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Identifying the Most Effective Delaying Factors Using FCEM-AHP: A Case Study of Pakistan's Construction Industry

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Abstract
This article seeks to identify the most recurrent and significant delay factors during all phases of construction in Pakistan and to evaluate the top effective delay factors in a case study project. Two research approaches were employed to gain the objective of the study. A questionnaire was designed comprised of 42 delaying factors that were grouped into six categories based on their relativity to the consultant, contractor, client, project manager, financial, and external group. Relative Importance Index (RII) was used to rank the delaying factors. A hybrid of fuzzy comprehensive evaluation method-analytical hierarchy process (FCEM-AHP) was utilized to evaluate the significance of top-ranked delaying factors in the case study project. The findings of the study show that factors from consultants, clients, and external groups such as improper project feasibility study, poor design, unreasonable constraints to clients, financial difficulties, political benefits, and political involvement were considered the most significant delaying factors in the construction industry of Pakistan. This is the first study wherein identified delay factors are further evaluated in a case study project to validate the findings of the study. The study also provides conceivable recommendations to both local and foreign construction firms engaged in Pakistan that could be attained to reduce the impact of delays in construction projects.

Keywords Relative Importance Index (RII) · Fuzzy comprehensive evaluation method (FCEM) · Analytic hierarchy process (AHP) · Construction industry

Introduction

The construction industry plays a crucial role in the economic development of nations by stimulating various other sectors, including power, communication, water resources development, oil, gas, petrochemicals, architecture, and public health.

Extended author information available on the last page of the article

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Recognizing its implication, governments worldwide allocate substantial budgets to construction projects to enhance national infrastructure and public welfare (Gardezi et al., 2014). Despite its importance, the construction industry is plagued by delays, a common global issue that has severe repercussions for all stakeholders involved. These delays often result in financial problems, legal disputes, project hazards, increased costs, decreased quality, reduced productivity, and in extreme cases, the complete abandonment of projects (Agyekum-Mensah & Knight, 2017).

In Pakistan, the construction industry, while being a substantial economic contributor, faces considerable challenges in achieving timely project completion. The amalgamation of numerous stakeholders, including consultants, owners, and contractors, coupled with the complex nature of construction projects, exacerbates these delays. As technological advancements and improved construction management techniques have not fully mitigated these issues, delays remain an integrated risk in the construction process that needs to be addressed (Bagherpour et al., 2020).

Uncertainties inherent in real-life construction projects further complicate management efforts and heighten the risk of delays. Recent approaches in project management have focused on overcoming these uncertainties, yet delays persist as a critical challenge (Mahmoudi et al., 2019). It is essential for all stakeholders to have precise information about delay factors to manage and mitigate these risks effectively and ensure the successful completion of projects (Kenny & Vanissorn, 2012).

Numerous studies have highlighted the prevalence of delays in construction projects globally. For instance, Moura et al. (2007) found that 40% of construction projects fail to meet their intended goals within the specified timeframe due to inadequate delay analysis. In Benin, a statistical study revealed that 22% of 13 projects executed between 1999 and 2005 required extensions of more than 2 years (Akogbe et al., 2013). Sweis (2013) reported that 81.5% of construction projects in Jordan experienced delays between 1990 and 1997. Similarly, Faridi and El-Sayegh (2006) identified that 50% of construction projects in the UAE faced delays. Studies by Doloi et al. (2012) in India, Durdyev et al. (2017) in Cambodia, and Chen et al. (2019) in China have all identified various factors contributing to construction delays. Rashid (2020) specifically investigated the causes and effects of delays in construction projects in Pakistan.

Given the critical impact of delays on the construction industry's efficiency and the broader economy, this study aims to identify the most recurrent and significant delay factors in Pakistan's construction sector. By employing the Relative Importance Index (RII) and a hybrid of the fuzzy comprehensive evaluation method-analytical hierarchy process (FCEM-AHP), this research evaluates these factors and validates the findings through a detailed case study. The objective is to provide actionable recommendations to improve project performance, reduce delays, and optimize costs, thereby enhancing the construction industry's contribution to Pakistan's economic development.

The study focuses on construction projects in the public sector of Pakistan. The public sector was chosen due to its distinct planning, execution, and evaluation mechanisms, which often differ significantly from those in the private sector. Concentrating on public sector projects allows for a detailed analysis and recommendations tailored to the specific challenges and opportunities within this domain. This focus enables a better understanding of the impact of delay factors unique to public construction projects and offers more relevant insights and solutions for stakeholders involved in these projects.

Problem Statement

The construction industry is often seen as the cornerstone of the country's economy; hence, governments spend a substantial amount of money on the construction industry to carry out nationwide mega-projects for public welfare, such as road construction, hospitals, airports, railroads, and schools. Although the construction industry in Pakistan does not operate to its fullest potential, its significance cannot be overlooked. It is the largest sector generating jobs and a significant source of economic growth in the country (Maqsoom & Charoenngam, 2014). Under the umbrella of China's One Belt One Road (OBOR) initiative, the China-Pakistan Economic Corridor (CPEC) agreement in 2015 is improving and boosting Pakistan's construction industry. Construction projects estimated over a billion dollars are currently underway which can be considered a significant factor for industrial and gross domestic product (GDP) growth. The industrial sector accounts for 20.3% of Pakistan's GDP, 12% of which belongs to the construction sector (Ullah et al., 2017). The Pakistan Economic Survey of 2018 reported a growth rate of 9.13% in the construction sector. Although Pakistan has much-anticipated spending on the construction industry, it still faces several problems, including schedule delays and cost overruns (Farooqui et al., 2012).

In the literature, numerous studies have been carried out regarding the identification of delay factors in many developed and developing countries. However, keeping in mind the aforementioned importance of the construction industry to Pakistan's economy, research on the identification of delay factors in Pakistan is very limited. Consequently, it is necessary to research this area to determine the factors contributing to delays in Pakistan's construction industry.

To address the delay problems of Pakistan's construction industry, the contributions of the current study can be summarized as follows:

- Identifying the most chronic delaying factors and highlighting their importance in Pakistan's construction industry.
- Evaluating the top most effective delaying factors identified in this study, in a case study project to find out its significance.
- Providing recommendations to decision-makers with the purpose of either avoiding entirely or diminishing delay risk in Pakistan's construction projects.

The findings of this study will help the stakeholders to be aware of the uncertain factors that can result in the delay of the project right from the start. It will be easy for them to manage these factors proactively and efficiently, which will help them to save their time and budget.

Literature Review

Construction delays might embark on a fundamental reason and can lead to a mixture of interconnected complex disputes, which can affect contract agreements. It usually affects the entire lifespan of the project, resulting in legal disputes and conflicts (Marzouk & El-Rasas, 2014).

Significance of this Work

Focusing on the unique challenges faced by Pakistan's construction industry, this research fills a critical gap in the literature by providing context-specific insights. Unlike studies centered on more developed regions, it considers the socio-economic and political conditions unique to Pakistan. Employing a hybrid methodology that combines the Relative Importance Index (RII) and the fuzzy comprehensive evaluation method-analytical hierarchy process (FCEM-AHP), this research offers a nuanced understanding of delay factors with enhanced robustness and depth.

Furthermore, the empirical validation through a detailed case study ensures that the findings are not only theoretically sound but also practically relevant. This study's actionable recommendations are tailored to the local context, making them highly valuable for industry practitioners and policymakers aiming to improve project performance and mitigate delays. By addressing these pervasive issues, this research contributes to the broader economic development goals of Pakistan, highlighting the importance of efficient project management in the construction sector.

Importance of Construction Industry

The construction industry acts as a catalytic agent that stimulates financial development through the inter-divisional relationship between construction and other divisions, which sort out the domination of the construction division in the economy (Giang & Sui Pheng, 2011). For instance, the Indian construction industry, which is the second-largest industry, contributes around 8% to the GDP. Salifu-Asubay and Mensah (2015) concluded their study that in most countries, the construction industry is aiding 5 to 10% of the GDP. The Cambodian construction sector accounts for approximately 30.1% of the country's economy (CIPD, 2015). Similarly, according to the 2017 Global Power of Construction Report Canada, being the fifth-largest construction sector globally contributes 7% to Canada's GDP (Deloitte, 2019). Furthermore, the list of a few countries' average GDPs from the construction sector is shown in Table 1.

The construction industry is the main contributor to the GDP of Pakistan, yet its real potential is not fully explored. Today, construction is the second largest sector in Pakistan's economy after agriculture. According to Pakistan's Financial Survey 2016–2017, the construction sector has shown a steady growth of 9% in the

Table 1 Average GDP from construction industry

Country	Average gross domestic product (GDP)	Duration
USA	630.10 USD billion	2005–2019
China	163.91 USD billion	1992–2019
UK	31.30 USD billion	1990–2019
India	31.12 USD billion	2011–2019
Russia	12.98 USD billion	2003–2019
Pakistan	1.59 USD billion	2006–2018

outgoing year and added 2.7% to Pakistan's GDP, lower than the 14.6% increase in 2016, but much higher than the average growth of the past 5 years.

Categorization and Types of Construction Delays

Delay factors are broadly categorized into two groups. Internal delays arise within the project stakeholders (client, contractor, and consultants), while external delays occur due to unforeseen events. These events could be natural disasters, weather conditions, issues related to government, material supplies, and all other unpredicted events. Trauner et al. (2009) categorized delays into four significant groups critical or non-critical, excusable or non-excusable, compensable or non-compensable, and concurrent or non-concurrent delays. Critical delays prevent the contractor from completing the project within the scheduled time limit as stated in the contract, and delays which do not affect the completion of the project are non-critical. Excusable delays triggered by external events include acts of God (flood, earthquake, and all other climatic conditions), design changes, errors and omissions in plans and specifications, and intervention by outside agencies. Non-excusable delays caused by foreseeable events that are within the contractor's control are the contractor's responsibility (Ullah et al., 2024). The contractor will not be given any compensation for this type of delay. A delay where a contractor has the authority to ask for time allowance and surplus compensation is a compensable delay. Non-compensable delays are excusable delays where the contractor has the authority to ask for an extension of time only; they are not entitled to any extra compensation from the client. According to the Association for the Advancement of Cost Engineering (AACE), "When more than one type of delays coincides within the same project duration, and each delay can affect the final deadline of the project, these delays are called concurrent delays. Non-concurrent delays on the hand is condition where delays do not coincide with each other."

Factors Contributing to Construction Delays

The sources considered for collecting primary data related to factors contributing to construction delay are books, conference papers, journal papers, academic dissertations, and interviews with professionals in the construction field. Based on geographical, technological, and cultural limitations, every country has different delay factors. There are possibilities of some delay factors being measured as most significant in one country but not considered delay factors at all in other countries. In this study, we attempted to categorize the identified factors into 6 broad groups keeping in mind all aspects of the construction industry of Pakistan. These groups are consultants, contractors, clients, financial, project managers, and external delaying factors.

Naqash and Singla (2019) reckoned "change in material price," "lack of project management experts," "design errors," "payment delays," and "corruption" as main delay factors for construction. Algheth and Sayuti (2019) analyzed UAE building projects and concluded that "variation orders," "contractor's funding problems," "contractors site management expertise," and "interruptions by customers in decision making" are the factors which aid in the obstruction of construction projects. Roy et al. (2018) analyzed Indian government construction projects and stated that "client late payment," "delay in payment to the contractors," and "client's ability to pass the bills" were three significant factors that aid in the setback of projects. Chen et al., (2019) and Ullah et al., (2019) investigated grain bin construction projects in China and concluded that significant delay factors are from the contractor's category, i.e., "equipment shortage," "problems with subcontractors," "poor communication among parties," "inadequate design team," and "frequent change orders." Al-Emad et al. (2017) examined the Makkah construction industry and were of the view that "improper planning and scheduling," "shortage of workforce," "progress payment delays," "poor contract management," and "poor coordination among parties" are the primary obstructions in construction projects. Gardezi et al. (2014) were of the view that factors related to consultants are "poor site engineer," "inadequate consultant knowledge," "incompetent site staff," "consultant slow decision making," "lack of relevant documentation," and "poor communication in terms of information sharing." Rashid (2020) addressed the delay factors and their impact on construction projects. The author selected 172 experts from 37 construction companies to find and analyze the delay factors. The study was established based on a cause-and-effect approach while the causes were "contractor-related factors," "client-related factors," "consultant-related factors," "materials-related factors," "equipment-related factors," "labour-related factors," and "general equipment conditions," whereas the effects were including cost overrun, time overrun, litigation, and abandonment. Kadry et al. (2017) examined the main causes of delays in the construction project in the context of high geopolitical risks. They also studied the relationship between the causes of delays and the characteristics of the country. The study selected 18 experts from 36 construction projects to provide the input data for the research. Based on their research, the delays have been categorized into three major groups including "non-executable delays," "executable and compensable delays," and "executable non-compensable delays." Viles et al. (2019) attempted to employ quantitative analysis to identify the causes of the delays in construction projects. Their study has been established based on a literature review of 47 papers, including 1057 delay factors. They have considered five regions in the paper consist of Europe, Africa, America, Asia, and Turkey. Finally, they have illustrated Pareto charts by region which made their research impressive. Sanni-Anibire et al., (2020a, 2020b) have provided a global review of delay factors in construction projects based on the conducted studies from 15 years. They have identified 36 relevant factors, yet they stated that there are five critical factors including "contractor's financial difficulties," "delay in the approval of completed work," "slow delivery of materials," "poor site organization and coordination between various parties," and "poor planning of resources and duration estimation/scheduling." Hossain et al. (2019) explored the delay factors of different construction projects in Kazakhstan. The study identified 55 factors from the literature review and interviews which were relevant to different construction projects. They mentioned that this review could facilitate project managers for a better understanding of the reasons behind delays and controlling the projects. Perera et al. (2019) tried to enhance the success level of the delay claims which were submitted by the contractors in the country Sri Lanka. They collect the data using both qualitative and quantitative analyses from 248 projects. Heravi and Mohammadian (2019) evaluated the implementation of urban projects in terms of cost and time in Iran. They considered 72 projects of different sizes including small, medium, and large. They found that the cost performance in urban road projects is much better than in building projects. Sanni-Anibire et al., (2020a, 2020b) addressed the delay risk assessment with the aid of machine learning in tall building projects. They have provided a database including 48 factors while "slowness in decision making," "delay in sub-contractors work," "structural engineer's late issuance of instruction," and "waiting for approval of shop drawings and material samples" were the most common among them. Yaseen et al. (2020) proposed a hybrid model with the aid of the random forest classifier and genetic algorithm so as to predict the delays in the projects. It is interesting to mention that they have trained the model utilizing the delays factors in the previous projects. The accuracy of the proposed model was almost 91.67% which seems suitable to employ in construction projects. The current study aims to and rank the most important delay factors in Pakistan employing a hybrid approach named FCEM-AHP. In the next section, we intend to explain the methodology first.

Research Methodology and Design

The methodology conducted in this study is designed to attain the aim and objective of this research. This study includes two sections; the first section contains a questionnaire survey using the RII techniques to identify the most effective delay factors in Pakistan's construction industry. In the second section, the fuzzy comprehensive evaluation method-analytical hierarchy process (FCEM-AHP) is used in a specific case study project to evaluate delay factors identified in the first section. Both the RII and FCEM-AHP methods have been used separately in numerous studies such as Gamil and Abdul Rahman (2020), Hossain et al. (2019), and Perera et al. (2019) and Li et al. (2017) and Xi and Qin (2013), respectively. Keeping in mind the objective of the study, the authors, therefore, suggest using RII for factors ranking and utilization of the FCEM-AHP method for further evaluation of analyzed and ranked delay factors. The workflow diagram for the study is illustrated in Fig. 1.

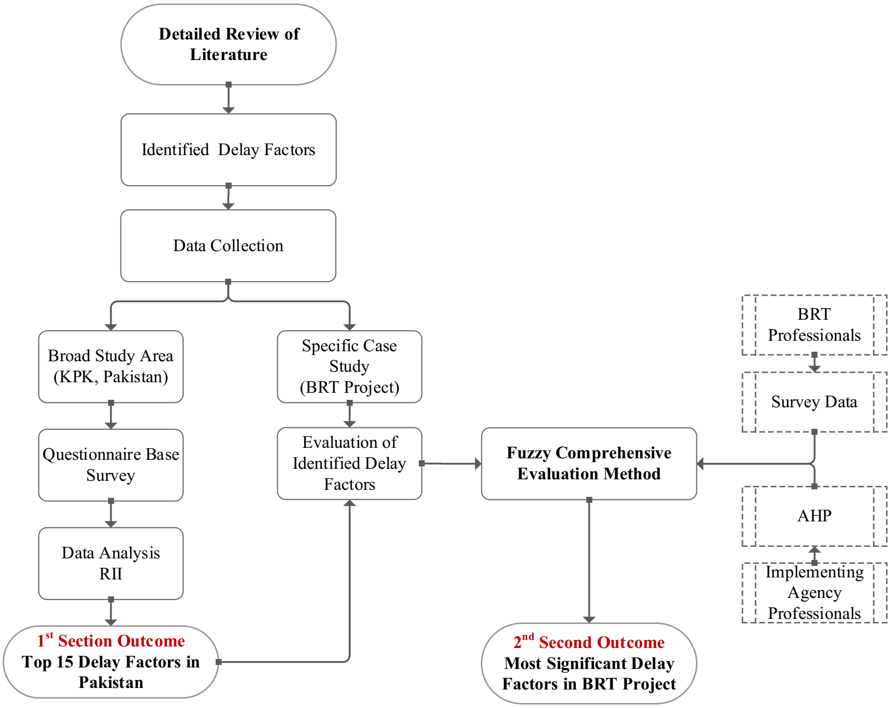

Fig. 1 Workflow diagram

Delay Factors and Ranking Methodology

This section includes the identification and ranking of delaying factors in Pakistan's construction industry. For this study, the author suggested evaluating 42 delay factors that were further subdivided into six categories, as shown in Fig. 2.

On the basis of a detailed literature review and considering the purpose of this study, questions were formulated to avoid a wide range of weaknesses associated with the questionnaire survey. Part A of the questionnaire was designed to receive demographic information from the respondents, and in Part B, the respondents were requested to rank delaying factors. A 5-point Likert scale (1 = least effective, 2 = low effective, 3 = neutral, 4 = effective, 5 = most effective) was used for data collection from respondents to rank the causes of construction delaying factors.

Major consulting and constructing firms and clients of various large buildings in Pakistan were the primary targets for data collection. The targeted professionals were architects, designers, engineers, and project managers from these consulting and construction firms. The firms were selected, bearing in mind that they are registered from various government institutions like the Pakistan Engineering Council (PEC). Keeping in mind the quantitative nature and objectives of the study, two sampling techniques were used. After obtaining a list of consultants, contractors, and clients, random sampling was used to shortlist contractors and consultants. The clients and owners were selected based on the snowball sampling technique. A total of 50 respondents were

Fig. 2 Identified delaying factors from experts' judgement

shortlisted for this study; however, selecting a population with vast experience and competency level aids in shielding the weaknesses. By the end of the time allocated for the data collection 40 (80%), usable questionnaires were received, which were considered adequate for the study.

Relative Importance Index (RII)

The RII analysis technique is utilized in this study, which ranks the factors according to the degree of their effectiveness, as indicated by the respondents. The RII is computed using Eq. 1 as:

$$\mathrm{RII} = \frac{\sum W}{N * A} \tag{1}$$

where W depicts the weight given to each factor by respondents (ranges from 1 to 5), A depicts the highest weight, and N depicts the total number of respondents.

FCEM-AHP Methodology

This section includes the evaluation of the delay factors already identified in the case study project using the FCEM-AHP method. Since the FCEM-AHP differs from the traditional questionnaire-based survey, it involves the collection of questionnaire-based survey data from contractors and subcontractors directly involved in the Bus Rapid Transit (BRT) project (case study) and includes expert opinion to measure the weight of the delay factors in the BRT project. Thirty professionals from the BRT project including site engineers, project manager, construction manager, and procurement manager of contractors and subcontractors were the primary targets for data collection. The respondents were asked to rank factors based on their significance to the BRT project. For expert opinion, interviews were conducted with experts from BRT executing and implementing agencies, Khyber Pakhtunkhwa Urban Mobility Authority (KPUMA), and Peshawar Development Authority (PDA). The interviewers were fully aware of the construction process as they were bound to pay routine site visits. The experts were instructed about the scope and objectives of the study before requesting their opinion.

Fuzzy Comprehensive Evaluation Method (FCEM)

Fuzzy mathematics was born in 1965; its founder is Professor Chad (L. A. Zadeh). The FCEM uses the synthesis principle of fuzzy relations to quantify factors that have no clear boundaries (Hendiani et al., 2020). It evaluates the target comprehensively from the perspectives of various factors, as explained in the following steps:

1. Determining evaluation set—It involves the selection of all the factors in a set that are intended to be evaluated. A set of evaluation factors with n members is written in Eq. 2.
2. Determining appraisal set—It is composed of evaluation ranks or remarks for the effectiveness of delaying factors. The appraisal set is shown in Eq. 3.
3. Determining fuzzy evaluation matrix—This matrix defines the relation of U to V. The fuzzy evaluation matrix R of every factor from the index set U to the appraisal set V can be determined, as shown in Eq. 4.
4. Determining weight for evaluation factors—It provides the proportion of each evaluation factor in an evaluation system based on its significance and importance. The weight set is shown in Eq. 5.

There are different ways to determine the weight for evaluation factors in set U, such as expert evaluation method, entropy method, least squares estimation, and analytic hierarchy process (AHP). The AHP method is used in this study because instead of asking experts to give weight to a particular evaluation factor directly, they will be asked to rate the factors relatively based on their importance. The

Table 2 Saaty's evaluation table

Scale	Degree of preferences
1	Equally important
3	Moderate importance of one factor over another
5	Strong or essential importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Values for inverse comparison

Table 3 Saaty's consistency ratio table

n	1	2	3	4	5	6	7	8	9	10
R.I	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.14	1.46	1.49

n order of matrix

AHP was created by Thomas L. Satty in the 1970s and is widely used in solving multi-criteria decision problems and project management (Feylizadeh et al., 2018). AHP procedure is summarized below:

- Create the hierarchical structure figure for the decision-making problem in hand, which contains the goal to achieve.
- Develop a pairwise comparison matrix based on expert judgment. Each of the judgments is assigned a number on the scale (adapted from Saaty), as shown in Table 2. The factors are judged based on the relative importance of a construction delay.
- Calculate the Eigen vector for each matrix.
- Check the consistency of the judgments. The constancy ratio (C.R) is determined by the Random Index (R.I) dividing the Consistency Index (C.I). Saaty suggests that if the C.R ratio exceeds 0.1, the set of judgments may be unreliable. A C.R of 0 depicts that the judgments are entirely consistent. Table 3 shows Saaty's consistency ratio.
- Determining results of evaluation—Complex calculation between weights of evaluation factors *W* and fuzzy evaluation matrix *R* should be carried out to obtain the final result of a comprehensive evaluation, as shown in Eq. 6. Figure 3 demonstrates the step-by-step process of FCEM.

$$U = \{U_1, U_2, U_3, \dots ..U_n\} \tag{2}$$

$$V = \{V_1, V_2, V_3...., V_m\} \tag{3}$$

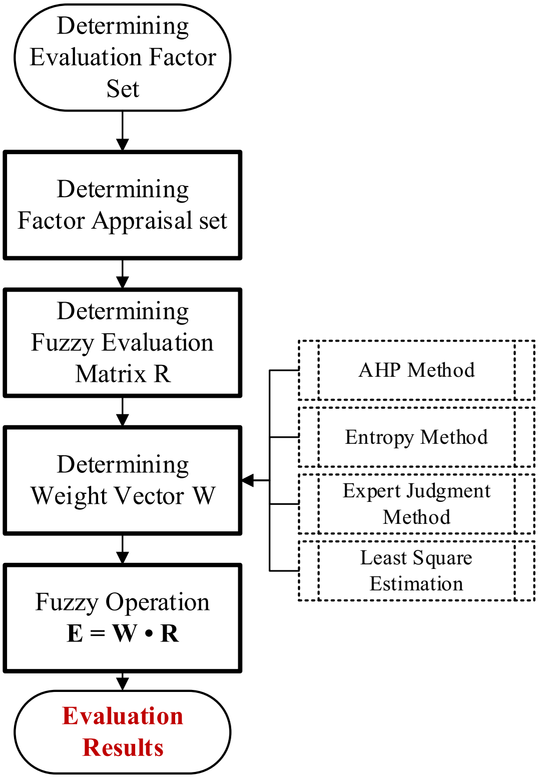

Fig. 3 FCEM process

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} \tag{4}$$

$$W = \{W_1, W_2, W_3, \ldots ..W_n\} \tag{5}$$

$$E = W * R = \{e_1, e_2, e_3, \ldots .e_m\} \tag{6}$$

Delay Factors and Prioritizing

This section includes the extraction of information from the analysis and interpretation of the data collected, as described in the preceding section.

Analysis and Ranking of Delaying Factors

This study uses MS-Excel and RII to calculate the frequency of the respondents and rank the factors based on their significance, respectively. Table 4 illustrates the demographic details of the respondents. Additionally, a detailed analysis of each group is given in Tables 5, 6, 7, 8, 9, and 10.

The study showed that the consulting group's aggregated RII is 0.677 and ranked fourth in terms of questionnaire respondents. Table 5 indicates that the critical factors related to the consultant group contributing to construction delay were "inadequate experience of a consultant" (RII = 0.832), "poor design" (RII = 0.805), and "improper project feasibility study" (RII = 0.748). On the other hand, "slow response and inadequate inspection," "incomplete drawings," and "delay in design" were considered insignificant with the least RII of 0.563, 0.560, and 0.555, respectively.

The aggregate RII of the contractor group is 0.678. Table 6 presents that the most significant factors in contractor groups were "contractor financial difficulties" (RII = 0.842), "strikes" (RII = 0.772), "insufficient number of equipment"

Table 4 Respondent's demographic information

Demographic data	Frequency	Percentage
Respondents role		
Site engineer	14	35.0%
Construction manager	12	30.0%
Other	9	22.5%
Project manager	5	12.5%
Respondents types		
Contractor	18	45.0%
Consultant	15	37.5%
Client	7	22.5%
Respondents experience		
1–5 years	16	40.0%
6–10 years	11	27.5%
11–15 years	10	25.0%
16–20 years	2	5.0%
20 > years	1	2.5%
Duration of project delay		
0–2 years	31	77.5%
3–4 years	4	10.0%
5–6 years	3	7.5%
6–8 years	2	5.0%
Type of delay respondents experienced		
Excusable-compensable delay	15	37.5%
Excusable-non compensable delay	13	32.5%
Concurrent delay	7	17.5%
Non-excusable delay	5	12.5%

Table 5 Ranking of consultant-related factors

Delay factors	Relative Importance Index				Avg	Rank
	Consultant	Contractor	Client	PM		
Inadequate consultant experience	0.83	0.86	0.80	0.84	0.832	1
Poor design	0.80	0.84	0.78	0.80	0.805	2
Improper project feasibility study	0.85	0.72	0.66	0.76	0.748	3
Slow response and poor inspection	0.57	0.60	0.56	0.52	0.563	4
Incomplete drawings	0.48	0.62	0.58	0.56	0.560	5
Delay in design	0.36	0.60	0.66	0.60	0.555	6

Table 6 Ranking of contractor-related factors

Delay factors	Relative Importance Index				Avg	Rank
	Consultant	Contractor	Client	PM		
Contractor financial difficulties	0.87	0.86	0.80	0.84	0.842	1
Strikes	0.79	0.78	0.76	0.76	0.772	2
Insufficient number of equipment	0.69	0.80	0.76	0.72	0.743	3
Shortage of skilled labor	0.71	0.80	0.74	0.72	0.742	4
Inaccurate site investigation	0.72	0.72	0.68	0.64	0.690	5
Slow mobilization of labor	0.63	0.74	0.68	0.68	0.682	6
Inadequate contractor experience	0.59	0.68	0.62	0.76	0.662	7
Late delivery of material	0.65	0.66	0.62	0.68	0.653	8
Low motivation	0.52	0.74	0.70	0.60	0.640	9
Equipment allocation problem	0.64	0.66	0.64	0.60	0.635	10
Inadequate modern machinery	0.68	0.60	0.56	0.56	0.600	11
Labor productivity	0.52	0.62	0.58	0.64	0.590	12
Inappropriate construction method	0.60	0.62	0.50	0.52	0.560	13

Table 7 Ranking of client-related factors

Delay factors	Relative Importance Index				Avg	Rank
	Consultant	Contractor	Client	PM		
Slow decision making by client	0.85	0.86	0.80	0.84	0.838	1
Client financial difficulties	0.87	0.86	0.82	0.80	0.837	2
Unreasonable constraints to client	0.55	0.84	0.78	0.84	0.752	3
Change orders	0.80	0.72	0.70	0.72	0.735	4
Lowest bidding procedure	0.69	0.40	0.46	0.48	0.508	5

Table 8 Ranking of project manager–related factors

Delay factors	Relative Importance Index				Avg	Rank
	Consultant	Contractor	Client	PM		
Inaccurate cost estimation	0.88	0.86	0.88	0.84	0.865	1
Incompetent project team	0.87	0.86	0.80	0.84	0.842	2
Inaccurate time estimation	0.96	0.80	0.78	0.80	0.835	3
Lack of communication	0.87	0.80	0.82	0.80	0.822	4
Improper scheduling	0.75	0.78	0.74	0.56	0.707	5
Poor site management	0.72	0.74	0.68	0.64	0.695	6
Inadequate project management assistance	0.43	0.80	0.70	0.84	0.692	7
Improper planning	0.73	0.76	0.64	0.60	0.683	8

Table 9 Ranking of financial-related factors

Delay factors	Relative Importance Index				Avg	Rank
	Consultant	Contractor	Client	PM		
Wrong fund allocation	0.67	0.84	0.80	0.80	0.777	1
Monthly payment difficulties	0.40	0.80	0.74	0.80	0.685	2
Prices fluctuations	0.41	0.76	0.70	0.72	0.648	3
High interest rate	0.52	0.40	0.50	0.64	0.515	4

Table 10 Ranking of external factors

Delay factors	Relative Importance Index				Avg	Rank
	Consultant	Contractor	Client	PM		
Political benefits	0.80	0.74	0.80	0.80	0.785	1
Politicians involvement	0.73	0.74	0.78	0.84	0.773	2
Change in government laws	0.77	0.70	0.66	0.64	0.693	3
Terrorism	0.57	0.64	0.54	0.72	0.618	4
Government unsupportive policies	0.40	0.72	0.60	0.68	0.600	5
Weather	0.29	0.66	0.54	0.60	0.523	6

(RII = 0.743), and "shortage of skilled labor" (RII = 0.742). Furthermore, "inaccurate site investigation" (RII = 0.690), "slow mobilization" (RII = 0.682), "inadequate contractor experience" (RII = 0.662), and "low delivery of materials" (RII = 0.653) were ranked on a different significance level. On the other hand, "equipment allocation problems" (RII = 0.635), "inadequate modern machinery" (RII = 0.600), "labor productivity" (RII = 0.590), and "inappropriate construction method” (RII = 0.560) were considered the least significant among all the delaying factors related to contractors.

The client-related delay factors were placed second among other groups with an aggregate RII of 0.734. Table 7 depicts that slow decision making by clients (RII = 0.838), and client financial difficulties (RII = 0.837) were the most significant delay factors in this group. Additionally, unreasonable constraints to the client (RII = 0.752), change orders (RII = 0.735), and lowest bidding procedure (RII = 0.508) were placed less significant by the respondents as compared to problems related to finance.

In this study, the aggregate RII of the factors related to the project manager was 0.768 and placed first among other groups. The investigation of Table 8 portrays that “inaccurate cost estimation” (RII = 0.865), “incompetent project team” (RII = 0.842), “inaccurate time estimation” (RII = 0.835), and “lack of communication” (RII = 0.822) were considered most significant in the project manager group. Besides, “improper scheduling” (RII = 0.707), “poor site management” (RII = 0.695), “inaccurate project management assistance” (RII = 0.692), and “improper planning” (RII = 0.683) were also ranked on the different significance level.

The delaying factors related to the financial group were relatively less significant with an aggregate RII of 0.656 and placed fifth among other groups. Besides, Table 9 shows that “wrong fund allocation” (RII = 0.777), “monthly payment difficulties” (RII = 0.685), and “price fluctuations” (RII = 0.648) were considered the leading delaying factors in this group. On the other hand, “high-interest rate” was ranked least significant among the delaying factors related to financial issues.

According to the findings of this study, the factors related to external groups were less significant among all other groups with an aggregate RII of 0.523. The data in Table 10 depicts that “political benefits” (RII = 0.785), “political involvement” (RII = 0.773), and “changes in government laws” (RII = 0.693) were the most crucial factors in this group. On the other hand, “terrorism” (RII = 0.618), “government unsupportive policies” (RII = 0.600), and “weather conditions” (RII = 0.523) were the least important factors in this group. The most effective delaying factors in the Pakistan construction industry are shown in Table 11.

Comparative Analysis

For the validation of the findings of this study, a comparative analysis was conducted with the preceding studies. Table 12 relates the most significant delay factors of this study to the findings of recent research published in this domain. For this purpose, articles portraying the causes of delaying factors in seven countries, namely, Yemen, India, Malaysia, the United Arab Emirates, Saudi Arabia, Egypt, and Burkina Faso were selected and compared. Based on different terminologies and aspects considered in previous studies, a precise comparison was not possible. In Table 12, the numbers after the delay factors in previous studies indicate its ranking in the current study. If that number of any particular delay factors from a previous study is smaller than its ranking, it shows that delay factors in the current study are more relevant

Table 11 Top 15 delaying factors in Pakistan's construction industry

S. no	Q. no	Delay factor	Group	RII (%)	Rank
1	32	Inaccurate cost estimation	PM group	86.50	1
2	18	Contractor financial difficulties	Contractor group	84.17	2
3	29	Incompetent project team	PM group	84.17	2
4	21	Slow decision making by client	Client group	83.84	3
5	22	Client financial difficulties	Client group	83.67	4
6	31	Inaccurate time estimation	PM group	83.50	5
7	1	Inadequate consultant experience	Consultant group	83. 17	6
8	36	Lack of communication	PM group	82.17	7
9	2	Poor design	Consultant group	80.50	8
10	40	Political benefits	External group	78.50	9
11	25	Wrong funds allocation	Financial group	77.67	10
12	42	Political involvement	External group	77.34	11
13	11	Strikes	Contractor group	77.17	12
14	23	Unreasonable constraints to client	Client group	75.17	13
15	6	Improper project feasibility study	Consultant group	74.84	14
16	13	Insufficient number of equipment	Contractor group	74.34	15

and vice versa. Numerous delay factors are found to be less critical in this study than in previous studies, such as "inaccurate time estimation," "poor design," and "client financial difficulties" which were highly ranked in previous studies. On the other hand, delay factors such as "inaccurate cost estimation" and "political benefits" were not considered among the most significant factors in previous studies. In particular, the "political benefits" delay factor refers to the political scenario in Pakistan, where many constructions projects experience delays due to the inauguration of projects for political means without proper planning.

Evaluation of Most Effective Factors in Case Study Project Utilizing FCEM-AHP

Case Study Project

Peshawar BRT is a bus rapid transit project currently under construction by the executing agency, Khyber Pakhtunkhwa Urban Mobility Authority (KPUMA), and implementing agencies, Peshawar Development Authority and Trans Peshawar (urban mobility company). The project is in Peshawar, the capital of Pakistan's Khyber Pakhtunkhwa (KPK) province. The project will help to develop a sustainable urban transportation system in Peshawar, and it will directly benefit a population of 0.5 million.

The BRT project was inaugurated in October 2017, and the estimated deadline for the project was April 2018, with a total cost of Rupees 48 billion. Executive Committee of the National Economic Council (ECNEC) then reviewed the cost of

Table 12 Comparison of delay factors with previous studies

Rank	Pakistan (current study)	Yemen (Alaghbari et al., 2018)	India (Doloi et al., 2012)	Malaysia (Cheong Yong & Emma Mustaffa, 2012)	UAE (Mpofu et al., 2017)	Saudi Arabia (Abdellatif & Alshibani, 2019)	Egypt (Aziz & Abdel-Hakam, 2016)	Burkina Faso (Bagaya & Song, 2016)
1	Inaccurate cost estimation	Delay in receiving progress payment	Delay in material delivery by vendors	Financial capability (2, 5)	Unrealistic contract duration imposed by client (6)	Difficulties in financing project by contractor (2, 5)	Owner financial problem (5)	Financial capability of contractor (2)
2	Contractor financial difficulties	Client financial difficulties (5)	Non-availability of drawing/design on time (9)	Control of subcontractors works	Incomplete design at the time of tender (9)	Delay in progress payments	Shortage in equipment	Financial difficulties of owner (5)
3	Incompetent project team	Inadequate experience of client/contractor (8)	Financial constraints of contractor (2)	Consultant competence (7)	Too many scope changes and change orders (9)	Delay in approving design documents	Inadequate contractor experience	Equipment availability
4	Slow decision making by client	Poor site management and supervision (3)	Increase in scope of work	Cooperation in solving problems	Inadequate planning and scheduling	Slowness in decision making (4)	Construction materials shortage	Slow payments of completed work
5	Client financial difficulties	Lack of cash for project implementation	Obtaining permissions from local authorities	Team leader competence (3)	Poor project planning and control	Inadequate contractor experience	Equipment failure	Poor subcontractor performance
6	Inaccurate time estimation	Slow decision making and instruction (4)	Delay in material to be supplied by the owner	Consultant commitment (7)	Delay in obtaining permit/ approval from municipality Authorities	Ineffective project planning and scheduling	Design errors (9)	Inadequate planning and scheduling
7	Inadequate consultant experience	Delay in payments for completed work	Slow decision from owner (4)	Skillful workers	Poor labor productivity problems	Poor site management and supervision (3)	Mistakes in soil investigation	Weather condition

Table 12 (continued)

Rank	Pakistan (current study)	Yemen (Alaghbari et al., 2018)	India (Doloi et al., 2012)	Malaysia (Cheong Yong & Emma Mustaffa, 2012)	UAE (Mpofu et al., 2017)	Saudi Arabia (Abdellatif & Alshibani, 2019)	Egypt (Aziz & Abdel-Hakam, 2016)	Burkina Faso (Bagaya & Song, 2016)
8	Lack of communication	Weak planning, control, and management by contractors	Poor site management and supervision (3)	Adequacy of design details and specifications (9)	Slowness in decision making process by owner (4)	Poor communication and coordination with other parties (8)	Poor subcontractor performance	Low bidding of contractor
9	Poor design	Inadequate time period estimation (6)	Delay in materials procurement by contractor	Industry-related issues (availability of resources)	Design changes (9)	Design changes by owner or agent during execution/change orders	Rework due to change of design	Unfavorable site conditions
10	Political benefits	Lack of skilled labors	Unrealistic time schedule imposed in contract (6)	Communication among project stakeholders (8)	Inadequate site management, monitoring and control (3)	Insufficient data collection and work preparation	Poor site management (3)	Poor site management and supervision (3)

the project Rupees 68.4 billion with June 2019 as the specified date of completion of the project. After missing six deadlines, the project is now expected to be completed by the end of 2019 with an estimated cost of Rupees 71 billion, although construction on bus depots will be completed in 2020 (Ali, 2019). The salient features of the BRT project are shown in Fig. 4.

The BRT project has been delayed for almost 2 years, and the construction of the project is still in process. Therefore, this study was selected to identify delay factors significantly.

Calculation and Procedure for Fuzzy Evaluation Method

The steps taken for the calculation of the fuzzy evaluation method are discussed in the section below:

1. Determining Evaluation Factor Set—Six evaluation factor sets were considered one for each group. Sets of evaluation factors can be written as Eq. 2, for example:

$$U_1 = \{u_{11}, u_{12}, u_{13}\}, U_2 = \{u_{21}, u_{22}, u_{23}\}, U_3 = \{u_{31}, u_{32}, u_{33}\}, U_4 = \{u_{41}, u_{42}, u_{43}, u_{44}\}, U_5 = \{u_{51}\}, U_6 = \{u_{61}, u_{62}\}$$

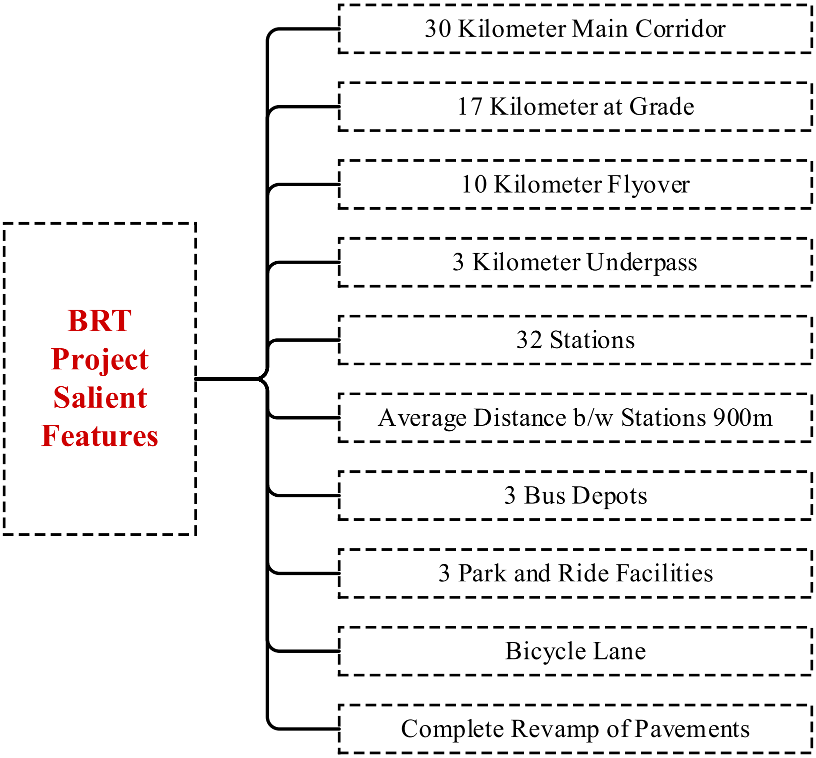

Fig. 4 BRT project features

2. Determining Appraisal Set—Four different appraisal levels were considered for evaluation based on Eq. 3. For example, V = most significant, moderate significant, least significant, not significant.
3. Determining fuzzy evaluation matrix—For the fuzzy evaluation matrix, the questionnaires were distributed among 30 professionals. These professionals independently decide the level of factors to the BRT project in terms of construction delay. After collecting data from the professionals, the actual survey result is shown in Table 13.

After calculation, the result of a single evaluation factor can be written as, $R11 = (0.60, 0.23, 0.03, \text{and } 0.13)$, using Eq. 7 as:

$$r = n/N \tag{7}$$

where r = degree of membership from evaluation factor set (U) to appraisal set (V), n = number of respondent's comment on the grade of appraisal set, and N = number of the total sample.

Table 13 Actual survey data for fuzzy evaluation

Groups	Delaying factors	Most significant	Moderate significant	Least significant	Not significant
Consultant (U_1)	Inadequate consultant experience (u_{11})	18	7	1	4
	Poor Design (u_{12})	20	5	3	2
	Improper project feasibility study (u_{13})	24	3	1	2
Contractor (U_2)	strikes (u_{21})	4	6	15	5
	Insufficient number of equipment (u_{22})	6	5	7	12
	Contractor financial difficulties (u_{23})	5	9	15	1
Client (U_3)	Slow decision making by client (u_{31})	10	10	5	5
	Client financial difficulties (u_{32})	12	6	10	2
	Unreasonable constraints to client (u_{33})	17	6	3	4
Project manager (U_4)	Incompetent project team (u_{41})	17	10	2	1
	Inaccurate time estimation (u_{42})	15	8	4	3
	Inaccurate cost estimation (u_{43})	21	5	3	1
	Lack of communication (u_{44})	14	8	5	3
Finance (U_5)	Wrong funds allocation (u_{51})	2	3	10	15
External (U_6)	Political involvement (u_{61})	21	7	1	1
	Political benefits (u_{62})	18	5	6	1

The fuzzy evaluation matrix for all delay groups and subgroups are mentioned in Eqs. 8, 9, 10, 11, 12 and 13 as:

$$R_1 = \begin{bmatrix} R_{11} \\ R_{12} \\ R_{13} \end{bmatrix} = \begin{bmatrix} 0.60 & 0.23 & 0.03 & 0.13 \\ 0.67 & 0.17 & 0.10 & 0.07 \\ 0.80 & 0.10 & 0.03 & 0.07 \end{bmatrix} \tag{8}$$

$$R_2 = \begin{bmatrix} R_{21} \\ R_{22} \\ R_{23} \end{bmatrix} = \begin{bmatrix} 0.13 & 0.20 & 0.50 & 0.17 \\ 0.20 & 0.17 & 0.23 & 0.40 \\ 0.17 & 0.30 & 0.50 & 0.03 \end{bmatrix} \tag{9}$$

$$R_3 = \begin{bmatrix} R_{31} \\ R_{32} \\ R_{33} \end{bmatrix} = \begin{bmatrix} 0.33 & 0.33 & 0.17 & 0.17 \\ 0.40 & 0.20 & 0.33 & 0.07 \\ 0.57 & 0.20 & 0.10 & 0.13 \end{bmatrix} \tag{10}$$

$$R_4 = \begin{bmatrix} R_{41} \\ R_{42} \\ R_{43} \\ R_{44} \end{bmatrix} = \begin{bmatrix} 0.57 & 0.33 & 0.07 & 0.03 \\ 0.50 & 0.27 & 0.13 & 0.10 \\ 0.70 & 0.17 & 0.10 & 0.03 \\ 0.47 & 0.27 & 0.17 & 0.10 \end{bmatrix} \tag{11}$$

$$R_5 = \left[R_5\right] = [0.070.100.330.50] \tag{12}$$

$$R_6 = \begin{bmatrix} R_{61} \\ R_{62} \end{bmatrix} = \begin{bmatrix} 0.70 & 0.23 & 0.03 & 0.03 \\ 0.67 & 0.17 & 0.20 & 0.03 \end{bmatrix} \tag{13}$$

4. Determining weight for evaluation factor—The hierarchical structure figure of evaluation factor (delaying factors) groups and subgroups for AHP is shown in Fig. 5. With the help of the expert's discussion, the pairwise comparison matrixes were established and are shown from Eqs. 14, 15, 16, 17, 18, 19 and 20 as:

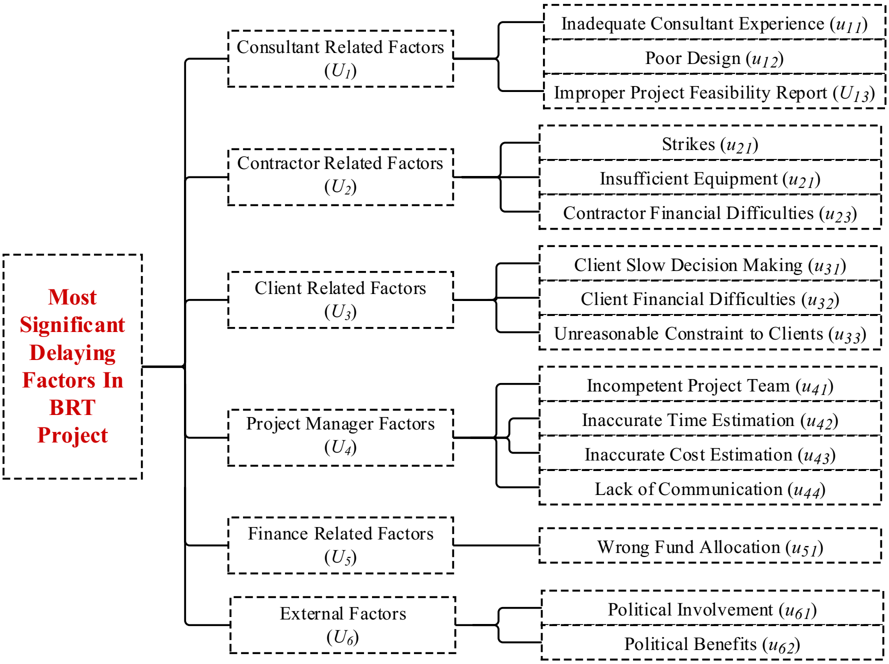

Fig. 5 Evaluation factor groups and subgroups

$$U=\begin{bmatrix}U_1\\U_2\\U_3\\U_4\\U_5\\U_6\end{bmatrix}=\begin{bmatrix}1&4&5&2&6&3\\1/4&1&3&1/4&4&1/3\\1/5&1/3&1&1/4&3&1/4\\1/2&4&4&1&5&2\\1/6&1/4&1/3&1/5&1&1/4\\1/3&3&4&1/2&4&1\end{bmatrix}\tag{14}$$

$$\mathrm{U}_1=\begin{bmatrix}u_{11}\\u_{12}\\u_{13}\end{bmatrix}=\begin{bmatrix}1&1/5&1/7\\5&1&1/2\\7&2&1\end{bmatrix}\tag{15}$$

$$\mathrm{U}_2 = \begin{bmatrix} u_{21} \\ u_{22} \\ u_{23} \end{bmatrix} = \begin{bmatrix} 1 & 4 & 1/3 \\ 1/4 & 1 & 1/6 \\ 3 & 6 & 1 \end{bmatrix} \tag{16}$$

$$\mathrm{U}_3 = \begin{bmatrix} u_{31} \\ u_{32} \\ u_{33} \end{bmatrix} = \begin{bmatrix} 1 & 1/3 & 1/5 \\ 3 & 1 & 1/3 \\ 5 & 3 & 1 \end{bmatrix} \tag{17}$$

$$\mathrm{U}_4 = \begin{bmatrix} u_{41} \\ u_{42} \\ u_{43} \\ u_{44} \end{bmatrix} = \begin{bmatrix} 1 & 1/5 & 1/3 & 3 \\ 5 & 1 & 2 & 7 \\ 3 & 1/2 & 1 & 5 \\ 1/3 & 1/7 & 1/5 & 1 \end{bmatrix} \tag{18}$$

$$\mathrm{U}_5 = \left[u_{51}\right] = [1] \tag{19}$$

$$\mathrm{U}_6 = \begin{bmatrix} u_{61} \\ u_{62} \end{bmatrix} = \begin{bmatrix} 1 & 1/2 \\ 2 & 1 \end{bmatrix} \tag{20}$$

All the judgment matrixes pass the consistency ratio test. The final results are gathered, and the weight of the delaying factors groups and sub-factors are obtained, as shown in Table 14. The weight of delaying factor groups and subgroups are also shown from Eqs. 21, 22, 23, 24, 25 and 26 as:

$$W_1 = \left(w_{11}, w_{12}, w_{13}\right) = (0.0755, 0.3338, 0.5907) \tag{21}$$

$$W_2 = \left(w_{21}, w_{22}, w_{23}\right) = (0.2737, 0.0869, 0.6393) \tag{22}$$

$$W_3 = \left(w_{31}, w_{32}, w_{33}\right) = (0.1062, 0.2605, 0.6333) \tag{23}$$

$$W_4 = \left(w_{41}, w_{42}, w_{43}, w_{44}\right) = (0.1244, 0.5205, 0.2971, 0.0581) \tag{24}$$

$$W_5 = \left(w_{51}\right) = (1) \tag{25}$$

Table 14 Weight of delaying factors groups and subgroups

Objective	Delay factor groups	Weight to delaying groups	Delaying factors	Delaying factor weights	Factors weights to groups (W)
Delaying factors in BRT project (U)	U_1	0.3651	u_{11}	0.0755	0.0276
			u_{12}	0.3338	0.1219
			u_{13}	0.5907	0.2157
	U_2	0.1061	u_{21}	0.2737	0.0290
			u_{22}	0.0869	0.0092
			u_{23}	0.6393	0.0678
	U_3	0.0654	u_{31}	0.1062	0.0069
			u_{32}	0.2605	0.0170
			u_{33}	0.6333	0.0414
	U_4	0.2502	u_{41}	0.1244	0.0311
			u_{42}	0.5205	0.1302
			u_{43}	0.2971	0.0743
			u_{44}	0.0581	0.0145
	U_5	0.0391	u_{51}	1.0000	0.0391
	U_6	0.1741	u_{61}	0.3333	0.0580
			u_{62}	0.6667	0.1161

$$W_6 = \left(w_{61}, w_{62}\right) = (0.333, 0.6667) \tag{26}$$

5. Determining evaluation results—Fuzzy evaluation results can be determined by multiplying weight vector Eq. 5 to the fuzzy evaluation matrix Eq. 4, as shown in Eq. 27. E_i is the fuzzy vector representing all the evaluation factors that contribute to the BRT project construction delay. After calculation, the results are shown below from Eqs. 28, 29, 30, 31, 32 and 33.

$$E_i = W_i * R_i = \left\{e_1, e_2, e_3, \ldots .e_m\right\}, i = 1,2,3,4,5,6 \tag{27}$$

$$E_1 = W_1 * R_1 = (0.7415, 0.1332, 0.0534, 0.0745) \tag{28}$$

$$E_2 = W_2 * R_2 = (0.1616, 0.2613, 0.4765, 0.1005) \tag{29}$$

$$E_3 = W_3 * R_3 = (0.5002, 0.2138, 0.1673, 0.1186) \tag{30}$$

$$E_4 = W_4 * R_4 = (0.1244, 0.5205, 0.2971, 0.0581) \tag{31}$$

$$E_5 = W_5 * R_5 = (0.0667, 0.1000, 0.3333, 0.5000) \tag{32}$$

$$E_6 = W_6 * R_6 = (0.6333, 0.1900, 0.1500, 0.0300) \quad (33)$$

Let $R = \begin{bmatrix} R_1 \\ R_2 \\ R_3 \\ R_4 \\ R_5 \\ R_6 \end{bmatrix}$, and then the fuzzy evaluation results for delay groups' significance can be seen in Eq. 34.

$$E = W * R = (0.5751, 0.1893, 0.1479, 0.0880) \quad (34)$$

Analysis of Fuzzy Evaluation Results

The evaluated results are demonstrated in Table 15**.** The result highlights that the factors related to consultant, client, and external group were the most significant delaying factors for the BRT project. The fuzzy method comprehensively evaluates consultant group factors as 74.15% most significant, due to factors such as improper project feasibility study and poor design. External factors followed the trend, with 63.33% most significant groups of delaying factors. The percentage was high due to delaying factors like political benefits and political involvement. Client group delaying factors were evaluated as 50.02% most significant due to factors such as unreasonable constraints to clients and clients' financial difficulties. On the other hand, project manager, contractor, and financial group factors were evaluated as moderately significant, least significant, and not significant, respectively.

Table 15 Appraisal grades of each factor groups

Fuzzy evaluation	Appraisal grades percentages			
	Most significant	Moderate significant	Least significant	Not significant
Consultant factors	74.15	13.32	5.34	7.45
Contractor factors	16.16	26.13	47.65	10.05
Client factors	50.02	21.38	16.73	11.86
Project Manager factors	12.44	52.05	29.71	5.81
Financial factors	6.67	10.00	33.33	50.00
External factors	63.33	19.00	15.00	3.00

Furthermore, Fig. 6 also shows that the top effective delaying factors in Pakistan's construction industry were evaluated as 57.51% most significant causes of construction delay in the BRT project.

Discussion

This study attempts to identify the delaying factors affecting projects in Pakistan's construction industry. In addition to previous literature, the findings of this study also indicate numerous delay factors aiding in the setback of the construction process. The consequences of the delays can be mitigated through the implementation of a specific project strategy that combines and manages the skills of all stakeholders involved in the project. The top effective delay factors identified in this study can be seen in Table 11.

Consultant Group

Under the consulting group, "inadequate experience of a consultant" was the most significant delay factor. It was expressed that inexperience members of consultant firms highly contribute to delay since this can result in a massive blunder in construction activities, which will eventually affect the progress of other activities as well. The second most crucial variable in this group was "poor design." It can significantly affect the progress of the project because the approval and corrections of the design require an enormous amount of time, which can lead to time overrun. It was followed by an "improper project feasibility study," which was ranked third in this category. It can cause a project to suffer both cost and time overrun since the feasibility study is the basis for the project design itself.

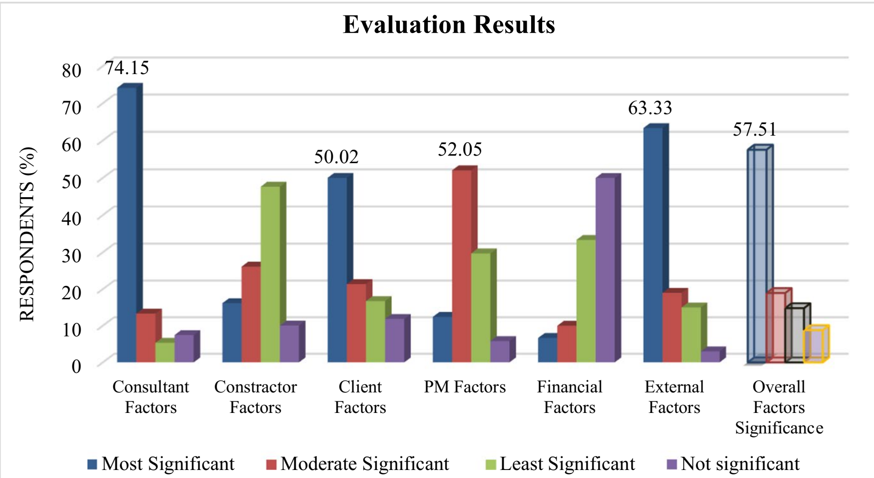

Fig. 6 Summary of the findings

Contractor Group

After analyzing all the factors related to contractors, the respondents agreed that "contractor's financial difficulties" were the most significant. It can lead to other delay factors such as less equipment acquisition and a low labor force. Contractors have to ensure the availability of funds and equipment throughout the project. It was followed by "strikes" and "insufficient number of equipment" as significant delay factors aiding in schedule delay. Laborers are often paid low salaries, which compel them to strike for their rights. These factors cause low efficiency and even lower productivity, which can cause a project deadline extension. "Inappropriate construction method" was deemed less necessary in the construction process for hindrances.

Client Group

"Slow decision making by client" is considered most effective in the category of client. It indicates that the client's slow response and reluctance to any risk or change in the construction site can lead to delay in the time overrun of the project. The client's positive attitude and interest in the project may omit this problem. "Client financial difficulties" were ranked second most effective in this category, which can be linked to bureaucracy and irregularities in the client's organization. It was followed by "unreasonable constraints to clients" which is due to the client's dependency on electricity, water, gas, and telecommunication sectors. The client is bound to ensure legal permission from all the authorities before the execution of any activity.

Project Manager Group

The project manager group considered the "inaccurate cost estimation" to be the most critical factor in construction delay. It might be due to poor management of the design and unrealistic deadlines imposed by clients. "Incompetent project team" was considered the second effective delay factor. It indicates that lacking experience and coordination among project team members can significantly aid in construction delays. Followed by "inaccurate time estimation" and "lack of communication" as the third and fourth rank in this category. The project's inaccurate duration could be attributed to the arbitrary deadline imposed by the client, which is also the responsibility of the project manager to give them adequate advice. Surprisingly, "improper planning" was found less critical in terms of project delays in Pakistan.

Financial and External Group

The only factor from the financial group that broke into the top 15 delay factors was "wrong fund allocation." It appeared to have no correlation with the client's late payment and could be a sign of cash flow mismanagement. Of the top 15, the only two external group factors were “political benefit” and “political involvement.” It implies that most government-sponsored projects in Pakistan are initiated for political advantages without proper planning and scheduling and also due to the involvement of political groups in the bidding process, which can result in the project deadline being extended.

Comparison with Other Studies

This section compares previous studies in other developing countries with the current research by analyzing the top ten delay factors, as shown in Table 12. Even though these studies are not entirely identical in terms of their purpose and methodology employed, the comparison is a useful way to understand delay issues in developing countries. The selected articles are up to date and have been published over the last decade. Additionally, Fig. 7 shows the occurrence percentage of the delay factors in selected articles.

Comparative analysis shows that “incompetent project team” is not only the most encountered delay factor in Pakistan, but also ranked among the top ten delay factors in other countries like Yemen (rank 4), India (rank 8), Malaysia (rank 5), UAE (rank 10), Saudi Arabia (rank 7), Burkina Faso (rank 10), and Egypt (rank 10) with an occurrence percentage of 100%. Followed by “client’s financial difficulties” being a critical delay factor in Yemen (rank 2), Malaysia (rank 1), Saudi Arabia (rank 1), Egypt (rank 1), and Burkina Faso (rank 2) with an occurrence of 75%. “Contractors financial difficulties,” “slow decision making by the client,” and “poor design” have been ranked among the top 10 delay factors in selected studies with an occurrence percentage of 62.50%. “Inaccurate time estimation” and “lack of communication”

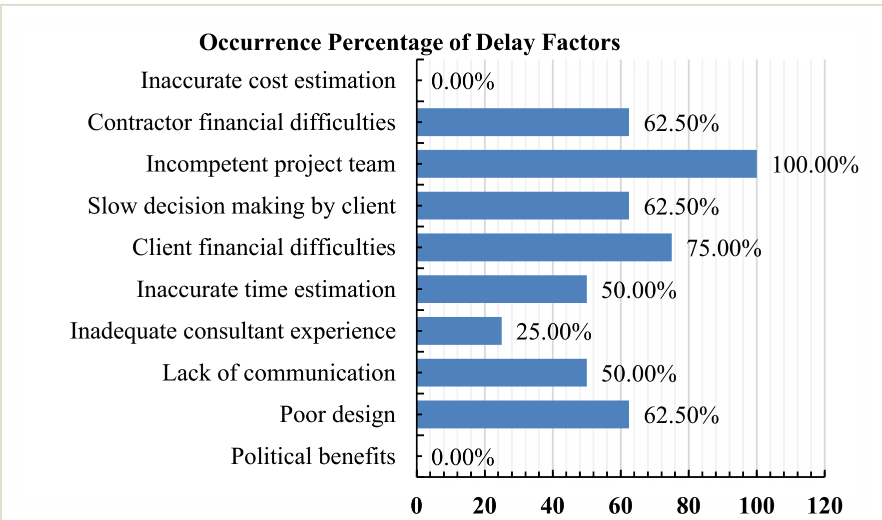

Fig. 7 Occurrence percentage of top delay factors

have an occurrence percentage of 50%. On the other hand, it is worth noting that in all selected studies, except for the current study, "inaccurate cost estimation" and "political benefits" have not been among the top ten delay factors. This implies that these delay factors are particularly relevant to the context and characteristics of Pakistan's construction industry.

The comparison of this study with past research showed exciting insights into the subject. It highlights both the relevance and disparities with previous studies on different delay factors. For example, delay factors related to financial problems, management flaws, and lack of expertise were similar to prior studies, while factors related to subcontractors, equipment, materials, and weather conditions were not consistent with previous studies. As Sambasivan and Soon (2007) affirm, delay factors can be country-specific, and the disparities among different studies could be triggered by geographic, cultural, and socio-economic factors. To resolve problems and develop project performance, consistent collaboration and relationships between practitioners are needed throughout the project life cycle. Practitioners should strive to use information that already exists within the public domain and develop ways of tackling the industry's problems. Numerous studies of delay factors have been carried out but the novelty of this research is that identified factors have subsequently been evaluated in an existing delayed project. Results show that these factors are also significantly effective in the case study project, which can be regarded as validation for the findings of this study.

Conclusion and Recommendations

Construction has always been one of Pakistan's major industries contributing significantly to the country's GDP. Despite this, construction delays are among the key issues restricting projects to accomplish on time. This study was designed to assess the perception of different stakeholders regarding construction delay factors to find out the top recurring delaying factors in the construction industry of Pakistan and to evaluate its significance in a specific case study project. Through a comprehensive review of literature, 42 factors were identified and categorized into six groups as consultant, contractor, client, project manager, financial, and external factors. Data was collected through a questionnaire survey, and factors were analyzed and ranked using the RII technique. Subsequently, the top 15 delaying factors were ranked and further evaluated in a case study project using the FCEM-AHP method to evaluate its significance.

The results emphasized the factors related to the consultant, client, and external group which were the most significant delaying factors for this case study project. From a consultant group, "improper project feasibility study" and "poor design" were responsible factors. Similarly, from the client group, "unreasonable constraints to clients" and "financial difficulties of the client" were the most significant. Political benefits and political involvement were considered to be the most significant delaying factors in the external delaying factors group. Based on a comparative analysis of eight selected countries, the findings of this study showed both relevance and disparities with previous research. "Incompetent project team" and "client's financial difficulties" are the most frequent delay factors affecting South Asian, Middle Eastern, and African developing countries with an occurrence of 100% and 75%, respectively. The results from this study may serve as a reference for both Pakistani construction firms and foreign builders engaged in the construction sector in Pakistan. Finally, the study emphasizes that it is necessary to analyze and identify delay factors at an early stage of constructing any project even before preparing the execution plan so that decision-makers can take necessary steps in advance to minimize or avoid the effects of delay in future construction projects.

There are no upfront solutions for impending delay factors, highlighted in Table 14. However, some scrupulous steps could be taken to minimize their impacts. In this study, recommendations are put forward for the developing countries based on previous literature and findings of this study:

- During the estimation and planning phase, an increase in the prices of materials should be borne in mind to prevent these problems. There should also be a sufficient contingency plan ready to cope with the increase in material prices. Additionally, inaccuracy in time estimation is also the leading problem causing delays in projects. Authorities must ensure designers and planners should have enough experience to design and plan construction projects.
- By providing proof of appropriate funds, contractors must allocate sufficient resources to projects to ensure completion within a specified timeframe.
- Highly skilled and experienced project managers can play a crucial role in ensuring competence within the project management team. The track record of project manager must be checked to ensure the hiring of highly professional and well-trained project managers.
- Public strikes can be avoided by not destroying any public property and always asking for permission from legal authorities and the consent of the surrounding people. Monitoring of work is essential, but to avoid worker strikes, contractors must ensure workers and subcontractors are paid on time.
- Political leaders must support and facilitate construction projects initiated for public welfare rather than taking personal advantages and political benefits. Furthermore, government organizations in charge of the issuance of licenses are also advised to simplify the authorizing process and requirements in order to facilitate the timely acquisition of relevant licenses.
- During the construction process in Pakistan, clients are bound to unreasonable constraints from electric, water, gas, and telecommunication supply companies. The client must ensure legal permission from the authorities before the commencement of any project. Issues with these companies can cause serious lawsuit problems for the project, which can significantly affect the project deadlines.
- The efficient and timely use of financial resources and on-time payments to staff, equipment, and material resources may significantly reduce the delay factors associated with the financial group.

The present study also has some limitations regarding the methodology section. When there are many delay factors, it is difficult to use the AHP method due to an increase in the size of the pairwise comparison matrix. Also, the experts' opinions should have a suitable inconsistency ratio and, in some cases, are not usable. Therefore, the number of respondents selected for the broad study area (Pakistan's construction industry) was limited to 50 only, where a more significant number of respondents would have a positive impact on study results. Secondly, out of the total 42 relevant delaying factors to the construction industry of Pakistan, only 15 delaying factors were considered for evaluation in a case study project. Third, the top 15 delaying factors were only evaluated in a single project. However, future studies should evaluate these delaying factors in various construction projects to have an in-depth understanding of these delaying factors by comparing their results.

Data Availability Data generated or analyzed during the study are available from the corresponding author upon request.

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