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IDENTIFICATION AND ANALYSIS OF SIGNIFICANT DELAY FACTORS IN CONSTRUCTION PROJECTS

Rasool Niaz Khan
Department of Construction and Engineering Management, Superior University Lahore, Pakistan.
Email: *rasoolniaz50@gmail.com*

Muhsin Azam
Department of Construction and Engineering Management, Superior University Lahore, Pakistan.
Email: *muhsinkhan1993@gmail.com*

Imran Ghafoor Chudhry
Department of Construction and Engineering Management, Superior University Lahore, Pakistan.
Email: *imran_g@yahoo.com*

Abstract

Construction delays have a significant impact on private and public sector projects in Khyber Pakhtunkhwa, Pakistan. This study analyzes data from 73 industry professionals to identify key delay factors in construction projects. Delay reasons were categorized into six groups: Contractor-Related, Design-Related, Labor-Related, Management and Administrative, Financial and Payment-Associated, and Technical Elements. Cronbach's Alpha confirmed the reliability of survey data, thereby supporting valid conclusions. Descriptive statistics revealed a range of impacts, some with higher means and greater variability than others. The RII method ranked these elements, with the political situation (RII = 0.7068), contractor payment delay (RII = 0.7041), and consultant design team experience (RII = 0.6904) being the most influential. Pareto Analysis emphasizes the importance of addressing these factors to effectively mitigate delays. Cluster analysis revealed three types of delays: resource and communication issues, design and decision-making complications, and other variables, emphasizing their interconnected nature. Network analysis visualizes the interactions between delay factors, providing insight into their complex interplay.

Keywords. *Construction Management, Construction Delays, Delay Factors Analysis, Pareto Analysis, Network Analysis, Contractor-Related Factors.*

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INTRODUCTION

The construction industry, a vital source of income for numerous developing countries worldwide, plays a pivotal role in driving economic growth and development[1]. Its impact on a nation's economy can be transformative, shaping its trajectory toward success or challenges. Uniquely set apart from other sectors, the construction industry boasts distinctive attributes stemming from individual projects' diverse and intricate nature[2]. With society's ever-growing demands, a continuous influx of new construction systems and projects has become the norm, encompassing a wide spectrum of structures such as factories, hospitals, schools, bridges, and hydro dams. The significance of these projects in national development cannot be overstated [3]. In this context, the timely completion of construction projects emerges as a cornerstone, reflecting the efficiency and prowess of the construction industry. It stands as a litmus test for the industry's capabilities and project performance assessment. A construction project achieves true success when it not only meets but exceeds expectations in terms of both time and cost[4]. Pursuing this goal necessitates effective project management, an indispensable factor in ensuring construction endeavors' smooth and efficient functioning.

The role of construction management in orchestrating the successful completion of projects cannot be emphasized enough[5]. Effective management ensures quality, cost-effectiveness, and adherence to schedules of construction projects, thereby laying the groundwork for success. However, inadequate management practices can lead to various challenges, including cost and schedule overruns. It becomes evident that construction management wields considerable influence over project outcomes[6]. Among the vast tapestry of difficulties that construction management faces, the specter of construction delays looms prominently. Among these challenges, construction delays stand out as a pressing concern, significantly impacting project timelines and overall success[7-9]. Notably, the characteristics and severity of delay factors vary based on the project's scope and duration, ranging from minor disruptions to substantial setbacks spanning months or even years. Frequently, construction delays are attributed to mismanagement, underscoring the imperative of analyzing potential consequences with precision to prevent avoidable setbacks[10]. The research underscores that adopting robust project management principles can significantly alleviate challenges tied to delays, particularly within the construction domain. Yet, a significant stumbling block in addressing these challenges lies in the absence of effective project management practices tailored to tackle delays head-on[11, 12]. The ramifications of project delays extend beyond the realm of cost, rippling into productivity, schedules, and client satisfaction. The interplay of critical project activities hinges on their timely

execution, making delays in commencement or completion a precarious scenario. Such delays may stem from a host of factors, ranging from environmental conditions to design-related issues or planning complications[13]. Termed as delay factors, they encompass a broad spectrum of construction, consultancy, and contracting influences. These factors can be categorized into internal and external types, with the former originating within the project itself and the latter arising from external events and conditions. Undoubtedly, timely completion remains the hallmark of construction project success. This assertion gains credence from a body of literature and practical experiences that highlight the pivotal role of construction projects' timely execution. However, despite decades of research scrutinizing delay factors' identification and analysis, there remains room for further refinement. This need is especially pronounced given the constraints in resources and skills that many developing countries face, where construction delays pose a significant hurdle. Moreover, the prevalence of small local companies focusing primarily on skills rather than comprehensive project management exacerbates the challenge, perpetuating project delays[14].

Pakistan, as a rapidly developing nation, grapples with a prominent and multifaceted issue: construction project delays. These delays manifest due to a multitude of factors, impacting crucial projects across various provinces. Identifying and analyzing these factors becomes a pressing imperative to surmount these challenges[15]. This study seeks to bridge this knowledge gap by delving into, evaluating, and classifying the factors contributing to construction project delays, specifically spotlighting road and building initiatives in Khyber Pakhtunkhwa Pakistan.

The study employs a rigorous methodology, combining primary and secondary data collection methods, to identify and assess prominent delay factors. Statistical techniques validate the findings, ranking these factors to illuminate their significance in the Pakistani context. This ranking contributes to a nuanced understanding of the primary drivers of delays within Pakistani projects. Navigating the composition of this paper, the subsequent sections unfold a comprehensive narrative. The initial portion establishes the contextual backdrop of construction project delays, followed by an exploration of prior studies conducted across diverse nations. The subsequent elucidation of the employed methodology paves the way for unveiling the research findings derived from rigorous statistical analysis. This exploration naturally segues into a broader discussion of the implications arising from the study's findings. In conclusion, the paper culminates with a final section that presents overarching reflections and noteworthy recommendations. These recommendations advocate for the adoption of effective project management practices, underpinned by evidence-based insights. Such practices are instrumental in not only managing but also minimizing the critical delay factors identified in this study.

Ultimately, these recommendations extend beyond the confines of the study's focus in Pakistan, resonating with construction projects worldwide. By championing robust project management, the study envisions a future where construction delays are mitigated, fostering smoother, more successful project outcomes.

LITERATURE REVIEW

Controlling of delays is a challenge for our beloved country Pakistan especially for the management team of organizations. Many researchers have investigated many factors that can cause delays in construction projects of different locations[11, 16-20]. Several of these studies focused on analyzing delays in construction projects [21, 22] , Some studies specifically addressed delays in highway projects[23] , the other have investigated delay factors as a whole.

The following literature review focuses on delay factors that are considered pertinent to the present study.

(Fashina, Omar, Sheikh, & Fakunle, 2021) conducted research in Hergeisa, identifying a total of 51 delay factors within diverse construction industries. Employing the RII method, their analysis revealed that "Delay in honoring payment progressively" stood out as the foremost and most impactful factor contributing to construction delays [11]. Subsequently (Ogbeifun & Pretorius, 2022) built upon this research and reinforced the notion that the client's failure to meet financial obligations for services rendered remains the most significant factor causing construction delays[24]. In Zimbabwe by (Ngendakumana & Kakono, 2020) conducted a study aimed at ranking delay factors in construction projects. Their findings pointed to "Lack of funds" as the foremost factor responsible for project delays in the region[25]. Similarly (Nadir & Ahmed, 2020) that found that "Inconsistent cash flow" not only ranked as the primary factor causing project delays but also contributed to cost overruns[26].

(Esperance & Sung-hoon, 2019) published a comprehensive study on construction delay factors, emphasizing the need to rank delays to manage risks effectively. Their research underscores the importance of understanding the likelihood of delay occurrence and assessing its impact on project timelines[27]. Meanwhile (Tahmasebinia & Song, 2022) explored various delay factors within the Cambodian Construction Industry and highlighted "Poor planning and scheduling" as a major contributor to construction project delays [28].

Trans-Nzoia City, as studied by (Murithi, Makokha, & Otieno, 2017) identified "Insufficient Funding" as the predominant factor responsible for construction project delays [29]. In Malysia (Ramli et al., 2018) identified five major factors contributing to delays: improper construction methods, adverse weather conditions, delivery challenges, equipment breakdowns, and inadequate qualifications of technical staff.

Addressing these factors emerged as crucial for fostering timely project completion and sustainable growth in the construction sector [30]. (Abdulghafour & Salman, 2023)) conducted a study on delay factors in Makkah, identifying "difficulties in project financing," "poor site management," and low labor productivity as the top three factors influencing construction project delays[31]. (Khatib, Poh, & El-Shafie, 2018) investigated 14 delay factors for construction projects, meticulously ranking them based on their impacts[32]. Notably, the research by (Nadir & Ahmed, 2020) revealed "Inconsistent Cash Flow" as the most significant factor, with "Weather Severity" having the least impact[26]. (Ogunlana, Promkuntong, & Jearkjirm, 1996) delved into construction project delays, focusing on high-rise buildings in Thailand and Bangkok, where resource supply issues emerged as the most prominent concern[33]. Additionally, (Karim & Amin, 2021) study concentrated on delay factors in government construction projects in Malakand Division, Khyber Pakhtunkhwa, Pakistan. They identified 10 major causes of time overrun, including funding issues, delayed inspections, adverse weather conditions, terrorist activities, and delays in bill payments [34].

The research gap in this context pertains to the limited exploration of delay factors within the construction projects of KPK, Pakistan, and the prevailing reliance on a single analytical method, namely the RII method, to assess these factors. Existing studies have primarily focused on other regions and countries while overlooking the specific dynamics of this region. Furthermore, these studies often employ a singular analytical approach, missing out on the comprehensive insights that can be gained through the integration of various methods such as network analysis, Pareto analysis, and descriptive analysis. Therefore, the research gap is the need for a more holistic and region-specific investigation into construction project delay factors in KPK, Pakistan, utilizing a multifaceted analytical framework to provide a more nuanced understanding of these challenges.

METHODOLOGY/DATA COLLECTION

The study employed a quantitative research approach to gather information and data from the study population through on-site sources. The questionnaire survey was formulated by incorporating delay factors commonly identified in the literature review, along with aligning it with the study's objectives. A comprehensive examination of 30 distinct delay-influencing factors was undertaken in this research. The participants were requested to rate these factors on a Likert scale with 5 ordinal measures, ranging from 1 to 5, 1 indicating "Very Low" 2 representing "Low" 3 denoting "Average" 4 signifying "High" and 5 denoting "Very High".

The questionnaires were divided into people, of which 73 respondents were received.

***Table.1** delay factors in construction projects.*

ID	*Description*

1	*Design Changes during construction*
2	*Delay in Contractor Payment*
3	*Incomplete or improper designing*
4	*Shortage or Delay of material*
5	*Ineffective project planning and scheduling*
6	*Political Situation*
7	*Shortage of labors*
8	*Delay in obtaining permits licenses from authorities*
9	*Slowness in decision-making*
10	*Poor communication and coordination*
11	*Experience of consultant design team*
12	*Price fluctuations*
13	*Poor quality control*
14	*Location of the Project*
15	*Late reviewing and approving design documents*
16	*Poor procurement strategies of construction material*
17	*Changes in material types and specifications during construction*
18	*Site handover/Site change*
19	*Providing a Safe Working Environment for Employees*
20	*Delay in performing inspection and testing*
21	*Different culture problems*
22	*Low efficiency of equipment*
23	*Personal conflicts among workers*
24	*Rework due to errors*
25	*Conflicts between consultant and design engineer*
26	*Sudden failures actions*
27	*Insufficient data collection and survey before design*
28	*Poor use of advanced engineering design software*
29	*Unclear and inadequate details in drawings*
30	*Equipment allocation problem*

METHODS/CRONBACH'S ALPHA DATA RELIABILITY TEST

Cronbach's alpha is a measure of internal consistency, or how closely related two or more items are. It is thought to be a scale reliability metric. Cronbach's alpha of 70 or above is considered good, 80 or higher is considered better, and 90 or higher is considered exceptional.

Despite the fact that the pilot survey was used to determine the survey questionnaire's dependability or relevance to the construction sector, It was also

important to use Cronbach's Alpha to assess the dependability of the gathered data. This was accomplished by calculating the Cronbach's Alpha using Eq. below:

$$\alpha = \frac{K}{K-1}[1 - \frac{\sum Vi^2}{Vx^2}]$$

where K represents the number of items, Vi represents the variation of scores on each item, and Vx represents the variance of the observed total test results.
The reliability coefficient and Cronbach's Alpha were determined using SPSS Statistics Software to demonstrate the data's internal consistency.

DESCRIPTIVE ANALYSIS

It is the branch of statistics that is primarily concerned with summarizing and presenting data in a relevant and informative manner. The primary goals of descriptive analysis are to determine the central tendency, dispersion, frequency distribution, percentile, and so on of huge amounts of data. It is also used to rank data based on the mean. Descriptive analysis is essential in data analysis and research because it serves as the foundation for comprehending data before more advanced analyses are performed. It's important in sectors like market research, social sciences, economics, and quality control, where having a clear image of the data is critical for making decisions and communicating findings. It's important in sectors like market research, social sciences, economics, and quality control, where having a clear image of the data is critical for making decisions and communicating findings. The descriptive statistics emphasize the multidimensional character of project delays, indicating the variable degrees of influence that various causes have. These insights can help project managers prioritize their efforts, allocate resources, and develop specialized strategies to solve the unique problems offered by each element. It's worth noting that the data provide a quantitative lens on delay factors, but qualitative research might supplement these findings by diving into the underlying causes of respondents' beliefs. For descriptive analysis, SPSS statistical software is employed.

RELATIVE IMPORTANCE INDEX

It is a statistical approach which is called weight mean or weight average technique, used in the research for the ranking of different variables based on their importance or impact. In construction research, it is used for ranking different factors influencing construction. It shows the rating of different factors, and these ratings typically represent the contribution of each factor to a specific outcome. This was employed to assess the ratings obtained from the questionnaires and determine an average rating score, which signifies the rating for each group of contributors. The RII can be calculated by

$$RII = \frac{\sum W}{A \times N}$$

Where, W = weighting that is assigned to each variable by the respondent, A = highest weight, and
N = total number of respondents.

PARETO ANALYSIS

It is also known as 80/20 or the Pareto principle. It is a decision-making and problem-solving technique used to identify and prioritize the most significant factors contributing to a problem. It is usually shown by a bar chart which is called a Pareto chart which shows the rank of the data in descending order. This concept finds application in diverse scenarios to emphasize tasks, distribute resources, and concentrate on the most influential aspects. It serves as a mechanism for recognizing and dealing with the key elements that hold the greatest sway over a desired result, all the while reducing the emphasis on the less important elements, often referred to as the less consequential many. Excel was used for performing the Pareto analysis of these delay factors.

CLUSTER ANALYSIS

Cluster analysis is a data analysis approach that groups together comparable data points or observations, where data points within the same cluster are more similar to one another than to data points from other clusters. Cluster analysis seeks to uncover underlying patterns or structures in a dataset and classify it into meaningful groupings based on commonalities. Overall, cluster analysis is a useful method for exploratory data analysis, pattern discovery, and data structure understanding. It aids in the discovery of hidden links and groups that can be used to inform decision-making and subsequent analysis.

NETWORK ANALYSIS

It is a method of data analysis that focuses on comprehending and visualizing the relationships or connections between various variables or factors in your survey data. It can assist highlight patterns, dependencies, and structures that aren't always obvious when looking at typical summary statistics or charts. Network analysis of questionnaire survey responses can be an effective approach for identifying hidden patterns in your data and gaining insights into the intricate relationships between variables. It is especially effective when working with large datasets or investigating the interaction of numerous variables in a survey. Python was used to perform the network analysis for the responses.

RESULTS AND DISCUSSION/SURVEY RESULTS

Out of the multiple questionnaires that were distributed in a random manner among the designated respondents chosen from both private and public construction

firms in Khyber Pakhtunkhwa Pakistan, a total of 73 completed questionnaires were collected. Out of the 73 participants, 97.1% of responses were from males, while merely 2.9% were from females. Figure 02 depicts the responses of different delay factors received from various construction industry professionals.

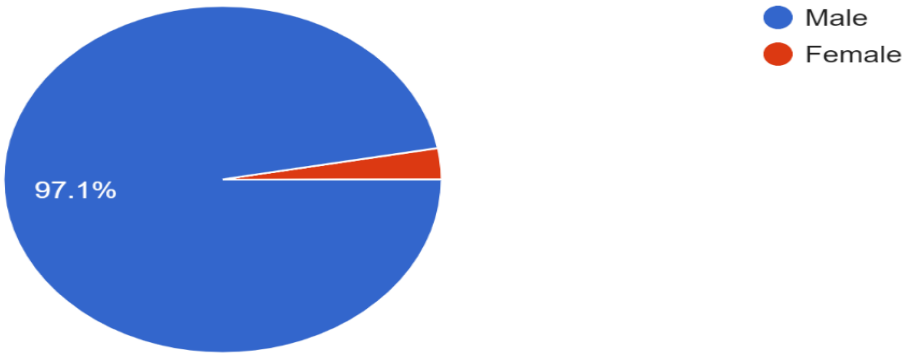


Figure. 1 *Contribution Percentage of Gender*

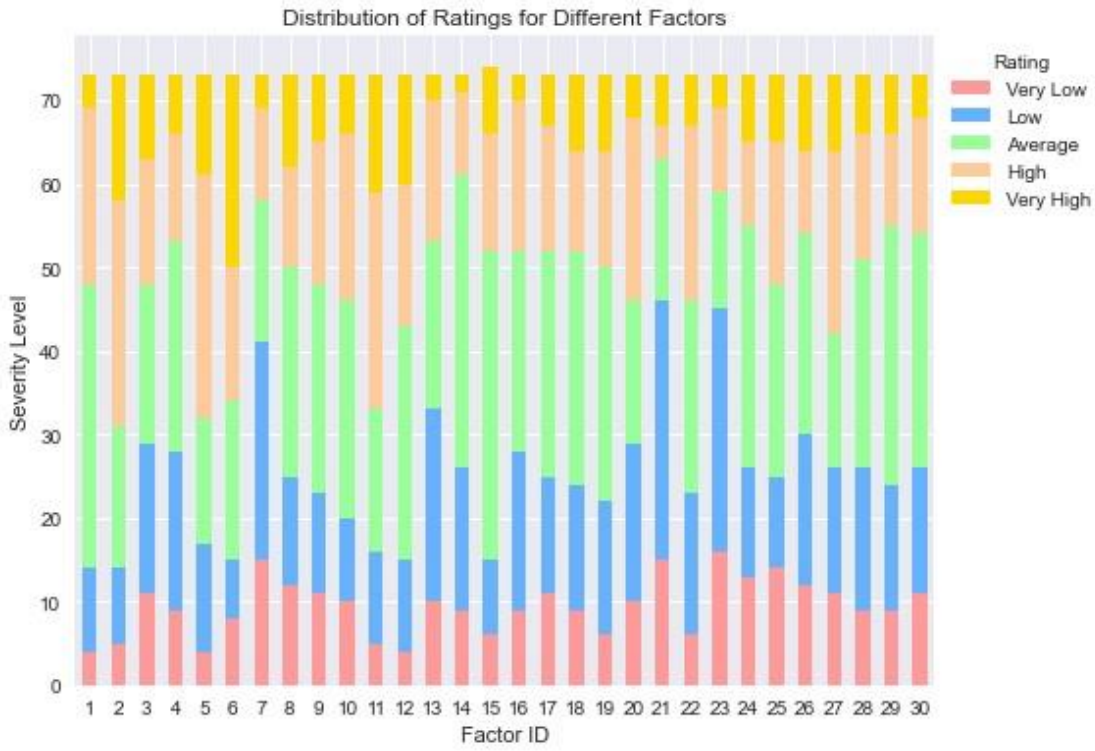


Figure. 2 *Responses from Experts*

DIVIDING DELAY FACTORS INTO CATEGORIES

The delay factors are divided into six categories including Contractor-Related

Factors, Design-Related Factors, Labor-Related Factors, Management and Administrative Factors, Financial and Payment-Related Factors, Technical Factors. The table shows the details of categorical division of delay factors:

Table.2 *categorical distribution of delay factors*

Factor ID	***Delay Factors***	***Category***
1	*Delay in Contractor Payment*	***Contractor-Related Factors***
2	*Poor procurement strategies of construction material*	
3	*Equipment allocation problem*	
4	*Rework due to errors*	
5	*Shortage or Delay of material*	
6	*Design Changes during construction*	***Design-Related Factors***
7	*Incomplete or improper designing*	
8	*Late reviewing and approving design documents*	
9	*Changes in material types and specifications during construction*	
10	*Unclear and inadequate details in drawings*	
11	*Shortage of labors*	***Labor-Related Factors***
12	*Low efficiency of equipment*	
13	*Personal conflicts among workers*	
14	*Ineffective project planning and scheduling*	***Managementand Administrative Factors***
15	*Slowness in decision-making*	
16	*Poor communication and coordination*	
17	*Location of the Project*	
18	*Site handover/Site change*	
19	*Poor use of advanced engineering design software*	
20	*Equipment allocation problem*	
21	*Price fluctuations*	***Financial and Payment-Related Factors***
22	*Political Situation*	
23	*Delay in obtaining permits licenses from authorities*	
24	*Insufficient data collection and survey before design*	
25	*Poor quality control*	***Technical Factors***

26	Delay in performing inspection and testing	
27	Experience of consultant design team	
28	Conflicts between consultant and design engineer	
29	Sudden failures actions	
30	Providing a Safe Working Environment for Employees	

CRONBACH'S ALPHA DATA RELIABILITY TEST RESULTS

Prior to analyzing the questionnaire survey findings, Cronbach's Alpha data reliability results were gathered to assess the internal consistency of the respondents' answers using the Likert scale. The overall Cronbach's Alpha reliability test for the 30 factors reveals that the internal consistency is outstanding, with a Cronbach's Alpha of 0.954. This means that the respondents' responses to the 30 factors influencing construction delay have an outstanding reliability of 95.4%.

Table.3 *Cronbach's Alpha Value*

Cronbach's Alpha	***N of Items***
0.954	*30*

DESCRIPTIVE ANALYSIS RESULTS

The provided descriptive statistics offer a comprehensive overview of the distribution and central tendencies of various delay factors in the context of construction projects. These statistics, including minimum, maximum, mean, standard deviation, and variance, shed light on the variability and intensity of each factor's impact on project delays. From the statistics, it's evident that the delay factors exhibit a range of values, indicating diverse levels of influence on project timelines. Notably, certain factors show a relatively higher mean, such as "Political Situation," "Delay in Contractor Payment," "Ineffective project planning and scheduling," and "Experience of consultant design team.". These factors, with their higher means, suggest that they tend to play a more substantial role in contributing to project delays compared to others.

Moreover, the standard deviations and variances highlight the dispersion of responses around the mean for each factor. Factors with higher standard deviations and variances, like "Political Situation" and "Incomplete or improper designing," indicate greater variability in respondents' perceptions regarding their influence on delays.

Table.4 *descriptive analysis of delay factors*

Description	***N***	***Minimum***	***Maximum***	***Mean***	***Std. Deviation***	***Variance***

Design Changes during construction	*73*	*1*	*5*	*3.151*	*0.92303*	*0.852*
Delay in Contractor Payment	*73*	*1*	*5*	*3.521*	*1.15602*	*1.336*
Incomplete or improper designing	*73*	*1*	*5*	*2.932*	*1.27289*	*1.62*
Shortage or Delay of material	*73*	*1*	*5*	*2.863*	*1.14643*	*1.314*
Ineffective project planning and scheduling	*73*	*1*	*5*	*3.438*	*1.13022*	*1.277*
Political Situation	*73*	*1*	*5*	*3.534*	*1.32374*	*1.752*
Shortage of labors	*73*	*1*	*5*	*2.493*	*1.14411*	*1.309*
Delay in obtaining permits licenses from authorities	*73*	*1*	*5*	*2.959*	*1.27408*	*1.623*
Slowness in decision-making	*73*	*1*	*5*	*2.986*	*1.20754*	*1.458*
Poor communication and coordination	*73*	*1*	*5*	*3.055*	*1.16536*	*1.358*
Experience of consultant design team	*73*	*1*	*5*	*3.452*	*1.16716*	*1.362*
Price fluctuations	*73*	*1*	*5*	*3.329*	*1.10623*	*1.224*
Poor quality control	*73*	*1*	*5*	*2.726*	*1.09621*	*1.202*
Location of the Project	*73*	*1*	*5*	*2.712*	*0.94985*	*0.902*
Late reviewing and approving design documents	*73*	*1*	*5*	*3.11*	*1.03497*	*1.071*
Poor procurement strategies of construction material	*73*	*1*	*5*	*2.822*	*1.07164*	*1.148*
Changes in material types and specifications during construction	*73*	*1*	*5*	*2.877*	*1.15404*	*1.332*
Site handover/Site	*73*	*1*	*5*	*2.959*	*1.17187*	*1.373*

change						
Providing a Safe Working Environment for Employees	*73*	*1*	*5*	*3.055*	*1.11667*	*1.247*
Delay in performing inspection and testing	*73*	*1*	*5*	*2.904*	*1.18045*	*1.393*
Different culture problems	*73*	*1*	*5*	*2.384*	*1.12583*	*1.268*
Low efficiency of equipment	*73*	*1*	*5*	*3.055*	*1.09151*	*1.191*
Personal conflicts among workers	*73*	*1*	*5*	*2.411*	*1.14061*	*1.301*
Rework due to errors	*73*	*1*	*5*	*2.822*	*1.2058*	*1.454*
Conflicts between consultant and design engineer	*73*	*1*	*5*	*2.918*	*1.26659*	*1.604*
Sudden failures actions	*73*	*1*	*5*	*2.808*	*1.23218*	*1.518*
Insufficient data collection and survey before design	*73*	*1*	*5*	*3.041*	*1.27408*	*1.623*
Poor use of advanced engineering design software	*73*	*1*	*5*	*2.918*	*1.15173*	*1.326*
Unclear and inadequate details in drawings	*73*	*1*	*5*	*2.89*	*1.11258*	*1.238*
Equipment allocation problem	*73*	*1*	*5*	*2.822*	*1.12228*	*1.26*
Valid N (listwise)	*73*					

RESULTS OF RII ANALYSIS

The data was examined in Excel to determine the Relative Importance Index (RII) of each factor. The equation RII was used, and the desired results were obtained. According to the results, the weightage of the Political Situation factor was higher, and it is considered ad top-most factor affecting the construction projects and causing the delay of the construction projects.

Table.5 *RII value of delay factors*

Factor	***Description***	***RII***	***RII (%)***

ID			
1	*Design Changes during construction*	*0.63013699*	*63.0136986*
2	*Delay in Contractor Payment*	*0.70410959*	*70.4109589*
3	*Incomplete or improper designing*	*0.58630137*	*58.630137*
4	*Shortage or Delay of material*	*0.57260274*	*57.260274*
5	*Ineffective project planning and scheduling*	*0.68767123*	*68.7671233*
6	*Political Situation*	*0.70684932*	*70.6849315*
7	*Shortage of labors*	*0.49863014*	*49.8630137*
8	*Delay in obtaining permits licenses from authorities*	*0.59178082*	*59.1780822*
9	*Slowness in decision making*	*0.59726027*	*59.7260274*
10	*Poor communication and coordination*	*0.6109589*	*61.0958904*
11	*Experience of consultant design team*	*0.69041096*	*69.0410959*
12	*Price fluctuations*	*0.66575342*	*66.5753425*
13	*Poor quality control*	*0.54520548*	*54.5205479*
14	*Location of the Project*	*0.54246575*	*54.2465753*
15	*Late reviewing and approving design documents*	*0.63287671*	*63.2876712*
16	*Poor procurement strategies of construction material*	*0.56438356*	*56.4383562*
17	*Changes in material types and specifications during construction*	*0.57534247*	*57.5342466*
18	*Site handover/Site change*	*0.59178082*	*59.1780822*
19	*Providing a Safe Working Environment for Employees*	*0.6109589*	*61.0958904*
20	*Delay in performing inspection and testing*	*0.58082192*	*58.0821918*
21	*Different culture problems*	*0.47671233*	*47.6712329*
22	*Low efficiency of equipment*	*0.6109589*	*61.0958904*
23	*Personal conflicts among workers*	*0.48219178*	*48.2191781*
24	*Rework due to errors*	*0.56438356*	*56.4383562*
25	*Conflicts between consultant and design engineer*	*0.58356164*	*58.3561644*
26	*Sudden failures actions*	*0.56164384*	*56.1643836*
27	*Insufficient data collection and survey before design*	*0.60821918*	*60.8219178*
28	*Poor use of advanced engineering design software*	*0.58356164*	*58.3561644*
29	*Unclear and inadequate details in drawings*	*0.57808219*	*57.8082192*
30	*Equipment allocation problem*	*0.56438356*	*56.4383562*

Figure. 3 RII Value of Delay Factors

The bars show the RII values of different delay factors, as the 6th bar is the largest which shows that this factor is affecting more as compared to others.

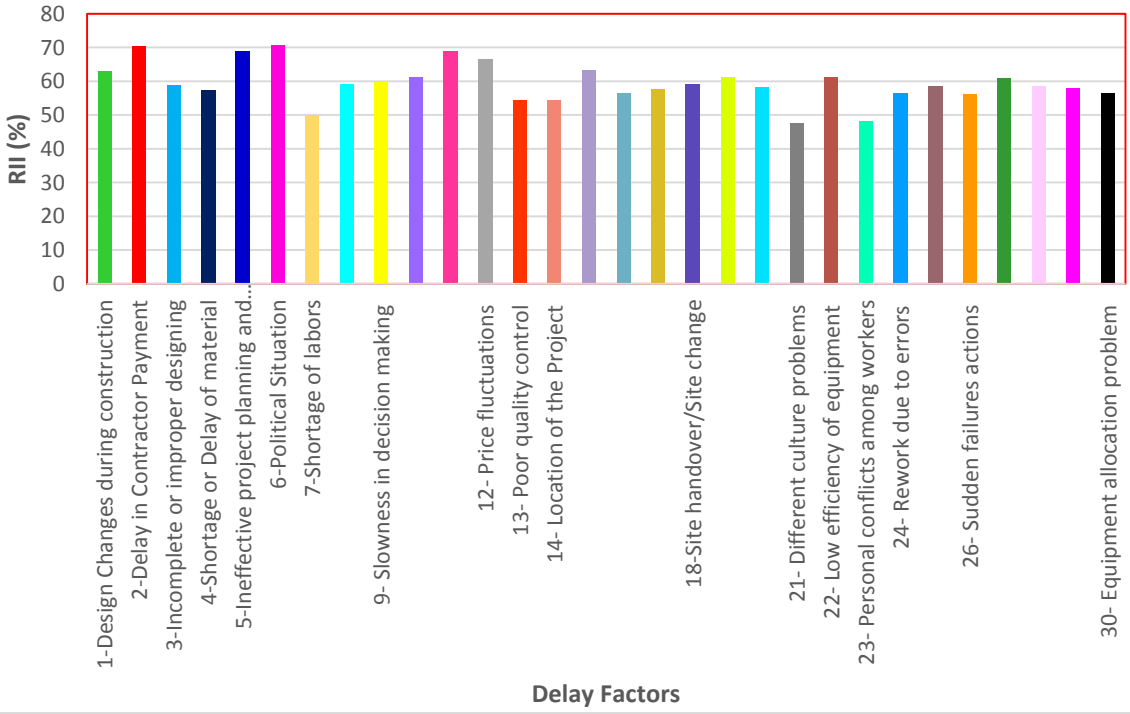


Table.6 *Ranking of Delay Factors*

ID	***Description***	***Rank***	***RII (%)***
6	*Political Situation*	*1*	*70.68493151*
2	*Delay in Contractor Payment*	*2*	*70.4109589*
11	*Experience of consultant design team*	*3*	*69.04109589*
5	*Ineffective project planning and scheduling*	*4*	*68.76712329*
12	*Price fluctuations*	*5*	*66.57534247*
15	*Late reviewing and approving design documents*	*6*	*63.28767123*
1	*Design Changes during construction*	*7*	*63.01369863*
22	*Low efficiency of equipment*	*8*	*61.0958904*

			1
19	*Providing a Safe Working Environment for Employees*	*9*	*61.09589041*
10	*Poor communication and coordination*	*10*	*61.09589041*
27	*Insufficient data collection and survey before design*	*11*	*60.82191781*
9	*Slowness in decision making*	*12*	*59.7260274*
8	*Delay in obtaining permits licenses from authorities*	*13*	*59.17808219*
18	*Site handover/Site change*	*14*	*59.17808219*
3	*Incomplete or improper designing*	*15*	*58.63013699*
25	*Conflicts between consultant and design engineer*	*16*	*58.35616438*
28	*Poor use of advanced engineering design software*	*17*	*58.35616438*
20	*Delay in performing inspection and testing*	*18*	*58.08219178*
29	*Unclear and inadequate details in drawings*	*19*	*57.80821918*
17	*Changes in material types and specifications during construction*	*20*	*57.53424658*
4	*Shortage or Delay of material*	*21*	*57.26027397*
16	*Poor procurement strategies of construction material*	*22*	*56.43835616*
24	*Rework due to errors*	*23*	*56.43835616*
30	*Equipment allocation problem*	*24*	*56.43835616*
26	*Sudden failures actions*	*25*	*56.16438356*
13	*Poor quality control*	*26*	*54.52054795*
14	*Location of the Project*	*27*	*54.2465753*

			4
7	Shortage of labors	28	49.8630137
23	Personal conflicts among workers	29	48.21917808
21	Different culture problems	30	47.67123288

Table 5 talks about the ranking of the delay factors on the base of the RII factor. As indicated in Table 6, it is evident that the Political Situation (RII = 0.7068), Delay in Contractor Payment (RII = 0.7041), and Experience of the consultant design team (RII = 0.6904) emerge as the top three influential factors identified by the respondents as major triggers for project delays.

PARETO ANALYSIS RESULTS

The frequency of each delay factor is represented by the bars, and the cumulative percentage of each delay factor is represented by the black line. The graph is

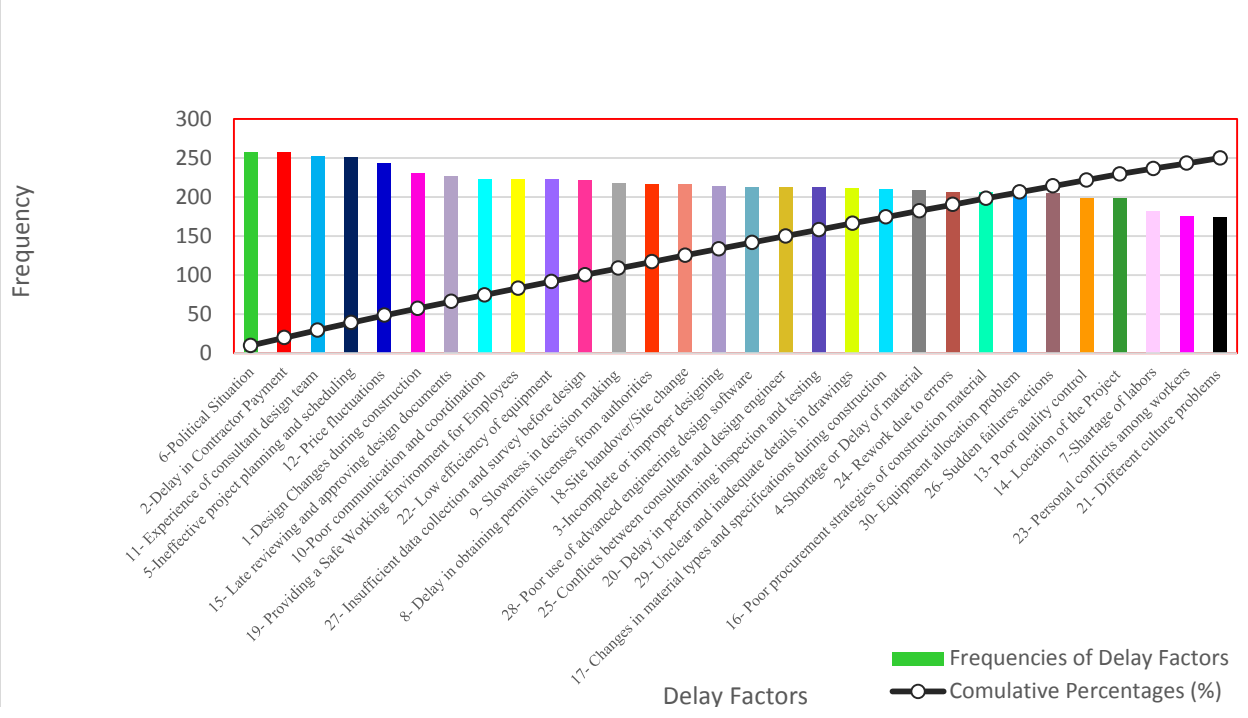


Figure. 4 Pareto analysis of delay factors

accompanied by a cumulative percentage line, showing the cumulative impact of the causes moving from the most significant to the least significant.

By pinpointing these factors, the Pareto Analysis directs attention toward areas that warrant focused intervention and strategic planning to mitigate delays effectively. The implications for construction management are notable. Prioritizing resources and efforts to address these high-impact factors can lead to more effective project

scheduling, budgeting, and coordination. Additionally, this analysis validates the significance of thorough project planning, accurate cost estimation, and robust financial arrangements to ensure smoother project execution.

CLUSTER ANALYSIS RESULTS

The Cluster Analysis, performed using the input data, sheds light on the inherent relationships and patterns among the identified delay factors. This analysis groups factors based on their similarity, offering insights into potential connections and themes that contribute to project delays within the construction domain.

The resulting Cluster Analysis diagram reveals clusters of delay factors that share common characteristics according to respondents' perceptions. Factors positioned closely on the diagram's y-axis signify a higher level of similarity in how respondents view these factors. Conversely, factors placed farther apart on the y-axis indicate distinctions in respondents' assessments of these factors.

There are three clusters of diagrams that have divided the delay factors into groups.

Cluster 1: *Resource and Communication Challenges*

Factors attributed to the first color category resonate with challenges primarily related to resource scarcity and communication deficiencies. This cluster encompasses "Shortage or Delay of material," "Delay in obtaining permits licenses from authorities," "Unclear and inadequate details in drawings," "Rework due to errors," "Sudden failures," "Poor communication and coordination," and "Conflicts between consultant and design engineer." The amalgamation of these factors within this cluster indicates a shared influence on project delays, driven by issues spanning resource unavailability, regulatory hurdles, and communication breakdowns.

Cluster 2: *Design and Decision-Making Complexities*

The second color category encapsulates factors that pertain to intricate design processes and decision-making challenges. This cluster comprises "Changes in material types and specifications during construction," "Experience of consultant design team," "Site handover/Site change," "Poor use of advanced engineering design software," "Slowness in decision making," "Delay in Contractor Payment," and "Equipment allocation problem." The proximity of these factors on the diagram underscores their collective role in causing project delays, highlighting the significance of meticulous design choices and effective decision-making.

Cluster 3: *Miscellaneous Factors*

Factors represented by the third color category are encompassed within the miscellaneous cluster. This grouping includes "Political Situation," "Shortage of labors," "Late reviewing and approving design documents," "Different culture problems," "Insufficient data collection and survey before design," "Poor procurement strategies of construction material," "Location of the Project,"

"Providing a Safe Working Environment for Employees," "Delay in performing inspection and testing," "Low efficiency of equipment," "Personal conflicts among workers," and "Poor quality control." While these factors may not share strong thematic commonalities, they collectively contribute to the narrative of project delays. Their presence in the third cluster emphasizes the diverse range of challenges that collectively impact project timelines.

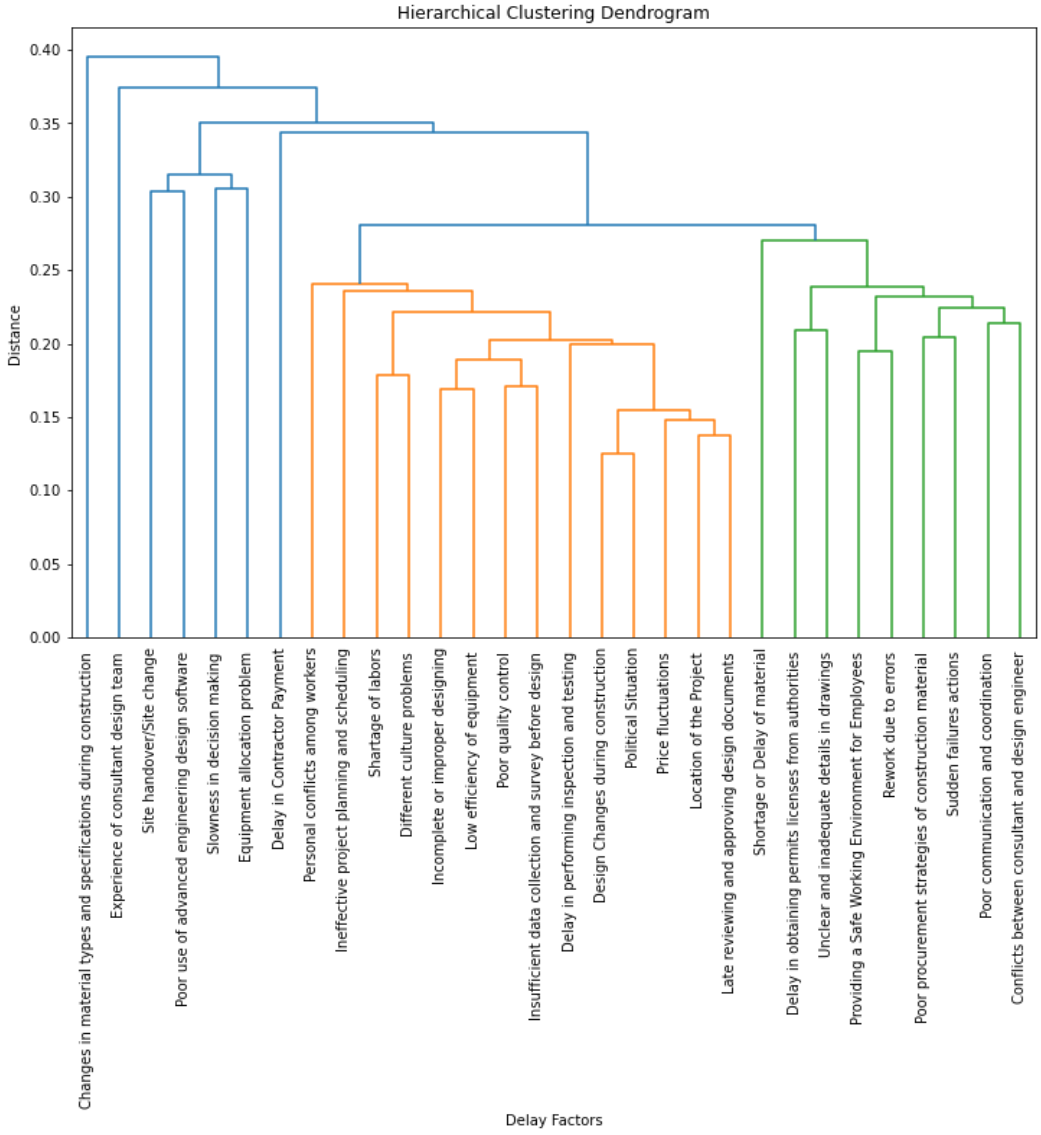
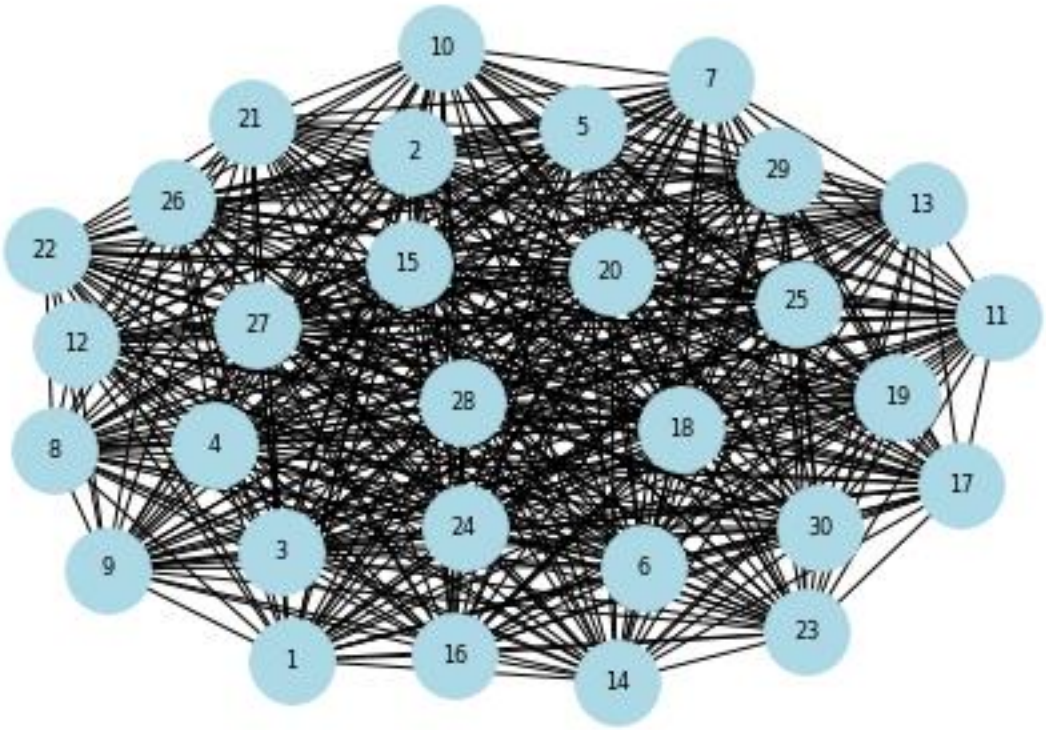


Figure. 5 *Cluster analysis of delay factors*

NETWORK ANALYSIS RESULTS

Each node signifies a delay factor, and the edges illustrate how these factors

are linked to one another based on their co-occurrence, perceived relationships, or shared attributes. This approach goes beyond traditional linear analysis by uncovering the intricate web of interactions that contribute to project delays. The network's structure provides insights into which factors are more central, acting as pivotal points that connect with multiple other factors. These central nodes could represent factors that have cascading effects on other aspects of the project, underscoring their



potential to exacerbate delays.

Figure. 6 Network analysis results

Additionally, clusters or communities of nodes within the network may emerge, indicating subsets of factors that frequently appear together or impact one another. These clusters reveal thematic groupings that contribute collectively to specific project delay sce

CONCLUSION

The study conducted in Khyber Pakhtunkhwa, Pakistan, meticulously identified and categorized construction project delay factors into six distinct categories, shedding light on the multifaceted nature of challenges faced by the

construction industry in the region. Using the Relative Importance Index (RII) method, the research ranked these delay factors based on their impact, revealing " The "Political Situation" emerged as the most potent disruptor, echoing the significance of external influences on construction projects. Delays in contractor payments and the experience of consultant design teams closely followed, underscoring the impact of financial and technical aspects. Thematic clustering illuminated common patterns, revealing resource and communication challenges, design and decision-making complexities, and a range of miscellaneous factors as drivers of project delays. Network analysis uncovered the intricate web of interactions among these factors, emphasizing central nodes that have far-reaching implications for project management. Moreover, the outstanding internal consistency of survey responses instills confidence in the reliability of these findings. This research offers actionable insights for construction stakeholders, highlighting the need for targeted strategies that address both technical and non-technical challenges. In essence, this study provides a valuable foundation for informed decision-making, resource allocation, and policy formulation aimed at enhancing project management practices and fostering timely project completion in Khyber Pakhtunkhwa's construction sector. As the construction industry plays a pivotal role in economic growth, these insights have the potential to drive sustainable development and prosperity in the region. Future endeavors can build upon this research to implement practical solutions that mitigate delays and ensure the successful execution of construction projects.

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