

## IDENTIFICATION AND ASSESSMENT OF CRITICAL RISK FACTORS IN CONSTRUCTION PROJECTS IN KHYBER PAKHTUNKHWA PAKISTAN

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### **Abstract**

This study systematically identifies and analyzes risk factors in construction projects. A review of the literature yielded a list of 34 risk factors, which served as the foundation for empirical research. The survey's reliability was confirmed by a high Cronbach's Alpha score of 0.895, indicating internal consistency. The descriptive analysis identified "High Inflation/Increase in Prices" as the factor with the highest rating (mean score 4.04). "High Inflation/Increase in Prices (RII = 0.73151)," "Shift in Political Leadership (RII = 0.63014)," and "Delayed Payment on Contract (RII = 0.62192)" were the top-ranked risk factors, according to the Risk Index of Importance (RII). Prioritization based on occurrence frequency was followed by Pareto analysis. The study concluded with cluster analysis, which classified 66 respondents according to their risk attitudes and behaviors. According to a probabilistic analysis, "High Inflation/Increase in Prices" has the highest likelihood of occurring in future construction projects. This study provides useful insights for proactive risk management and strategic planning in the construction industry, allowing for informed risk mitigation and project success.

**Keywords.** Construction Industry, Relative Importance Index, Risk Management, Probability of Occurrence, Risk Analysis.

## **INTRODUCTION**

The economic growth rate of developing countries like Pakistan is deeply linked with the construction industries of the country[1, 2]. Serving as a catalyst for progress, the construction industry plays a vital role in shaping today's modern world, providing essential infrastructures that cater to societal needs. It not only improves the regime of a country by providing infrastructure but is also responsible for its development [3]. Moreover, the construction industry significantly contributes to employment generation, providing opportunities for skilled and unskilled labor[4]. As labor-intensive projects, construction ventures empower individuals, uplift communities, and contribute to the overall well-being of society. In consort with its significance, the construction industries face multiple challenges, especially in developing countries[5]. In these challenges, risk is a big and common challenge for all construction industries, and it appears in all construction projects irrespective of their size and scope[6]. In terms of annual business failures and resulting liabilities, the construction industry ranks near the top of other industries. This is due to the fact that it is a risky business with numerous uncertainties that management must deal with[7]. The construction industry is known for its complexity and vulnerability to various risks. The timely completion and success of a construction project depend on the level of risk. The risks can vary based on the project's location, complexity, scale, and other factors. So, each Construction project, irrespective of its size, presents its unique set of risks, with varying degrees of impact on project objectives and deliverables[8,9].

Risk is the possibility or chance of experiencing losses or facing potential danger. Uncertain events or circumstances A risk is something that could have a positive or negative impact on the project's goals. The potential for an event to occur, the likelihood of that event occurring, and the potential consequences of that event occurring are all elements of risk. Risk can be measured and evaluated to assess its probability and potential impact on a particular situation or endeavor. Risk can be measured and evaluated to assess its probability and potential impact on a particular situation or endeavor[10]. These risks may be financial risks, environmental risks, safety risks, accidental risks, etc. Despite the advancement in modern technologies in the construction management field, the construction industry is continuously facing uncertainties and risks[11]. Building risk has received attention as a result of time and cost overruns in construction projects. It is a construction management axiom that a project is considered successful if it is completed on time, under budget, and to a high level of customer satisfaction[12]. Construction sector expansion is a common and contemporary goal of many urban development programs in many countries. The development of the construction business also necessitates knowledge of risk management policies[13, 14]. The risk management technique is employed

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*infrequently due to a lack of understanding and awareness among the general public. The track record is also quite bad in terms of dealing with hazards in projects, which results in project objectives being neglected. Rather than responding to potential future risks, risk management is used to prevent them[15]. Risk management entails both preventing future problems and detecting actual problems as soon as they occur. [16]. Risk is unavoidable and exists in all human situations. It is present in people's daily lives as well as governmental and private sector enterprises[17]. Risk management is becoming a vital aspect for successful project management, as projects get more complicated, and competition becomes stronger by the day. It is feasible to examine project hazards from two perspectives. From the client's perspective, who is crucial to project decision-making, and from the perspective of the contractor, who generally increases costs to hedge risks, However, because the marginal utility is decreasing, the practice is becoming unprofitable. These two groups have different reactions to project hazards and various options for shifting risks to the party best prepared to manage them. In the construction industry, risk management is now reactive, semi-permanent, casual, and unstructured, resulting in a lack of capacity to manage risks correctly[18-20].*

*This research is crucial for a number of reasons in the context of construction projects in Khyber Pakhtunkhwa, Pakistan. By detecting and evaluating key risk variables that could hamper project success, it will aid stakeholders like project managers, contractors, policymakers, and investors in carrying out construction projects more efficiently. Identifying and evaluating key risks is crucial for delivering high-quality infrastructure and long-term benefits to local communities by reducing the likelihood of project delays, cost overruns, and substandard construction. In addition, our research will help lessen the monetary losses and legal conflicts that frequently accompany construction projects fraught with risks and uncertainties. Financial prudence and accountability in the construction industry can be fostered by the proactive management of these risks, which reduces the financial impact of disputes, claims, and project failures. In essence, this study will aid construction sector participants in carrying out projects more effectively and reducing potential dangers.*

### **LITERATURE REVIEW**

*Various risk assessment projects have been conducted by experts in the field of construction, with some focusing on specific project types such as highway projects [21], building projects[22], hydraulics infrastructure projects[23, 24], while others have taken a broader approach by assessing risks across various types of construction projects[25]. These assessments have contributed to a better understanding of the unique challenges and risk factors associated with different project categories and have*

also highlighted commonalities in risk management strategies that can be applied more broadly across the construction industry. A comprehensive literature review reveals multiple studies addressing construction project risk factors and the importance of risk management. Abd Karim et al. (2021) examined construction risks from a contractor's perspective in the Batu Pahat and Muar districts, identifying 25 key risk factors. These factors include material shortages, late deliveries, insufficient technology, poor workmanship, and cash flow difficulties, providing a foundational understanding of risk management in construction projects[26].

In Ethiopia, the construction industry experts identified 17 independent risk factors and one dependent factor (project performance). The most impactful risk factors included inflation, flawed design, poor material quality, delayed payments, and subpar work. In contrast, the least significant risks encompassed worker strikes, unclear scope, access delays, and site inaccessibility[27]. Pejman Rezakhani's 2011 study underscored the necessity of identifying, classifying, and assessing inherent risks in construction projects. It emphasized key risk factors significantly influencing project objectives and introduced a hierarchical risk classification validated through case studies[28].

Vicknayson Thevendran and M.J. Mawdesley 2004 focused on human risk factors in construction projects, highlighting the importance of incorporating these factors into project risk management[29]. Luka Goji Tipili and Muhammad Sa'adiya Ilyasu's 2014 research in the Nigerian construction industry identified and assessed risk factors related to cost overruns and project performance, emphasizing cost and time-related risks' impact[30]. Renuka et al. 2014 's study reviewed critical risk factors in infrastructure development projects, underscoring the need for early risk identification and assessment during the bidding stage to enhance cost and time overrun estimation[31]. Sharma and Swain 2011 addressed the pervasive nature of risks in construction projects, emphasizing the need for effective risk management. Their study aimed to identify, categorize, and mitigate construction project risks and introduced a quantitative approach using the Analytical Hierarchy Process (AHP) [32]. Laila Mohamed et al. 2015 's research identified significant risk probabilities in Egyptian construction projects between January 2011 and January 2013. The study assessed risks' impact on cost, time, and quality-related project objectives and proposed tailored risk response strategies[33].

Sharma & Gupta 2017 assessed risk factors in construction projects and found political risk factors as the top ranking risk the construction projects [34]. The study of Bahamid, Doh, & Al-Sharaf 2019, mainly focused on the risk factors in construction projects of developing countries. 111 risk factors were collected from previous studies and analyzed. A list of 56 risk factor were figured out as the most critical [35]. Sharma & Gupta 2019 worked on risk factors analysis and found five top

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risk factors in construction projects including unavailability of funds, design errors and poor engineering, poor site supervision and management, contractual risks, changes in laws and regulations [36]. Farid, et al. 2020 conducted research in Pakistan to assess risk in construction projects. Unforeseen impediments, payment delays from client and unreasonable and inflexible decisions are ranked as crest risk factors in construction projects [37]. Bahamid, Doh et al. 2020 assessed risk factors in construction projects where they found that 42 factors are the most crucial risk factors among 56 factors affecting the construction projects. Exchange rate fluctuation was found as the top rank risk factor in construction projects [38]. Nguyen et al. 2021 evaluated the risk factors in construction projects of office building in Ho Chi Minh City, Vietnam [39]. The following risk factors are considered as critical factors: natural (storm, rains, climate effects), human made issues (soil instability, safety behavior, owner design change) and schedule risk factors.

Vivek et al. 2022 analyzed 42 risk factors and divided them into four major groups. They evaluate the effect of the risk factors on construction project costs and conclude that the main risk factors included in cost overrun of a project are price fluctuations, quality control and management experience [40]. Yousri et al. 2023, researched the risk factors in construction projects. They used 35 risk factors in the research and conclude that the risk factors in construction projects are contractors funding problems, price fluctuations, unrealistic estimate and shortage of materials in market [41]. Fathi & Shrestha 2023, identified risk factors in the construction projects of public-private partnership namely revenue stream projections, construction risks, design risks language in contract are extracted the top factors [42].

The aforementioned discussion shows that various researchers have used various risk factors and found some critical risk factors. Proper preventative measures should be adopted based on the identified risk factors to ensure projects success. The various techniques like RII are used for analysis of these risk factors but, It needs the modern techniques to identify and assess the risk factors in Khyber Pakhtunkhwa (KP).

**METHODOLOGY DATA COLLECTION**

We carefully crafted a questionnaire survey sheet as a primary instrument of our study. 34 risk factors were extracted from the following literature as demonstrated by Table 1.

Table 1 Risk factors are extracted from the literature.

<b>.NO</b>	<b>Authors</b>	<b>Title</b>	<b>Citations</b>
	(Wang & Chou, 2003)	Risk allocation and risk handling of highway projects in Taiwan	[21]

	(Rezakhani, 2012)	<i>Classifying key risk factors in construction projects</i>	[43]
	(Chien, Wu, & Huang, 2014)	<i>Identifying and assessing critical risk factors for BIM projects</i>	[44]
	(Sharaf & Abdelwahab, 2015)	<i>Analysis of risk factors for highway construction projects in Egypt</i>	[45]
	(Jaber, 2015)	<i>Establishing risk management factors for construction projects in Iraq</i>	[46]
	(Mishra & Mishra, 2016)	<i>A study on risk factors involved in the construction projects</i>	[47]
	(Maseko, 2017)	<i>Identification of risk factors affecting construction of projects</i>	[34]
	(Abd El-Karim, Mosa El Nawawy, & Abdel-Alim, 2017)	<i>Identification and assessment of risk factors affecting construction projects</i>	[48]
	(Sharma & Gupta, 2019)	<i>Risk Identification and Management in Construction Projects</i>	[36]
0	R. A. Bahamid, Doh, & Al-Sharaf, 2019)	<i>Risk factors affecting the construction projects in the developing countries</i>	[35]
1	(Bahamid, Doh, Al-Sharafi, & Rahimi, 2020)	<i>Risk factors influencing the construction projects in Yemen from expert's perspective</i>	[49]
2	(Viswanathan & Jha, 2020)	<i>Critical risk factors in international construction projects: An Indian perspective</i>	[38]
3	(Farid, Kureshi, Babar, & Mahmood, 2020)	<i>Critical risk factors of construction industry of Pakistan for improving project outcome</i>	[37]
4	(Nguyen et al., 2021)	<i>Exploring critical risk factors of office building projects</i>	[39]
5	(Jahan et al., 2022)	<i>Modeling Profitability-Influencing Risk Factors for Construction Projects</i>	[50]
6	(Tessema, Alene, & Wolelaw, 2022)	<i>Assessment of risk factors on construction projects in Gondar city</i>	[27]
7	(Philemon, Msomba, Samson, & Ramadhan, 2022)	<i>Establishing and Ranking of Project Dimensions which Influences Risks Management in Construction Projects</i>	[51]
8	(Vivek & Rao, 2022)	<i>Identification and analysing of risk factors affecting cost of construction</i>	[40]

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		projects	
9	(Issa, Marouf, & Faheem, 2023)	Analysis of risk factors affecting the main execution activities of roadways construction projects	[52]
0	(Yousri, Sayed, Farag, & Abdelalim, 2023)	Risk Identification of Building Construction Projects in Egypt. Buildings	[41]

After extracting these factors from the above research papers, this comprehensive list formed the basis of our investigation. A questionnaire survey sheet was prepared to conduct a survey from industry expert online and receive their response about each factor. The five-point Likert scale was used to evaluate these factors. This questionnaire is distrusted online and received responses online. These questionnaires were elaborately crafted to probe for nuanced associations between the risk factors of interest.

Table 2. List of Risk Factors in Construction Projects

<b>Factors ID</b>	<b>Risk Factors</b>
Factor 1	Safety hazards that lead to worker accidents and injuries
Factor 2	Defective Design
Factor 3	High inflation/increase of prices
Factor 4	Delayed payment on contract
Factor 5	Weather Condition
Factor 6	Poor cost control
Factor 7	Problem with availability of labors, equipment's and material
Factor 8	Defective construction work
Factor 9	Design change by owner
Factor 10	Earthquake effect
Factor 11	Pandemic effect
Factor 12	Effect of time and schedule overrun
Factor 13	Shift in political leadership
Factor 14	change in laws and regulations
Factor 15	inadequate site investigation or incomplete design
Factor 16	Inadequate or low-quality procurements of resources
Factor 17	Unsafe working conditions
Factor 18	Fire effect
Factor 19	Theft effect
Factor 20	Delay in possession of the site
Factor 21	Claims and disputes

Factor 22	<i>Inadequate communications infrastructure</i>
Factor 23	<i>Inability to take timely corrective actions</i>
Factor 24	<i>Lack competent/ experienced persons in the project team</i>
Factor 25	<i>A project being too complex for the available resources</i>
Factor 26	<i>wrong selection of project team</i>
Factor 27	<i>Unforeseen site ground condition</i>
Factor 28	<i>Change in government laws or actions</i>
Factor 29	<i>Difficulty to access the site (very far)</i>
Factor 30	<i>High competition in bids</i>
Factor 31	<i>Monopolization of materials due to closure and other unexpected political situation</i>
Factor 32	<i>Actual quantities differ from contract quantities</i>
Factor 33	<i>Management staff experience and quality level</i>
Factor 34	<i>The price ratio of same product</i>

### **METHODS FIVE-POINTS LIKERT SCALE**

Each factor was rated via the five-point Likert scale. Respondents were given a five-point scale to rate the intensity of each factor: "Very High," "High," "Average," "Low," and "Very Low." For the analysis, these ratings are converted to numerical values. The 5 value is assigned to Very High, 4 to High and so on. The five-point scale is widely used as it is easy and simple for respondents to understand. It provided a balance between offering sufficient details and keeping the survey simple for respondents [53]. This scale is well-established in the literature and extensively studied due to its psychometric properties. The study concludes that the five-point scale exhibits reliability and validity in measuring attitudes and perceptions across various domains [54]. It is widely used in statistical analysis and allows the calculation of mean, standard deviation, and other statistics [55]. Researchers suggested that a five-point scale is easier for respondents to survey, leading towards maximum and accurate responses [56]. It creates a level of comparability and consistency among different field studies and enhances the ability to integrate the findings of present research [57].

### **CRONBACH'S ALPHA DATA RELIABILITY TEST**

Cronbach's alpha, or Cronbach's (alpha), is a statistic used in psychometrics and questionnaire-based research to evaluate the consistency or reliability of a data collection. It determines how well different questions on a test or questionnaire measure the same underlying construct or concept [58]. Cronbach's Alpha is a statistical measure that helps researchers check the reliability and validity of a survey or test questions. This can be calculating the by using Eq. below:

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

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**

Descriptive analysis, a fundamental branch of statistics, involves systematically collecting, organizing, summarizing, and presenting data to distill key characteristics and patterns within a dataset. By employing measures of central tendency, dispersion, and visual representations like charts and graphs, descriptive analysis offers a clear and concise understanding of data, making it accessible to both experts and non-experts, and serving as a foundational step in more advanced data analysis [59]. It is also used to provide ranking of the factors on the basis of their mean values. For descriptive analysis, SPSS statistical software is employed.

### **RELATIVE IMPORTANCE INDEX**

Analysis of the Relative Importance Index (RII) is a common statistical technique used in survey research and multiple regression modelling to rank the importance of individual variables or factors within a dataset [60]. In RII, these independent variables are given relative significance scores and their effects on the dependent variable are measured quantitatively. Market researchers and social scientists can both benefit from this method because it helps them priorities and prioritize the numerous aspects that contribute to a desired outcome [61]. 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**

Pareto analysis is a method for narrowing down potential options based on the observation that a disproportionately high number of outcomes may be traced back to just a handful of factors. The Pareto Principle, or "80/20 rule," proposes that roughly 80% of outcomes derive from 20% of inputs and serves as the basis for this research. The goal of applying Pareto analysis in the real world is to direct attention and resources towards the 20% of a dataset or process that has the greatest potential to make the biggest difference [62]. It is widely employed in quality assurance, corporate management, and issue-solving contexts to zero in on problem areas, identify key drivers of change, and accelerate the decision-making process [63]. Excel

**CLUSTER ANALYSIS**

It is a statistical approach for grouping or clustering respondents based on their answers to a series of survey questions [64, 65]. In this context, the major purpose of cluster analysis is to find patterns or similarities among respondents, which can aid researchers in understanding the traits or preferences of various subgroups within the surveyed population. When dealing with a large dataset and attempting to find underlying structures or segments within the data, this strategy is quite beneficial.

**PROBABILITY OF OCCURRENCE**

The probability of occurrence, sometimes known as "probability," is a measure of the likelihood of a particular event or outcome occurring. It is represented by a number between 0 and 1, where:

A probability of 0 means that the occurrence is impossible and will never happen [66].

The probability of one suggests that the occurrence is certain and will take place.

Probabilities between 0 and 1 describe the degree to which an event is likely to occur, with larger numbers suggesting a greater likelihood.

**RESULTS AND DISCUSSION DIVISION OF RISK FACTORS INTO GROUPS**

In order to present more clearly, the risk factors are divided into different groups based on their relations and on the basis of their levels.

Table 3 division of risk factors in groups and levels

<b>Groups</b>	<b>Risk Factors</b>	<b>levels of Risks</b>
<b>Project Execution and Operational Risk Factors</b>	1. Safety hazards that lead to worker accidents and injuries	micro
	2. Defective Design	macro
	3. Delayed payment on contract	macro
	4. Defective construction work	macro
<b>External and Environment</b>	5. High inflation/increase of prices	macro

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<b>al Factors</b>	6. <i>Weather Condition</i>	<i>acro</i>
	7. <i>Earthquake effect</i>	<i>acro</i>
	8. <i>Pandemic effect</i>	<i>icro</i>
	9. <i>Shift in political leadership</i>	<i>icro</i>
	10. <i>Change in laws and regulations</i>	<i>icro</i>
	11. <i>Difficulty to access the site (very far)</i>	<i>acro</i>
	12. <i>Monopolization of materials due to closure and other unexpected political situation</i>	<i>icro</i>
	13. <i>Change in government laws or actions</i>	<i>acro</i>
	14. <i>The price ratio of the same product</i>	<i>acro</i>
<b>Resource and Team Management Factors</b>	15. <i>Problem with availability of labors, equipment, and materials</i>	<i>icro</i>
	16. <i>Inadequate communications infrastructure</i>	<i>acro</i>
	17. <i>Inability to take timely corrective actions</i>	<i>acro</i>
	18. <i>Lack competent/experienced persons in the project team</i>	<i>acro</i>
	19. <i>A project being too complex for the available resources</i>	<i>acro</i>
	20. <i>Wrong selection of project team</i>	<i>acro</i>
	21. <i>High competition in bids</i>	<i>acro</i>
<b>Design and Planning Factors</b>	22. <i>Poor cost control</i>	<i>acro</i>
	23. <i>Inadequate site investigation or incomplete design</i>	<i>acro</i>
	24. <i>Ineffective project planning and scheduling</i>	

		<i>icro</i>
	<i>25. Slowness in decision-making</i>	<i>icro</i>
	<i>26. Location of the Project</i>	<i>acro</i>
	<i>27. Site handover/Site change</i>	<i>acro</i>
	<i>28. Insufficient data collection and survey before design</i>	<i>acro</i>
	<i>29. Management staff experience and quality level</i>	<i>acro</i>
<b>Other Unforeseen Factors</b>	<i>30. Fire effect</i>	<i>acro</i>
	<i>31. Theft effect</i>	<i>acro</i>
	<i>32. Claims and disputes</i>	<i>icro</i>
	<i>33. Unforeseen site ground condition</i>	<i>acro</i>
	<i>34. Actual quantities differ from contract quantities</i>	<i>icro</i>

**SURVEY RESULTS**

*Among the numerous online distributed questionnaire survey forms, we received responses from 66 experts. Out of these respondents, approximately 98.5% were male, while 1.5% were female. The data was collected from industry experts having experience from 1 to 23 years. The non filled responses are confirmed by the experts again and analyzed.*

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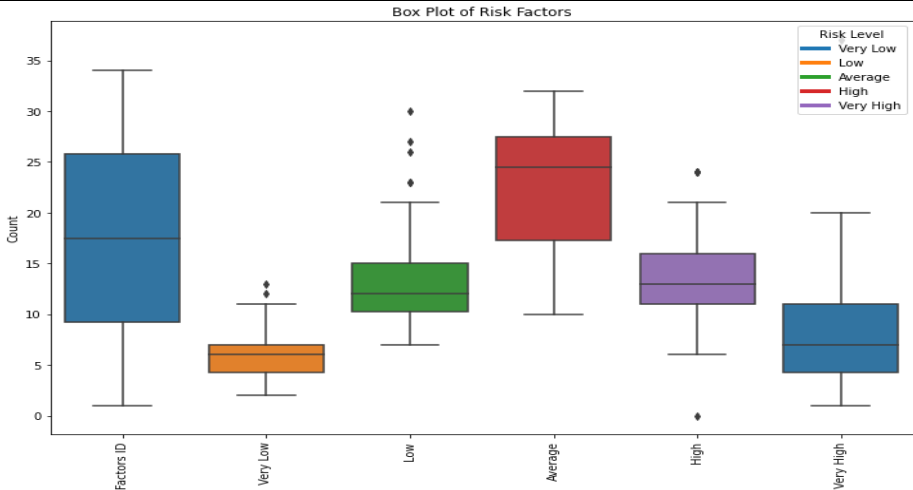


Figure. 1. Frequency of Different Evaluation Categories

The box plot in Figure 1 displays the frequency distribution of risk levels, from 'Very Low' to 'Very High,' for a wide variety of risk factors. Each box displays the data's IQR, while the 'Low' and 'High' whiskers go to the minimum and maximum values within 1.5 times the IQR, respectively. Notably, the color-coding in the plot makes it easier to distinguish between risk levels, making it clear that some risk factors consistently show higher or lower risk levels, while others span a broader range. These results illuminate the multifaceted character of project-related risks and offer useful guidance for developing risk assessment and management plans. Several important features of the box plot shown here shed light on the distribution of risk levels across various risk factors. The median, or the point in the middle of the box, is a reliable indicator of central tendency. The median can serve as a useful benchmark for determining the midpoint of the range of values found within a given risk factor group. In addition, data points outside the whiskers are represented by single dots to highlight possible outliers that require further analysis. Although they are not depicted in the graph, outliers are points in the data that have a risk factor value that is significantly different from the norm. Overall, the plot's readability is improved by including both medians and individual data points, allowing for a more nuanced understanding of the risk distribution within each factor.

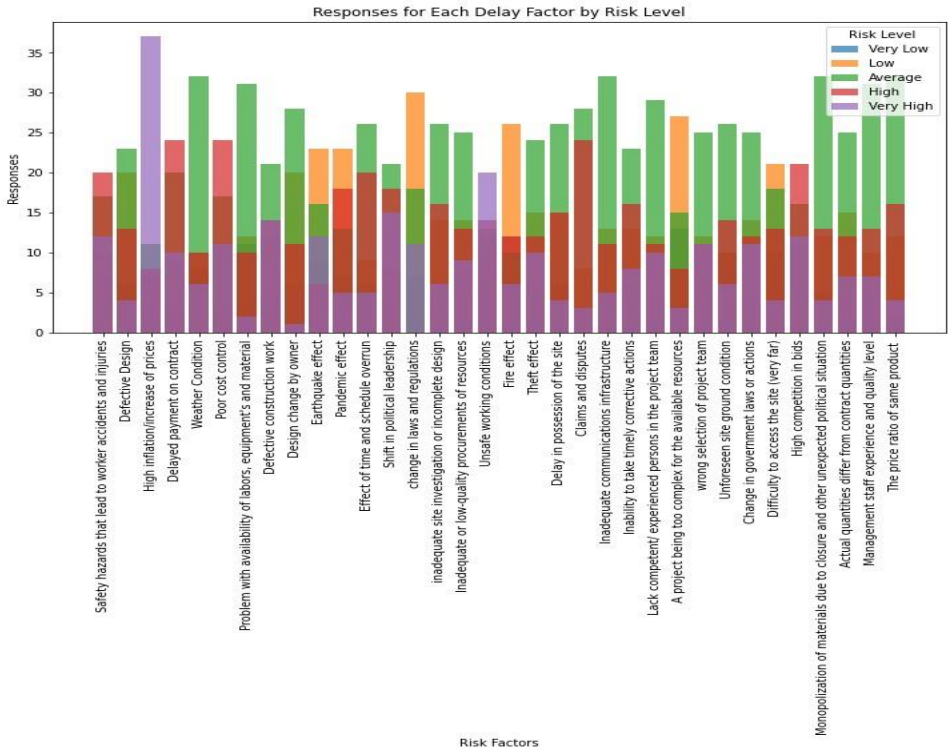


Figure. 2.Responses for each risk factor

Each risk factor is represented in the picture, and its evaluation is indicated by a different color. There is a significant stretch of "Very High" in the third bar. It's possible that the 1st will be chosen as the top one.

**CRONBACH'S ALPHA DATA RELIABILITY TEST RESULTS**

When working with several items or variables, Cronbach's Alpha becomes an important statistical measure for assessing the data's internal consistency. Cronbach's Alpha was computed for the overall group of risk factors in our study using SPSS [58]. The obtained value, around 90%, represents remarkable consistency within these elements. With Cronbach's Alpha that high, it's clear that there's a great degree of reliability in the data collected in this area. This discovery further demonstrates the accuracy of the data and the validity of our results.

Table 4.Cronbach's Alpha

Cronbach's Alpha	N of Items
0.895	34

**DESCRIPTIVE ANALYSIS RESULTS**

Table 5.Descriptive Analysis Results

Descriptive Statistics							
	Minimum	Maximum	um	ean	Std.	Variance	

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						<i>Deviation</i>	
<i>Factor 1</i>	6	1.00	5.00	18.00	.3030	1.23997	1.538
<i>Factor 2</i>	6	1.00	5.00	87.00	.8333	1.04636	1.095
<i>Factor 3</i>	6	1.00	5.00	67.00	4.0455	1.25798	1.583
<i>Factor 4</i>	6	1.00	5.00	27.00	.4394	1.05435	1.112
<i>Factor 5</i>	6	1.00	5.00	94.00	.9394	1.07958	1.166
<i>Factor 6</i>	6	1.00	5.00	227.00	3.4394	1.09725	1.204
<i>Factor 7</i>	6	1.00	5.00	78.00	.6970	1.02236	1.045
<i>Factor 8</i>	6	1.00	5.00	218.00	.3030	1.21490	1.476
<i>Factor 9</i>	6	1.00	5.00	79.00	.7121	0.90749	0.824
<i>Factor 10</i>	6	1.00	5.00	87.00	.8333	1.30777	1.710
<i>Factor 11</i>	6	1.00	5.00	89.00	.8636	1.16205	1.350
<i>Factor 12</i>	6	1.00	5.00	07.00	.1364	1.05081	1.104
<i>Factor 13</i>	6	1.00	5.00	30.00	.4848	1.15349	1.331
<i>Factor 14</i>	6	1.00	5.00	76.00	.6667	1.20682	1.456
<i>Factor 15</i>	6	1.00	5.00	04.00	.0909	1.03370	1.069
<i>Factor 16</i>	6	1.00	5.00	05.00	.1061	1.12494	1.266
<i>Factor 17</i>	6	1.00	5.00	26.00	.4242	1.37069	1.879
<i>Factor 18</i>	6	1.00	5.00	72.00	.6061	1.23884	1.535

Factor 19	6	1.00	5.00	05.00	.1061	1.15197	1.327
Factor 20	6	1.00	5.00	94.00	.9394	1.03595	1.073
Factor 21	6	1.00	5.00	14.00	.2424	0.89547	0.802
Factor 22	6	1.00	5.00	96.00	.9697	0.99181	0.984
Factor 23	6	1.00	5.00	05.00	.1061	1.13854	1.296
Factor 24	6	1.00	5.00	09.00	.1667	1.08958	1.187
Factor 25	6	1.00	5.00	59.00	.4091	1.08099	1.169
Factor 26	6	1.00	5.00	05.00	.1061	1.20421	1.450
Factor 27	6	1.00	5.00	94.00	.9394	1.16195	1.350
Factor 28	6	1.00	5.00	10.00	.1818	1.13557	1.290
Factor 29	6	1.00	5.00	78.00	.6970	1.13639	1.291
Factor 30	6	1.00	5.00	220.00	3.3333	1.21950	1.487
Factor 31	6	1.00	5.00	97.00	.9848	0.96862	0.938
Factor 32	6	1.00	5.00	95.00	.9545	1.12908	1.275
Factor 33	6	1.00	5.00	05.00	.1061	1.03966	1.081
Factor 34	6	1.00	5.00	06.00	.1212	0.88605	0.785

*Insights into the distribution and features of responses related to the 34 risk factors under examination are provided by the descriptive analysis results. There are 66 observations total for each factor, and the summary statistics show that the range of possible responses is from 1.00 (minimum) to 5.00 (maximum). The mean values, which are in the range of about 2.40 and 4.04, show the typical distribution across the factors. In addition, the dispersion and diversity within the replies are further*

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highlighted by the standard deviation and variance values, which range from roughly 0.79 to 1.88. Insight into the internal characteristics and variabilities of the risk variables is crucial for useful data interpretation and analysis, and these statistics paint a full picture of the distribution of the data. As the mean value is also used to rank the factors on the basis of their higher means. The 3<sup>rd</sup> factor of “High Inflation/increase of prices” has the highest mean of 4.04, so it is the top risk factors affecting most of the construction projects. This analysis was performed by using the SPSS [59].

**RESULTS OF RII ANALYSIS**

The risks factors have been subjected to a rigorous analysis using the Relative Importance Index (RII) method, and the results have led to their effective ranking in descending order based on their RII values [67-70]. This figure illustrates the risk factors, each prominently color-coded, with the most influential factors positioned at the top. This ranking provides valuable insights into the relative significance of these factors, facilitating informed decision-making and prioritization of risk management strategies.

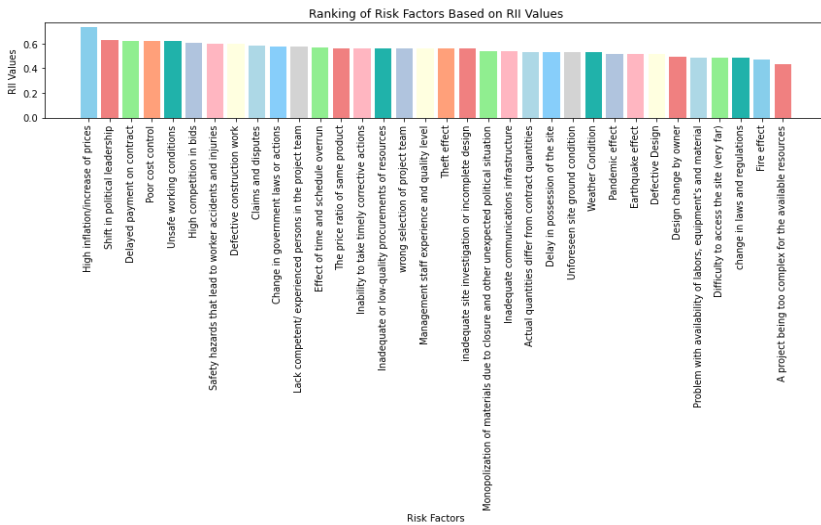


Figure. 3. Ranking of Risk Factors on the Base of RII Value

Table 6. Ranking of Risk Factors on the Basis of RII Values

Factors ID	Risk Factors	Ranking	RII \
2	High inflation/increase of prices	1	.73151
12	Shift in political leadership	2	

			.63014
3	<i>Delayed payment on contract</i>	3	.62192
5	<i>Poor cost control</i>	4	.62192
16	<i>Unsafe working conditions</i>	5	.61918
29	<i>High competition in bids</i>	6	.60274
0	<i>Safety hazards that lead to worker accidents and injuries</i>	7	.59726
7	<i>Defective construction work</i>	8	.59726
20	<i>Claims and disputes</i>	9	.5863
27	<i>Change in government laws or actions</i>	10	.57534
23	<i>Lack competent/ experienced persons in the project team</i>	11	.5726
11	<i>Effect of time and schedule overrun</i>	12	.56712
33	<i>The price ratio of same product</i>	13	.56438
22	<i>Inability to take timely corrective actions</i>	14	.56164
15	<i>Inadequate or low-quality procurements of resources</i>	15	.56164
25	<i>wrong selection of project team</i>	16	.56164
32	<i>Management staff experience and quality level</i>	17	.56164
18	<i>Theft effect</i>	18	.56164
14	<i>inadequate site investigation or incomplete design</i>	19	.5589
30	<i>Monopolization of materials due to closure and other unexpected political situation</i>	20	.53973
21	<i>Inadequate communications infrastructure</i>	21	

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			.53699
31	<i>Actual quantities differ from contract quantities</i>	22	.53425
19	<i>Delay in possession of the site</i>	23	.53151
26	<i>Unforeseen site ground condition</i>	24	.53151
4	<i>Weather Condition</i>	25	.53151
10	<i>Pandemic effect</i>	26	.51781
9	<i>Earthquake effect</i>	27	.51233
1	<i>Defective Design</i>	28	.51233
8	<i>Design change by owner</i>	29	.49041
6	<i>Problem with availability of labors, equipment's and material</i>	30	.48767
28	<i>Difficulty to access the site (very far)</i>	31	.48767
13	<i>change in laws and regulations</i>	32	.48219
17	<i>Fire effect</i>	33	.47123
24	<i>A project being too complex for the available resources</i>	34	.43562

**Pareto Analysis Results**

Pareto analysis, a vital technique for understanding cumulative contributions, was meticulously executed using Python programming to examine the risk factors. The accompanying plot visually represents the risk factors arranged in descending order, with each bar signifying a distinct factor. Simultaneously, the corresponding red line graphically traces the cumulative percentage attributed to each factor. This comprehensive analysis provides an intuitive means of identifying and prioritizing the most influential risk factors for effective decision-making and risk management [71].

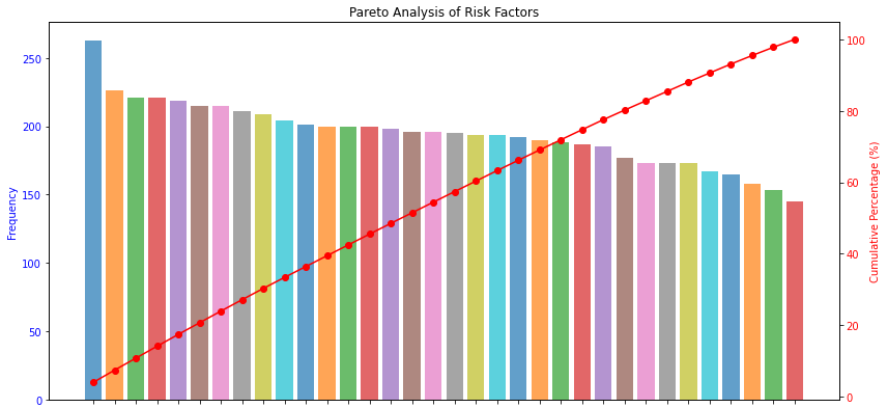


Figure. 4.Pareto Analysis

### CLUSTER ANALYSIS

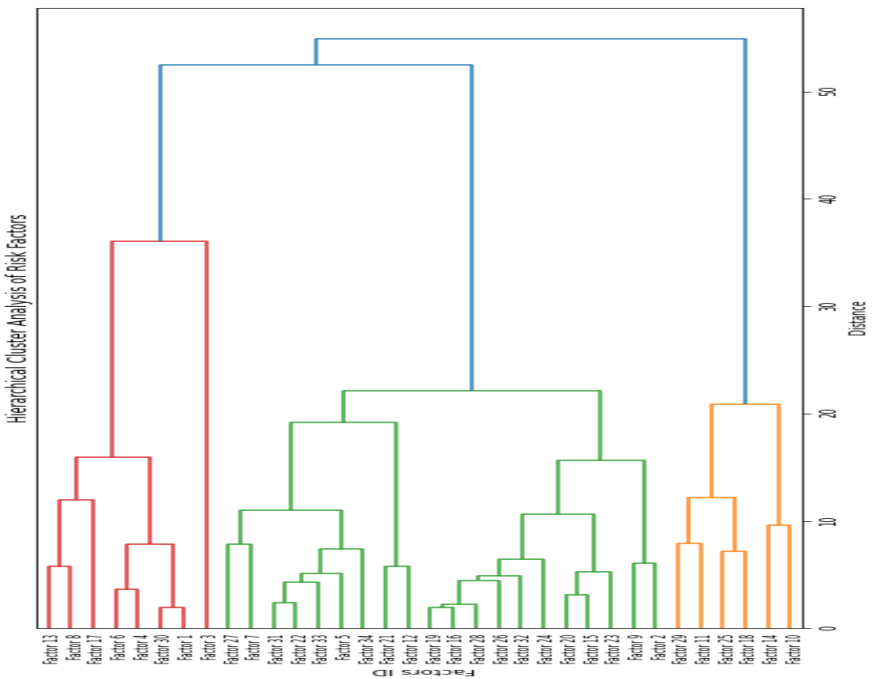


Figure. 5.Cluster Analysis Results

The different factors are divided into 3 main factors. The factors are clustered into groups on the basis of their received responses. The middle cluster shows that these factors are more related to each other [72].

### PROBABILITY RESULTS

The probability of occurrence of each factor was calculated by ranking these factors in ascending order on the base of RII [31] and Weibull plotting position [73]. The factors “High Inflation/increase of price” have 97% probability of occurrence in coming projects. The Table shows the probability of each factor.

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Table 7. Probability Analysis

<b>Risk Factors</b>	<b>Ranking</b>	<b>Probability</b>
<i>High inflation/increase of prices</i>	1	0.9714
<i>Shift in political leadership</i>	2	0.9429
<i>Delayed payment on contract</i>	3	0.9143
<i>Poor cost control</i>	4	0.8857
<i>Unsafe working conditions</i>	5	0.8571
<i>High competition in bids</i>	6	0.8286
<i>Safety hazards that lead to worker accidents and injuries</i>	7	0.8000
<i>Defective construction work</i>	8	0.7714
<i>Claims and disputes</i>	9	0.7429
<i>Change in government laws or actions</i>	10	0.7143
<i>Lack competent/ experienced persons in the project team</i>	11	0.6857
<i>Effect of time and schedule overrun</i>	12	0.6571
<i>The price ratio of same product</i>	13	0.6286
<i>Inability to take timely corrective actions</i>	14	0.6000
<i>Inadequate or low-quality procurements of resources</i>	15	0.5714
<i>wrong selection of project team</i>	16	0.5429
<i>Management staff experience and quality level</i>	17	0.5143
<i>Theft effect</i>	18	0.4857
<i>inadequate site investigation or incomplete design</i>	19	0.4571
<i>Monopolization of materials due to closure and other unexpected political situation</i>	20	0.4286
<i>Inadequate communications infrastructure</i>	21	0.4000
<i>Actual quantities differ from contract quantities</i>	22	0.3714
<i>Delay in possession of the site</i>	23	0.3429
<i>Unforeseen site ground condition</i>	24	0.3143

<i>Weather Condition</i>	25	0.2857
<i>Pandemic effect</i>	26	0.2571
<i>Earthquake effect</i>	27	0.2286
<i>Defective Design</i>	28	0.2000
<i>Design change by owner</i>	29	0.1714
<i>Problem with availability of labors, equipment's and material</i>	30	0.1429
<i>Difficulty to access the site (very far)</i>	31	0.1143
<i>change in laws and regulations</i>	32	0.0857
<i>Fire effect</i>	33	0.0571
<i>A project being too complex for the available resources</i>	34	0.0286

## **CONCLUSION**

*In conclusion, this research has shed light on the intricacies of risk factors affecting construction projects in Khyber Pakhtunkhwa, revealing that High inflation/increase of prices, Shift in political leadership, and Delayed payment on contracts stand out as the most pressing concerns. With a staggering probability of approximately 97%, high inflation threatens to disrupt project budgets and financial stability. The ever-present possibility of political leadership shifts adds a layer of unpredictability, requiring adaptability and strategic planning. Furthermore, the scourge of delayed payments poses a substantial risk to project cash flows and stakeholder relationships. To ensure the success and sustainability of construction projects in this region, it is imperative to employ robust risk mitigation strategies, prudent financial planning, and a proactive approach to address these critical factors. By doing so, stakeholders can navigate these challenges and contribute to the growth and stability of the construction industry in Khyber Pakhtunkhwa. In addition, it's essential to emphasize the broader implications of these findings for the construction industry not only in Khyber Pakhtunkhwa but also for regions facing similar challenges. High inflation, political instability, and payment delays are issues that transcend geographical boundaries and are integral to the global construction landscape. By recognizing and addressing these risk factors effectively, construction stakeholders can establish best practices and strategies that resonate beyond this study's scope. As the construction sector continues to evolve and adapt, the insights from this research provide valuable guidance for industry professionals, policymakers, and stakeholders in enhancing project resilience and overall sector sustainability.*



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