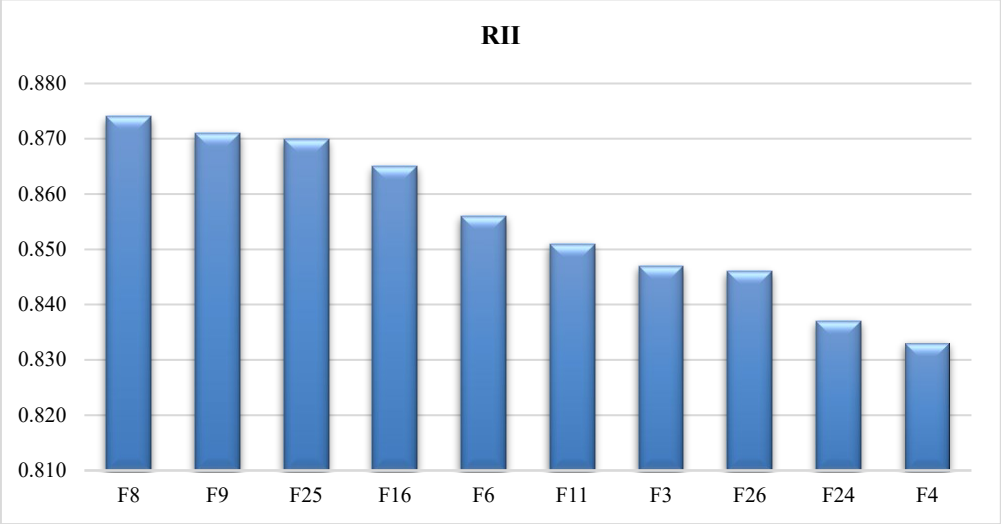

Fig. 2: Bar chart of RII score of top ten key success factors in road maintenance projects in Maysan province.

This research suggests several key factors for successful road maintenance projects, based on the results obtained. The first important factor is the systematic allocation of maintenance budget and timely payment of invoices to contractors and workforce. Negligence in budgeting can cause delays in completing maintenance plans. The second key factor is the quality of equipment and materials used, which requires continuous improvement planning and efforts. The third factor is the use of advanced technologies to accurately detect road defects in a timely manner. The fourth factor is effective communication and coordination among project organizations. The fifth factor is accurate budget estimation for the project to avoid time and cost overruns. The sixth factor is the selection of efficient road maintenance contractors with strict implementation of qualification assessment. The seventh factor is the use of modern and well-maintained machines to increase project productivity. Lastly, continuous monitoring of road maintenance sites is essential to ensure safety and quality improvement.

6. CONCLUSION

The significance of maintenance in systems with components that undergo wear and tear during operation is undeniable. Every year, a significant portion of Iraq's budget is allocated to the construction of new roads, while the maintenance of existing roads is neglected. Apart from the very low maintenance budget, the lack of an efficient road maintenance program has caused the failure of maintenance projects. Achieving success in road maintenance projects necessitates thorough planning. Considering the deterioration of Iraq's road infrastructure and the ineffective utilization of resources in maintenance projects, there is an immediate need to explore the critical factors that contribute to the successful execution of these projects.

The aim of this study is to recognize and prioritize the critical factors that lead to the success of road maintenance projects in Maysan province. To achieve this goal, the researchers initially identified 27 key success factors of road maintenance projects that were classified into three groups: management, technical, and resources, based on previous research. Following this, a questionnaire was developed, consisting of 27 questions, and was circulated among road maintenance engineers in Maysan. The data gathered from the questionnaires underwent statistical tests to assess normality, reliability, and correlation to ensure the precision and accuracy of the data. Finally, the relative importance index (RII) method was employed to

analyze the data, and the results indicated that all 27 key success factors had a significant impact on the success of road maintenance projects in Maysan.

Based on the study, the top 10 critical factors for the success of road maintenance projects are: 1) adequate funds, 2) timely payment to contractors and employees, 3) quality of materials, 4) use of advanced technology to detect or evaluate road defects, 5) communication and coordination among the involved parties, 6) accurate budget and time estimation, 7) selection of qualified maintenance contractors, 8) use of modern machinery, 9) adequate materials and equipment, and 10) senior management support.

To further research road maintenance, it is suggested to explore the dynamic management of road network maintenance through the system dynamics method. Additionally, studying the use of artificial intelligence in road maintenance management, particularly for detecting and evaluating road defects, is also recommended.

ACKNOWLEDGEMENT

The authors would like to acknowledge the respondents of the questionnaires.

REFERENCES

[1] Villalba-Romero F, Liyanage C. (2016) Evaluating success in PPP road projects in Europe: a comparison of performance measurement approaches. Transportation Research Procedia, 14: 372-381.
[2] Ghanbari M, Mehr AG, Nehzat H. (2015) Introducing an intelligent transportation system decision support model for the highways in Iran based on fuzzy logic. International Journal of Soft Computing and Engineering, 5(5): 101-104.
[3] Sewell SJ, Desai SA, Mutsaa E, Lottering RT. (2019) A comparative study of community perceptions regarding the role of roads as a poverty alleviation strategy in rural areas. Journal of Rural Studies, 71: 73-84.
[4] Shrestha KK, Shrestha PP. (2019) Change orders on road maintenance contracts: Causes and preventive measures. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 11(3): 04519009.
[5] Anastasopoulos PC, McCullouch BG, Gkritza K, Mannering FL, Sinha KC. (2010) Cost savings analysis of performance-based contracts for highway maintenance operations. Journal of Infrastructure Systems, 16(4): 251-263.
[6] Mehany MSHM, Guggemos AA. (2016) 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, 2(4): 05016001.
[7] Yarmukhamedov S, Smith AS, Thiebaud JC. (2020) Competitive tendering, ownership and cost efficiency in road maintenance services in Sweden: A panel data analysis. Transportation Research Part A: Policy and Practice, 136: 194-204.
[8] McPherson K, Bennett CR. (2006) Success Factors for Road Management Systems. Transport Notes Series; No. TRN 29. © World Bank, Washington, DC. http://hdl.handle.net/10986/11777 License: CC BY 3.0 IGO.
[9] Shrestha PP, Shrestha KK, Kandie TK. (2017) Effects of change orders on the cost and schedule of rural road maintenance projects. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 9(3): 04517010.
[10] Abdurrahman MA, Samang L, Adisasmita SA, Ramli MI. (2015) Modeling and determining urban road priority rank for maintenance program based on multi-criteria decision making in Makassar City, Indonesia. Traffic, 1, B3.
[11] Nautiyal A, Sharma S. (2021) Condition Based Maintenance Planning of low volume rural roads using GIS. Journal of Cleaner Production, 312: 127649.

[12] Hauashdh A, Jailani J, Rahman IA. (2021) Structural equation model for assessing factors affecting building maintenance success. Journal of Building Engineering, 44: 102680.
[13] Ouma YO, Opudo J, Nyambenya S. (2015) Comparison of fuzzy AHP and fuzzy TOPSIS for road pavement maintenance prioritization: methodological exposition and case study. Advances in Civil Engineering, vol. 2015, 12-28. https://doi.org/10.1155/2015/140189
[14] Kog YC, Loh PK. (2012) Critical success factors for different components of construction projects. Journal of Construction Engineering and Management, 138(4): 520-528.
[15] Toor SUR, Ogunlana SO. (2009) Construction professionals' perception of critical success factors for large-scale construction projects. Construction Innovation, 9(2): 149-167.
[16] Ataei Jafari AM, Ahmadvand AM. (2018) Identification of Pattern used in Determination of Critical Success Factors in ITS Projects, Case Study: Road Maintenance and Transportation Organization. International Journal of Transportation Engineering, 5(4): 319-330.
[17] Li Y, Song H, Sang P, Chen PH, Liu X. (2019) Review of Critical Success Factors (CSFs) for green building projects. Building and Environment, 158: 182-191.
[18] Banihashemi S, Hosseini MR, Golizadeh H, Sankaran S. (2017) Critical success factors (CSFs) for integration of sustainability into construction project management practices in developing countries. International Journal of Project Management, 35(6): 1103-1119.
[19] Ghanbari M, Mojtahedzadeh Asl M. (2021) Proposing a Building Maintenance Management Framework to Increase the Useful Life of the Building. International Journal of Industrial Engineering and Management Science, 8(1): 52-61.
[20] Chen YQ, Zhang YB, Liu JY, Mo P. (2012) Interrelationships among critical success factors of construction projects based on the structural equation model. Journal of Management in Engineering, 28(3): 243-251.
[21] Williams T. (2016. Identifying success factors in construction projects: A case study. Project Management Journal, 47(1): 97-112.
[22] Osei-Kyei R, Chan AP. (2017) Implementing public–private partnership (PPP) policy for public construction projects in Ghana: critical success factors and policy implications. International Journal of Construction Management, 17(2): 113-123.
[23] Tabish SZS, Jha KN. (2011) Identification and evaluation of success factors for public construction projects. Construction Management and Economics, 29(8): 809-823.
[24] Obeng DA, Tuffour YA. (2020) Prospects of alternative funding sourcing for maintenance of road networks in developing countries. Transportation Research Interdisciplinary Perspectives, 8: 100225.
[25] Issa A, Abu-Eisheh S. (2017) Evaluation of implementation of municipal roads' maintenance plans in Palestine: A pilot case study. International Journal of Pavement Research and Technology, 10(5): 454-463.
[26] Dann S, Fry ML. (2009) Benchmarking road safety success: Issues to consider. Australasian marketing journal, 17(4): 226-231.
[27] Aksorn T, Hadikusumo BH. (2008) Critical success factors influencing safety program performance in Thai construction projects. Safety Science, 46(4): 709-727.
[28] Yang J, Shen GQ, Ho M, Drew DS, Chan AP. (2009) Exploring critical success factors for stakeholder management in construction projects. Journal of Civil Engineering and Management, 15(4): 337-348.
[29] Nawi MNM, Lee A, Kamar KAM, Hamid ZA. (2012) Critical success factors for improving team integration in Industrialised Building System (IBS) construction projects: The Malaysian case. Malaysian Construction Research Journal, 10(1): 45-63.
[30] Chan AP, Chan DW, Chiang YH, Tang BS, Chan EH, Ho KS. (2004) Exploring critical success factors for partnering in construction projects. Journal of Construction Engineering and Management, 130(2): 188-198.
[31] Jesus M, Akyildiz S, Bish DR, Krueger DA. (2011) Network-level optimization of pavement maintenance renewal strategies. Advanced Engineering Informatics, 25(4): 699-712.
[32] Jorge D, Ferreira A. (2012) Road network pavement maintenance optimisation using the HDM-4 pavement performance prediction models. International Journal of Pavement Engineering, 13(1): 39-51.

[33] Mahmood M, Mathavan S, Rahman M. (2018) A parameter-free discrete particle swarm algorithm and its application to multi-objective pavement maintenance schemes. Swarm and Evolutionary Computation, 43: 69-87.
[34] Osman MA, Kimutai G. (2019) Critical success factors in the implementation of road projects in Wajir County, Kenya. International Academic Journal of Information Sciences and Project Management, 3(3): 73-104.
[35] Sultana M, Rahman A, Chowdhury S. (2013) A review of performance based maintenance of road infrastructure by contracting. International Journal of Productivity and Performance Management, 62(3): 276-292.
[36] Abu Samra S, Osman H, Hosny O. (2017) Optimal maintenance and rehabilitation policies for performance-based road maintenance contracts. Journal of Performance of Constructed Facilities, 31(1): 04016075.
[37] Shahsavand P, Marefat A, Parchamijalal M. (2018) Causes of delays in construction industry and comparative delay analysis techniques with SCL protocol. Engineering, Construction and Architectural Management, 25(4): 497-533.
[38] Zidane YJT, Andersen B. (2018) The top 10 universal delay factors in construction projects. International Journal of Managing Projects in Business, 11(3): 650-672.