CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ISLAMABAD

Development Of Economic Risk Factor Matrix For Sustainable Project Construction

by

Arsalan Nawaz

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This effort is devoted to my respected and cherishing parents, who helped me through each troublesome of my life and yielded every one of the comforts of their lives for my brilliant future. This is likewise a tribute to my best teachers who guided me to go up against the troubles of presence with ingenuity and boldness, and who made me what I am today.

CERTIFICATE OF APPROVAL

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Abstract

Construction industry is categorized as risk rising and full of challenges. Projects encounter number of risks, which affect the project objectives such as scope, cost, time and quality. Cost is considered as driving force and major problem among risks in construction projects. Like many countries, cost overrun is also considered as significant problem in Pakistan. Hence, this research aims to identify risk factor, which could affect the economically sustainable development of construction project in Pakistan. In order to meet the objectives, a critical literature review was carried out to identify the economic risk factors. Delphi technique was used to identify the significant factors to be included in the research. The Delphi process was concluded in three rounds. Different professionals from the construction field were requested to participate in the process. Based upon the interactions, sixty six (66) economic factors were shortlisted, which were further categorized into seven (07) groups including owner/client, contractor, consultant, political and government, market, technological limitations, and natural causes. A survey questionnaire was developed which was used to obtain the feedback from industry participants. A total of 170 questionnaire were distributed and 101 were received back. The response rate remained almost 60%. Using SPSS, the reliability of the data was checked which satisfied the threshold level of significance, confirming the reliability of data to proceed further with the analysis. In order to observe the data pattern, normality test was performed which resulted in a non-parametric pattern. The perception level criteria of the respondents in a non-parametric data pattern was analyzed using Kruskal Wallis test which remained positive. Economic risk factor matrix was developed for each group level as well as overall basis for top 34 risk factors identified. Impact was categorized into three zones i.e. low, moderate, and high on the bases of their criticality. An overall matrix on the basis of top identified economic risk factors was formulated. Out of thirty four (34), ten (10) factors were observed in high zone and remaining twenty (24) factors were in moderate zone. Scatter analysis was also performed for individual group. In case of owner / client group, the range of likelihood of occurrence and magnitude of impact was 0.35 to 0.61 and 0.25 to 0.42, respectively. For contractor, it remained

0.45 to 6.5 and 0.25 to 0.40. Whereas in case of consultant, it was 0.40 to 0.60 and 0.25 to 0.35 respectively. For the remaining groups like political and government, market related, and technological limitations, it was observed as 0.45 to 0.62 and 0.22 to 0.37, 0.42 to 0.55 and 0.22 to 0.35, 0.40 to 0.56 and 0.22 to 0.30, respectively. This study helped in early better understanding and awareness of economic risk factor. The study has achieved a mile stone in development of economic risk matrix with risk criticality values which is expected to guide the project stakeholders in conducting economic risk analysis during feasibility study. Based upon these analysis, proper remedial measures would be possible for incorporation at planning and strategy level to improve and manage these barriers.

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Abbreviations

ACM Additional Cost of Green Materials
AG Acts of God
BCO Budgeted Cost Overrun
BW Bad Weather
CC Contractual Claims (i.e. time with cost)
CD Claims and Disputes
CEI Changes in Economic Indicators
CG Conflicts with Government
CGP Changes in Government Funding Policies
CL Client
CLP Complexity Level of Projects
CN Consultant
CO Contractor
DAC Delays in Approvals/Change Orders
DC Design Changes
DCD Discrepancies in Contract Documents (Specifications, BOQ, Drawings etc.)
DP Delay in Payments
DRC Delay in Resolving Contractual Conflicts
DSI Delay of Site Instructions
ED Errors in Drawings
EM Equipment Malfunctioning
FC Funding Capacity
FCM Financial Condition of Local Market
FCR Fairness in Construction Laws and Regulations

FFDI Flow of Foreign Direct Investment
GDP Gross Domestic Product
GHG Greenhouse Gases
HCM High Cost of Machineries
ICE Inaccurate Cost Estimates
IDC Inadequate Duration of Contract Period
IETP Inefficient Equipment, Tools, and Plants
IFA Inadequate Financial Arrangements
IFCS Inadequate Financial Control on Site
IGP Inappropriate Government Policies
ILM Inflation in Labor Market
IMC Implementation of Monitoring and Control Systems
IMP Inadequate Man Power
IMT International Market Trends
IRC Industrial Regulatory Change
IRF Interest Rate Fluctuation
IRM Improper Resource Management
ISI Inadequate Site Investigations
ISM Inadequate Site Management
ISM Inappropriate Schedule Management
ISS Improper Site Selection
ITE Inaccurate Time Estimates
LO Likelihood of Occurrence
LPG Legal Proceedings with Government
LPT Lack of Professional Team
LR Lack of Responsibility
MDC Mistakes during Construction
MI Magnitude of Impact
MPF Material Price Fluctuation
MR Market
MT Monopoly of Technology Access

MW Material Wastage
NC Natural Causes
NCS Non-performance of Contractor and Subcontractor
PAR Progress Acceleration Required
PCM Poor Contract Management
PG Political and Government
PIR Poor International Relations
PTD Project Technical Difficulties
QMA Quality of Materials Available in Local Market
RC Risk Criticality
SAP Statutory Approvals and Permits
SC Sustainable Construction
SDM Slow Decision Making
SDM Supply and Demand in Local Market
SIW Slow Inspection of Completed Works
SL Shortage of Skilled Labor
SM Shortage of Materials
TC Tariff Changes
TL Technological Limitations
UCM Unsuitable Construction Methods
UI Unnecessary Interventions
UMS Unprecedented Market Situation
VR Variations
VTR Variations in Tax Regulations

Chapter 1

Introduction

1.1 Background

Now a days, world is facing serious economic and environmental challenges due to increased pressure on natural resources, energy consumption and ever increasing energy prices. Construction industry is one of the major consumer of all these resources [1]. Apart from this, it has also been observed as one of the major sector contributing negative impacts to economy and environment, as high amount resources intake and waste production from the activities of construction and destruction [2].

Keeping in view the impacts, the concept of sustainable development is increasing day by day in all areas of economic sector including construction. Sustainable project construction turned out to be major consideration in any construction activity due to characteristics of economically, environmentally and energy efficient throughout the life cycle. Sustainability in construction industry became force full idea to achieve more and more economic, social and environmental benefits [3]. However, the construction projects are becoming complex and expensive day by day, thus often involving economic, social and environmental challenges. The project owners and stakeholders continue to invest huge amount of finances with high risk of being over scheduled and over budget [4].

Project cost has been a prime considerations and important criteria throughout project management life cycle. The success of project construction is a great concern to stakeholders involved in it, who spend a lot of finance. However, construction sector is continuously facing number of challenges related to expenditure exceeding estimated budget along with delay in completion of project in time. Such factors affect project budget, quality and ultimately organizations profit. Cost overrun in constructions projects has become a common issue and thus posing major challenges to sustainable development.

So, it is important is to identify critical impact factors and activities which may occur from project execution to completion related to economic aspect of sustainability. If not identified in advance, these issues turn out to be risks and may lead to serious effects to project budget and completion subsequently. Therefore, it has becomes important to evaluate and assess these factors for achieving a sustainable economic development.

1.2 Research Motivation

Construction industry is a complex, uncertain and high risk business, where many parties are involved to meet the objectives of the projects. This multidimensional involvement have great impact on project economy and success, either positive or negative, thus leading to greater risks than any other sector of economy. Therefore, the importance of good risk management is increasing day by day as project exceeds deadlines or estimated budget [4]. Effective and efficient economic management directly affects the project budget, performance and completion. Analyzing, economic sustainability in construction has become very vital. Hence, investigations for economic risk factors related to sustainable project construction need to be explored in detail.

1.3 Problem Statement

Construction projects require a handsome expenditure for their execution, figure 1.1. Thus economic factor is also one of the key criteria while evaluating the feasibility of any project. Apart from the expenditure related to prescribed contractual quality requirements, the role of issues/ factors related to the stakeholders involved during the execution of project remain one of the major concern for sustainable development. Frequent changes incorporated during the execution phase of project life cycle may result in serious economic risks. A proper identification of impact level of economic factors during risk analysis at the planning stage has been vital concern in todays construction practices. It would not only act as a key to reduce the effect of these risks challenges but also promote economic sustainability at a very early stage of life cycle for efficient decision making.

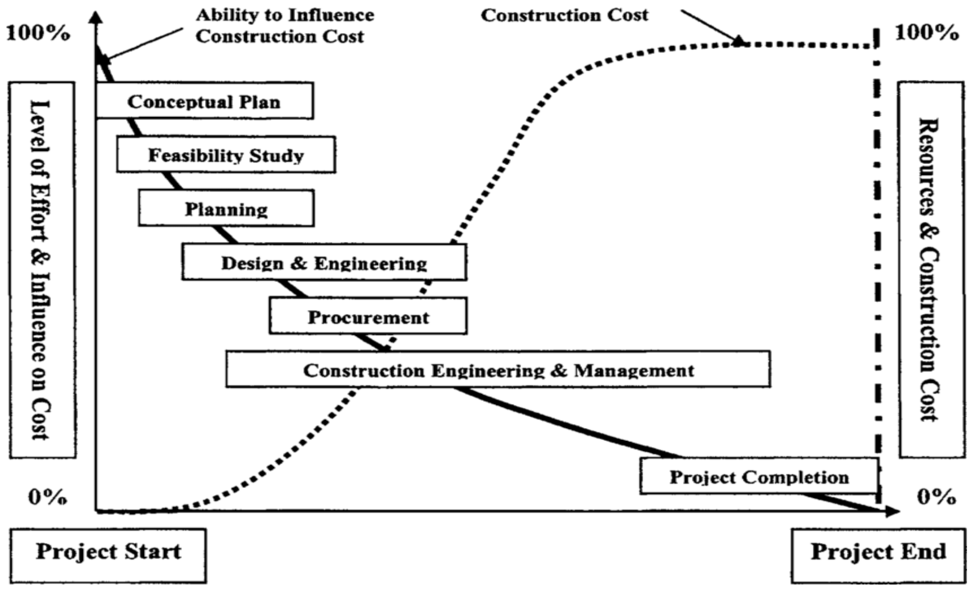

FIGURE 1.1: Cost saving options [5]

1.4 Research Objectives

The objectives of the study are to:

- Identify risk factors involved in project economic management strategy.

- To develop economic risk factor matrix based upon the identified factors to be opted as guidelines for the enhancement of the economic sustainability for future projects.

1.5 Scope of Work

In this research work, an investigations will be carried out to study the economic risk factors for sustainable project construction contributed from stakeholders and external issues. Although, sustainability rest on three pillars economic, social, and environmental respectively, however, in this research the economic pillar of sustainability has been considered. The primary data is collected from local construction industry to develop economic risk matrix.

1.6 Limitations of Study

The research work is limited to local condition of construction industry of Pakistan. The data collected to meet the research objectives was limited to the building projects of the country. Keeping in view aspects of sustainability, only economic aspect has been investigated for construction works in current research.

1.7 Brief Methodology

This research work consisted of three stages. In stage 1, economic risk factors were identified from extensive literature review. In Stage 2, these identified factors were shortlisted and survey instrument was developed using Delphi technique. A field survey using questionnaire was conducted to achieve the relevant data for each of the identified risk factor. In the last phase, the feedback from the industry professionals was analyzed using SPSS and proposed risk matrix developed at group level as well as on overall basis.

1.8 Thesis Layout

The thesis layout comprises of five main chapters

Chapter 1: It is entitled as introduction. It explains some background of sustainable project construction and economic strategy management, research motivation, research objectives, brief methodology with scope and limitations of the study.

Chapter 2: It provides the critical literature review on sustainability and its benefits, and its role in construction. It also overviews definition, economic assessment for previous works, tools and techniques usually adopted.

Chapter 3: This chapter deals with methodology and methods. It details research design, tools, techniques / methodology for data collection and data analysis for further elaborations.

Chapter 4: Results and discussions are presented in this chapter. It comprises of details of tests and analysis, findings and detailed discussions on achieved results and their significance.

Chapter 5: Conclusions have been formulated in this section along with future recommendations.

Chapter 2

Literature Review

2.1 Sustainability

Sustainability is one of the major issues of the world today. It has been defined in many ways. According to the report published in UN World Commission of Economic Development (WCED), "Development that meet the need of present without compromising the ability of future generations to fulfill their own needs" [6]. This report, adopted the conception of sustainability which later achieved a universal recognition.

The explanation of Sustainable development by United Nations "Development is a multidimensional responsibility for the achievement of high standard of living for all people. Whereas, economic, social development and environmental protection are mutually dependent and reinforcement components of sustainable development" [7]. Sustainability and its importance regarding performance of business is very popular, but the attention towards the goal how it can be integrated into an organization's strategy is quite new [8].

There have been two major progresses in the perception of sustainability: The first one is its classification as economic, social and environmental sphere. Secondly, its individuality in terms of strong and weak sustainability. Beside this, it has also gained importance in research of public oriented policies to achieve the above mentioned dimensions of sustainability [9].

The concept of sustainability is being dominated about the welfare of coming generations particularly with limited and non-renewable natural resources. It is general awareness which considers pillars of sustainability as three fundamental dimensions, which directs development requires mutual care of natural, social, and economic capital [10]. Thus, Sustainability has been accredited as essential guideline principle for development of modern societies comprising long term moral association of existing generations with the future ones [11].

2.1.1 Sustainability Spheres

Sustainability having three spheres derived from the Triple Bottom Line concept, figure 2.1. This new framework measures performance using three dimensions such as: social, economic and environment. These three dimensions are commonly named as three Ps: planet, profit, and people. According to triple bottom line concept these profits should be incorporated with care of the plane, set an example by provision of fundamental facilities for people [9] [10].

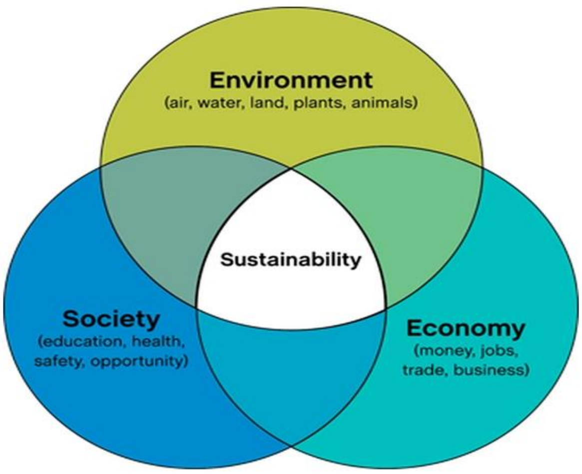

FIGURE 2.1: Triple bottom line concept [10]

2.1.1.1 Environment (Planet)

The term "Planet" concerns to environment, including the effective management of limited and non-renewable natural assets. It also deals with the outcome of industrial development with the aim of minimization of negative ecological impact. Being worried about environmental is compulsory because of its inherent significance as well as to reserve natural resources for upcoming generations [9].

2.1.1.2 Economy (Profit)

"Profit" concerns with the economic viewpoint, emphases the capital generated and propose long-term profits, as well as the organization's business practices impact on the economic system [10]. While sustainable construction consents for the reduction of limited energy resources usage, it is regarded as cost-effective savings [12].

2.1.1.3 Social (People)

"People" concerns social performance, refers to interaction between society and the organization, solving issues related to community [13]. It is the idea of providing value to the community and to conduct fair business to the labor [14].

2.2 Benefits of Sustainability

The benefits of sustainability are categorized as environmental, healthiness and community, financial (economic), market, and industry, along with most of the categories have tributary financial benefits as well. Environmental benefits comprises improvement of eco-systems and protection of biodiversity, improving water and quality of air, reduces waste generation and preserving natural resources [1] [15] [16].

As in case of health and community and social, its benefit include environment developments, enhancing inhabitants' well-being and health, minimizing undue load on infrastructure and improve in the overall excellence of life [17]. Furthermore, improving well-being is not only a moral act but also these enhancements will have an economic worth, along with increase in productivity [18].

Financial benefits as per its characteristics reduce life cycle energy costs, asses' value, elevate economic life cycle, improved indoor air quality, lower employee turnover and longer economic life of the facility, product or service [17]. Additionally, talking about economic benefits of sustainability its benefits in construction sector can never be denied. As green buildings performance is more viable as by design and yield financial benefits of 8% to 9% reduction in operating expenses, 7.5% worth increase of building, return on investment progressed 6.6%, habitation ratio increased of 3.5%, and also rental ratio increase of 3% [18].

2.3 Sustainability in Construction and Economy

According to United Nations Environment Program (UNEP), the construction sector has become a pronounced energy consumer sector, it consumes 40 to 50% of worldwide energy and 40% of raw materials available globally. It has been declared as foremost waste contributor by releasing 40% of greenhouse gas (GHG) emissions and yields 40% of solid waste worldwide [19]. Considering it as one of the principal sources of greenhouse gas emissions sector, its activities are in front of high pressure in declining these emissions. Thus, in recent year sustainable construction has been a serious concern for the stakeholders. An outward shift on business as usual to a sustainable construction have been observed in the sector [20] [21].

However, the construction industry struggles to achieve sustainable construction practices. In addition, construction projects are alleged with numerous challenges and risk because of providing high quality construction, safety protocol, and timely delivery of projects within the estimated budget [20]. Whereas, sustainable construction has progressed as compulsion for environmentally and economically responsive stakeholders and also for the governing bodies [21] [22]. Sustainable construction is a process-oriented practice, plans and techniques of reducing waste generation and consumption of energy throughout entire life cycle of the built environment. It also safeguards the natural environment and preserve resources as viable economically through operative assistance amongst project participants [1].

To attain the goal of green Construction, the adoption of advanced technologies and environmental friendly processes would be a key to sustainable construction [19]. In order to ensure this, targets for future are already set to design new buildings with a 50% reduction in carbon footprint by 2030 [17]. However, if timely and proper management of the risks linked with sustainable projects are not incorporated, they become hurdles on the way to achieve the goal of green construct. Such situations are required to be managed properly by addressing all the three concerned pillars of sustainability [14].

2.4 Role of Economy in Construction Projects

In construction management systems, project success indicators includes completion of project within the estimated budget, schedule, the specified contractual quality standards, safety standards, and environmental limitations [23]. Atkinson [24] has also defined project success criteria of construction project in terms of scope, time and cost as Iron triangle, see figure 2.2.

In project management life cycle, successful accomplishment of project is considered when contractual quality is achieved in the estimated time period and within the estimated budget [9]. Therefore, to ensure that project is proceeding within its defined cost the control on cost performance of project remains important concern. However project cost management, in this regard is necessary to execute and accomplish the project within its specified budget [25]. In construction projects the deprived cost performance affects the stakeholders of the project and confines their capabilities in investing on upcoming projects. This in term slowdowns economic activity in this as well as other industrial sectors [26]. Hence in construction sector, economic measures are required to certify whether the construction projects accomplish in specified time, within the estimated budget and achieve other specified objectives [27].

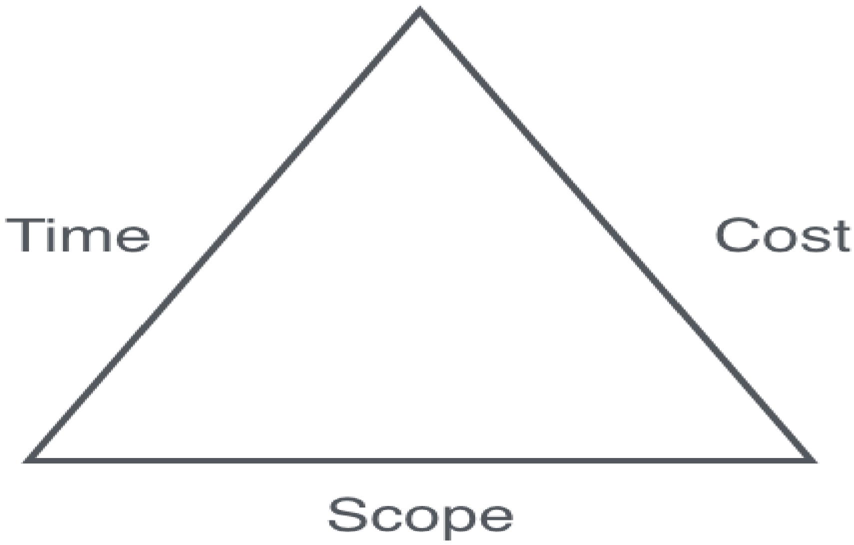

FIGURE 2.2: Iron Triangle [24]

2.5 Factor affecting Economy of Construction Project

Construction projects remain complex since they involve a wide range of human and non-human factors. Therefore, there are various sources of uncertainties in them, comprising the performance of stakeholders involved in it, availability of required resources, ecological conditions, direct and indirect participation of other parties [27]. Zhao et al. [20] highlighted research efforts of numerous researchers regarding identification of factors that have an effect on project time and cost performance globally. The author has also conducted a study in Singapore for risk assessment. The factors included were inaccurate cost estimations, delaying legal documents issuance, unclear details of design and specifications, undefined requirements of clients, poor material supply, damage of equipment and plants, strict safety and health protocols, client intervention , labor and materials price increase, changes in design, delay of payments from clients. These factors were categorized into 11 groups for analysis and top ten risks affecting construction projects were ranked.

Park [28] carried out study on cost overrun factors in Asian region and identified top causes of cost overrun. Rank wise factors were inadequate investigations of site, unexpected condition of site and ground, improper pre-construction studies , inaccurate estimates i.e. cost and time, unproductive duration of contract, incapable sub-contractors, unsuitable procurement route or contract, frequent changes by client leading to variations, poor site management by contractor, adverse weather conditions, acceleration required by client, delay of drawings and site instructions, price fluctuations and unsuitable construction method subsequently. In another study by Olawale and Sun [27], the researcher acknowledged the cost affecting inhabitant factors like changes in design, risks and uncertainty connected with construction projects, incorrect time or duration estimation of project, non-performance of subcontractors and designated suppliers, complications in commencing works, disagreements among stakeholders, inconsistencies in contract documentations, discrepancy in understanding contract and defined specifications, increase of prices, payments for accomplished work, lack of proper training and low skilled manpower as major concerns in this regard.

Memon et al. [29] investigated the factors affecting the large construction projects in Malaysia. From the study it is perceived that assigning contract to lowest bidder, poor site supervision and management by contractors, difficulties faced by contractors like cash flow and financial problems, inappropriate planning and scheduling by contractors, inefficient experience of contractor, shortage of site workers, delay in material procurement, incapable project team such as designers and contractors, materials price fluctuations, inaccurate project duration estimates resulting in schedule delay, communication gap among parties involved, slow decision making practice, unforeseen ground conditions, frequent changes in the scope work and numerous design changes were major economic risks. Lu and Yan [30] explored the measurement of risk among contractors in china. The perceived risks were inflation, design variations, lack of funds, inaccurate quantities estimates and government bureaucracy were major risk factors in contractor's perceptions affecting cost of construction projects. Similarly, in Egyptian construction industry El et al. [23] identified and assessed economic risk which included material price fluctuation, invoices delays, change in currency, owner financial capacity, type of fund, rate of interest, tax rate and project size.

Besides economic risk identification, Boateng et al. [31] worked on risk prioritization in mega projects. Their study concluded that changes in funding policies of government, tax regulation changes, wage and local inflation change, variations in foreign exchange rate, changes in construction material prices , economic recession, energy price increase, interest rate, disastrous environmental effects, and technical difficulties in project were priority wise cost effecting risks. Chileshe and Yivenkyi-Fianko [32] investigated risk factors impact on construction projects cost and discovered that price fluctuations, delayed payment on completed works, inflation, implementation of quality and performance control, construction methods, weather conditions, ground and contaminant conditions, poor financial markets and communication gap among project parties were the factors affecting projects in Ghanaian construction industry. El-Sayegh [33] observed economic risks in UAE construction sector and found that currency rate fluctuation, changes in raw material prices, shortage of materials availability and demand supply, deficiency in manpower availability, absence of equipment at site and equipment broke and damage were major concerns. Zou et al. [34] performed study on understanding key construction projects risk in Chinese construction industry. The study revealed that change orders by the client, fluctuation in construction material prices, design changes, tight project schedule, contractor's difficulty in compensation, incomplete or in-accurate cost estimations, low management capability of contractor, insufficient site information, inadequate program scheduling and bureaucracy of government were the economic factors affecting construction projects.

Evaluating risk patterns, the identified key economic risk factors by Ding et al. [35], included finance and capacity of owner, payment schedule of owner, budget and cash flow planning of owner, changes in regulations, inflation, changes in exchange rate, corruption and bureaucracy. Liu et al. [36] investigated macroeconomic and legal risks among Chinese contractors which analyzed that fluctuation in rate of currency, foreign exchange rate, inflation, interest rate changings, labor and material price fluctuation, changes in rules and regulations, fair implementation of construction laws and regulations, delay in payments, poor international relations. Iqbal et al. [4] highlighted project funding problems, delay in getting permits, changes in codes and regulations, payment delays, consequence of fluctuation in exchange rate, increase in prices, terrorism acts, corruption and bribery at sites and inaccurate estimates of bill of quantities as construction projects risks affecting the economic health in Pakistan. Odeyinka et al. [37] investigated risk issues in cash flow forecasting at projects among UK contracting organizations. They concluded economic risk reasons as changes of initial design, variations to work, labor shortage, delaying claims setting, and estimation errors, delayed or no payments from client, delay in releasing of retention amount increase in prices, accordance with new regulations, changes in interest rate, changes in currency rate and approach to funds at affordable rate of interest. Ling and Lim [38] investigated economic risks in china and found that price fluctuation of material and labor wages, contractor and subcontractor nonperformance, inflation, payments delay, restrictions on import / export, economic failure and interest rate fluctuation affected the economic output of projects.

Jarkas and Haupt [39] in their study considered major risk factors pointed by general contractors in Qatar. The economic risks under consideration among major construction risk were slow decision making process, delayed process of payments by client, frequent changes, error and omissions in drawings, contractor financial difficulties, client's financial stability, frequent changes in statutory regulations, escalation in material prices, poor labor productivity, delay in statutory approvals and permits. Rahman et al. [40] concluded study on large Malaysian construction projects for identifying significant cost overrun causing factors. It was perceived from study that the cost overrun causing risks were fluctuation in materials prices, difficulties faced by contractor regarding finance, mistakes and errors in design, delay in progress payment, inaccurate cost and time estimates and shortage of labor. Eybpoosh et al. [41] using structural equation modeling (SEM) identified risks in international construction projects. Specified economic risks observed were instability of economic conditions, currency rate fluctuations, alterations of economic indicators, high level of bureaucracy, taxation policies revision, change in regulations and policies, conflicts with government, labor and equipment prices fluctuation, change in availability of labor and materials.

Based upon the perceptions of Singapore's contractor lack of financial resources, financial stability of contractor, shortage of resources, inaccurate cost estimates, inaccurate time estimates were reported as risk factors by Hlaing et al. [42]. In another study on risk allocation and importance in contractor's perception delay in resolving contractual conflicts, payments delays, political instability, financial failure, permits and regulations, changes in government regulation and acts of God were economic risk factors in construction industry Pakistan [43]. Hwang et al. [19] pointed out economic risks in Singapore green residential building projects. Fluctuation in exchange rate, inflation, import/ export restrictions, inaccurate estimation, and fluctuation in material and labor prices, in-appropriate interventions of clients were the economic risk concluded. Hwang et al. [44] performed study on critical risk factors in green commercial building projects of Singapore. Increasing labor and material costs, funding capacity of organization, wrong market demand predictions, currency and interest rate volatility, high costs of being green materials and equipment's, changes in regulations were economic risks identified. Al-Sabah et al. [45] evaluating construction risk and their impact in Arabian Gulf region. Identified economic risks were tax rate, currency exchange, increase in prices, quality of resources and availability on site, political instability, bribery and corruption, disputes and strikes. Factors affecting the economy of construction projects are summarized in table 2.1.

Table 2.1: Summary of factors affecting economic aspect of construction projects

Sr. No.	**Author**	**Research Scope**	**Identified Economic Factors**
1	Iqbal et al. [4]	Risk Management in Construction Projects.	Inflation, delay in getting permits, inaccurate estimates of bill of quantities, payment delays.
2	Hwang et al. [19]	An Exploratory Analysis of Risks in Green Residential Building Construction Project: The Case of Singapore.	Import/ export restriction, shortage of funds, inaccurate estimation, fluctuation in material and labor prices, in-appropriate interventions of clients.
3	Zhao et al. [20]	A Fuzzy Synthetic Evaluation Approach for Risk Assessment: Green Projects.	Changes in design, damage of equipment and plants, material and labor price increase.
4	El et al. [23]	Identification and assessment of risk factors affecting construction projects.	Invoices delay, tax rate, fluctuation in prices, and owner financial capacity.
5	Ali and Kamaruzzaman [25]	Cost Performance for Building Construction Project in KLANG Valley.	High cost of machinery, inflation of project cost, construction cost under estimation.
6	Olawale and Sun [27]	Cost and time control of construction projects : inhabiting factors.	Nonperformance of subcontractors, complications in work, weak regulations, low skilled man power.

Sr. No.	**Author**	**Research Scope**	**Identified Economic Factors**
7	Memon et al. [29]	Factors affecting Construction Cost in Mara Large Construction Projects.	Poor site management, inaccurate project duration, cash flow and financial problems.
8	El-Sayegh [33]	Risk assessment and allocation in the UAE construction industry.	Shortage in materials and manpower, equipment broke and damage, material availability and demand.
9	Zou et al. [34]	Under-standing key risks in construction projects in China.	Variations by client, inadequate site information, improper scheduling.
10	Liu et al. [36]	Risk paths in international construction projects: Case study from Chinese contractor.	Funding capacity of owner, change in regulations, inflation, exchange rate, changes in rules and regulations.
11	Jarkas and Haupt [39]	Major construction risk factors considered by general contractors in Qatar.	Frequent change orders, errors in drawings, slow decision making process, delay in statutory approvals, and delay in payments.
12	Rahman et al. [40]	Significant factors causing cost overrun in large construction projects in Malaysia.	Fluctuation in material prices, mistakes during construction, delay in progress payments, labor shortage, and poor financial control on site.

Sr. No.	Author	Research Scope	Identified Economic Factors
13	Hameed and Woo [43]	Risk allocation and importance in the Pakistan Construction Industry.	Acts of God, changes in government regulations, delay in resolving contractual conflicts.
14	Hwang et al. [44]	Green Commercial Building Projects in Singapore: Critical Risk Factor and Mitigation Measures.	In-correct market demand, high costs of green materials and equipments, and change in legal regulations.
15	Al-Sabah et al. [45]	Evaluating impacts of Construction Risk in the Arabian Gulf Region.	Tax rate changes, resources availability and quality, government act, and disputes.

2.6 Economic Risk Management

Risks are alleged as the prospective of undesirable or else adverse magnitudes of an activity or an event. Risks associated with construction projects have been classified into three groups, i.e. economic, design and execution period risk, besides have direct impact on project objectives [34]. In constructions projects among the parties involved in it have different objectives.For contractors, the main objective remain turnover. For clients, the project objectives are prime amalgamation of time, cost, and quality, which also adds to their business objectives [46].

According to Olawale and Sun [27], economic risk management has been a keen area of research and variety of software's have been used as control remedy of projects such as Microsoft Project (MS Project), Asta Power project and Primavera P6 etc. Regardless of this, several construction projects undergo time and cost overruns. Furthermore, cost has been claimed as the most significant and essential for the survival of any project. Cost management is recognized as significant tool in construction, however, the industry still suffers highest rate of failure as compare to any sector of economy [37]. In project management life cycle, cost has been observed as significant constraints and the driving force of project with highly concerned for the parties involved [29]. Besides this recognized importance of cost management, cost overrun has become a common phenomenon and is nearly supplementary with approximately majority of the construction projects in the industry [47]. Many researchers have devoted their work and adopted various tools and techniques for identifying the main reasons behind cost overrun and deficiencies in economic risk management.

2.6.1 Adoption of Tools and Techniques

According to Project Management Institute [48], risk management planning, risk identification, risk analysis, risk response planning, risk monitoring and control has been a keen concern for successful implementation of project management processes. Risk management has become an essential requirement for construction projects. It is an organized procedure for identification, analyzing, and responding to risk affiliated to construction projects. It also includes taking full advantage of the likelihood of occurrence and consequences of constructive features (attributes) thus minimalizing consequences of these adversative factors to project objectives [23]. Many researchers have adopted different methods to investigate and assess the relative importance of risks associated with political, geographical, financial, ecological, governing body and social factors including economic risks [30].

Zhao et al. [20], used a Fuzzy Synthetic Evaluation approach for risk evaluation, calculated the frequency of occurrence, severity of impact and risk criticality of each identified risk factor. Park [28] using regression analysis method, based upon the frequency, impact and significance values obtained through systematic analysis of questionnaire data to rank causes of cost overrun and developed a statistical association among size of project and cost overrun. Zou et al. [34] managed a study on understanding key construction risks in Chinese construction industry. The adopted methodology comprised of risk identification and grouped them into different 7 categories on the bases of source of contribution using questionnaire survey method and statistical analysis. The results were compared with study performed on Australian construction industry. Ali and Kamaruzzaman [25] using questionnaire investigation for data collection performed analysis on SPSS (Statistical Package for social Sciences). Targeted Klang valley for data to identify cost performance for building construction project. El-Sayegh [33] carried out study on risk assessment and allocation in UAE, researcher identified risks from past studies and conducted questionnaire survey to get probability and impact values of risks from respondents for significant economic risk. Further using relative importance index formula ranked the identified risks. Memon et al. [29] used questionnaire survey method and correlation factor formula for the identification of cost affecting factor in Malaysian construction industry. Goh et al. [49] organized a study and used feedback form (questionnaire) method to obtain likelihood of occurrence and level of consequence of factors affecting cost, time, quality, and environmental objective of project. Hwang et al. [19],[44] performed exploratory analysis on risk in green residential and commercial buildings by identifying likely hood (LO) and magnitude of impact (MI), with Likert scale rating and risk criticality (RC) calculated by formula.

Al-Sabah et al. [45] performed descriptive study on identified risks from literature review, to calculate their impact on performance, cost, and schedule and also on performance of the company. Relative importance index (RII), significance score (SS) and principle component analysis formulas were used for systematic analysis. Jarkas and Haupt et al. [39] conducted closed end questionnaire survey using ordinal measurement for ranking. Importance level of each factor and comparative ranks of risks calculated with relative importance index (RII) formula. Dang et al. [35] identified risk factor from literature review and by using questionnaire survey, calculated likelihood and impact for risks and ranked the risk factors on the base of calculated values of probability and impact. Liu et al. [36] carried out questionnaire investigations to rate likelihood and impact of identified risks and calculated risk criticality using formula. . Iqbal et al. [4] conducting questionnaire based study identified risk significance, responsibility of attribute and effectiveness of different risk management techniques. First the study, calculated the cumulative score of each risk and then percentage score was calculated by using average score formula.

2.7 Research Gap Analysis

It has been observed through critical literature review, most of the studies comprises of identification of overall construction risk. The economic aspect has not investigated and reported in detail. Most of the works have reported ranking of risk factors but did not progressed further. In current research work, the risk criticality of each of the identified factor has been investigated and the criticality has been segregated into groups according to their source of contribution i.e. stakeholders which has not been observed in previous works. Based upon the results, a matrix has been developed for economic risk planning at an early stage of project. This aspect of sustainability was still a grey area requiring attention. Apart from this, majority of the highlighted studies were conducted outside of Pakistan, even though some of the characteristics of construction projects are similar worldwide but specific conditions like geographical, gross domestic product (GDP), construction sector require research in detail. The study, which addressed the critical area which need more consideration for proper management and serving as guidelines, helps the experts while planning the economic management of future construction projects.

Chapter 3

Research Methodology

This chapter describes the procedure of research work and approaches adopted for the achievement of the proposed objectives. A detailed literature review was conducted to establish the research gap. Delphi technique guided to develop a questionnaire for data collection. Gathered data was analyzed using statistical software and results were discussed. Detailed research methodology adopted in current research is explained in the subsequent sections.

3.1 Research Design

This research work has been designed to identify the economic risk factor affecting construction projects to achieve goals of economically sustainable project construction. Based upon the research objectives, a critical review of literature was conducted to study the related areas of research work and identifying the economic risk factors. Delphi technique was used to short list significant factors and to develop data acquisition instrument. Survey questionnaire was adopted as data acquisition tool based on the feedbacks from respondents. The findings from the survey were examined using statistical software and risk rankings were found which affect project economy. Results and conclusions were made after analyzing the data. Figure 3.1, details the graphical presentation of method adopted in current research.

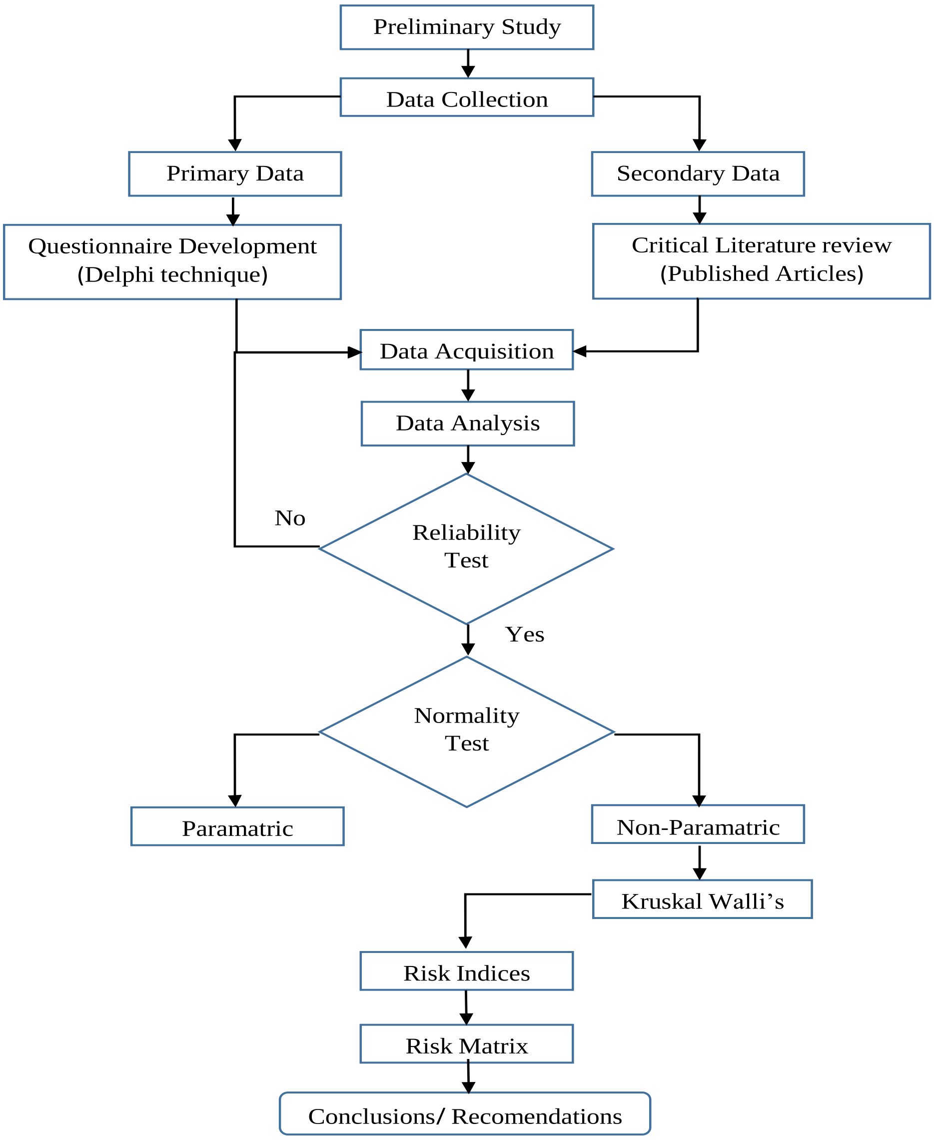

FIGURE 3.1: Research design flow chart

3.1.1 Preliminary Study

A preliminary study was conducted to gain essential knowledge about the topic and to ascertain the base of the research. Based on this study, problem statement was also developed, and research objectives were established.

3.1.2 Data Collection

Data comprises of two types, first one is primary data and the other is secondary data.

3.1.2.1 Primary Data

It was acquired through survey instrument, with the aim to get risk factors affecting economy of construction projects, and further development of economic risk factor matrix.

3.1.2.2 Secondary Data

Secondary data has been gathered through critical literature review of previous work and published relevant articles.

3.1.3 Literature Review

Critical literature review was performed to find out the risk factors that affect economy of construction projects. After gathering the relevant research articles and other relevant publications, the economic risk factors were identified. These factors were scrutinized and further categorized into groups.

3.1.4 Questionnaire Development

After critical literature review, Delphi technique was used to develop a survey questionnaire for data acquisition. Delphi is a process of group interactions and discussions involving researchers, specialists and identified experts. It has been used to acquire a consent on the subject of future developments, policy making and predictions by gathering information from experts and practitioners in a systematic way [50]. Usually, focus group discussions, nominal group technique and Delphi technique are being adopted for feedbacks. However, Delphi technique provides discussions, indirect interactions along with retrace-able written feedback process and reduced social pressure makes it more comprehensive, clear and efficient process than other methods [57]. The Delphi technique proceeds by the following steps, refer figure 3.2. Three round of Delphi technique were adopted in current study.

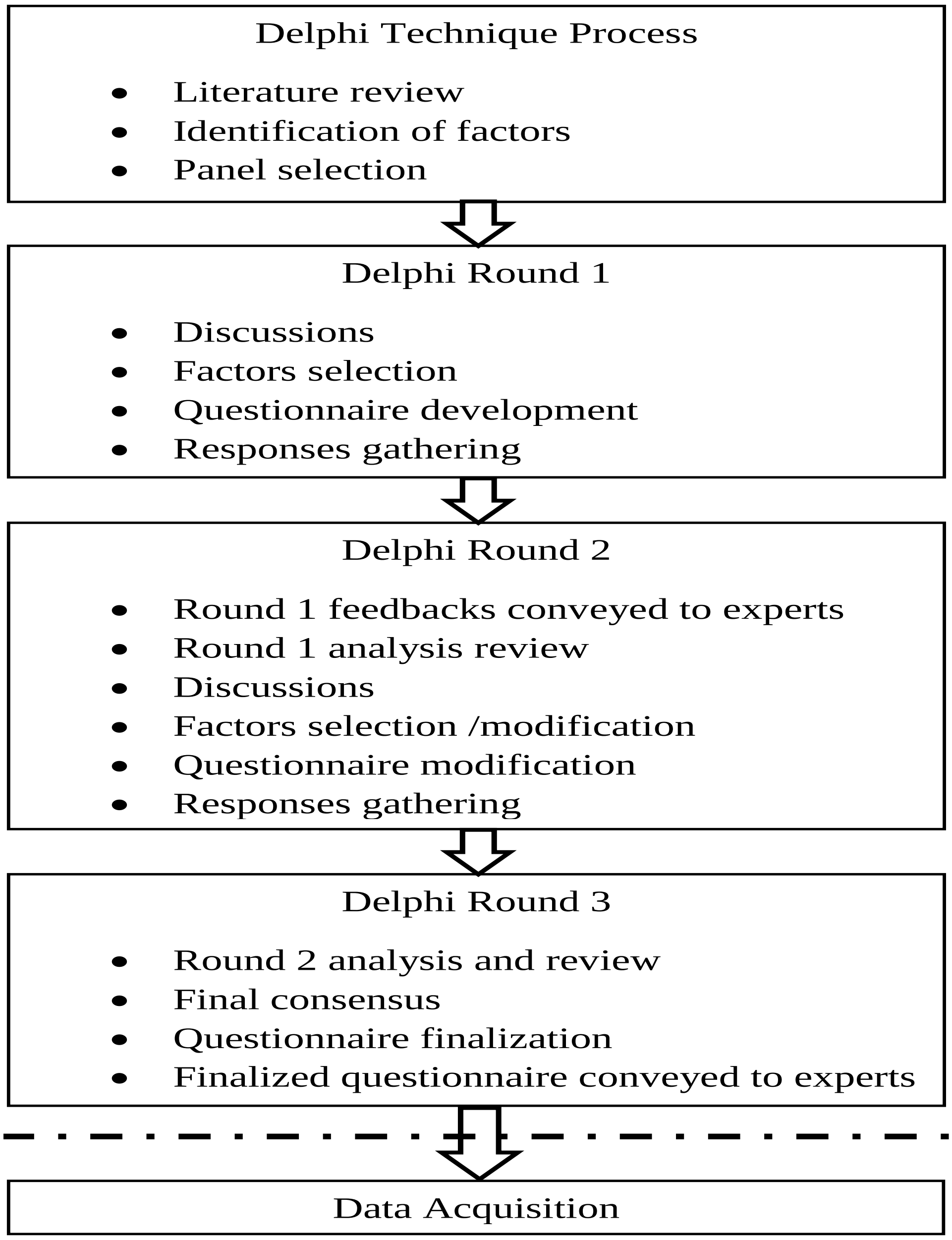

FIGURE 3.2: Delphi technique process adopted

Table 3.1, shows back ground of selected industry professional involved in this study to provide their valuable feedbacks for identification of significant factors and development of questionnaire. On the basis of responses gathered from experts, factors were shortlisted to be included in questionnaire for further data collection.

TABLE 3.1: Background of participants

Participants	**Designation**	**Experience**	**Category**	**Sector**
A	Assistant-Professor (CEM)	10 to 15 Years	Academia	Private
B	Principle Engineer	Up to 10 Years	Consultant	Public
C	C.E.O	20 to 25 Years	Contractor	Private
D	Assistant Director Services	10 to 15 Years	Client	Public
E	Deputy director	Up to 10 Years	Client	Public
F	Chief Engineer	15 to 20 Years	Contractor	Private
G	Director Planning	20 to 25 Years	Client	Public
H	Procurement Engineer	5 to 10 years	Client	Public
I	Manager Projects	15 to 20 Years	Contractor	Private
J	Design Engineer	10 years	Consultant	Public

After comprehensive discussion and feedback from experts, scrutiny of factors list for the current study is detailed in table 3.2. These factors were used to develop the questionnaire which has been presented in Annexure A.

Table 3.2: Identified factors

Identified Risks	**Inclusion Status**										
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**Total**
Delay in Payments	✓	✓	✓	✓	✓	✓	✓		✓		8
Variations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
Inadequate financial arrangements	✓		✓	✓		✓	✓	✓		✓	7
Unnecessary interventions	✓	✓	✓		✓		✓		✓	✓	7
Delays in approvals/ change orders	✓	✓	✓	✓	✓	✓	✓	✓		✓	9
Approved Design changes	✓	✓	✓		✓			✓	✓	✓	7
Improper site selection	✓	✓	✓		✓	✓		✓	✓	✓	8
Slow decision making	✓	✓		✓		✓	✓	✓	✓		7
Funding capacity		✓	✓	✓	✓	✓	✓	✓	✓		8
Longer period of maintenance*		✓				✓			✓		3
Budgeted cost overrun	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
Non-performance of contractor and subcontractor	✓	✓	✓	✓	✓		✓	✓	✓	✓	9
Material wastage	✓		✓		✓	✓		✓	✓	✓	7
Mistakes during construction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
Inadequate financial control on site	✓		✓	✓	✓	✓		✓	✓	✓	8
Contractual claims (i.e. time with cost)	✓	✓	✓		✓	✓		✓	✓	✓	8
Inappropriate schedule management		✓	✓		✓	✓	✓		✓	✓	7

Identified Risks	**Inclusion Status**										
Improper resource management	✓		✓	✓	✓	✓		✓	✓		7
Progress acceleration required	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
Inadequate site management	✓		✓	✓		✓	✓	✓	✓	✓	8
Inadequate duration of contract period	✓	✓	✓	✓	✓	✓	✓	✓		✓	9
Inadequate man power	✓	✓	✓			✓	✓	✓	✓	✓	7
Contractor work load*			✓		✓		✓		✓		4
Tendering maneuvers by contractor*								✓			2
Lags in cash flow*										✓	1
Lack of cash reports during construction*	✓			✓			✓		✓		4
Strikes by site personnel *			✓		✓	✓	✓	✓			5
Slow inspection of completed works	✓		✓	✓	✓	✓	✓	✓	✓		8
Delay of site instructions	✓		✓	✓	✓	✓		✓	✓	✓	8
Errors in drawings	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
Inaccurate time estimates	✓			✓	✓	✓	✓	✓	✓	✓	8
Lack of responsibility	✓	✓	✓			✓	✓	✓	✓		7
Lack of professional team	✓	✓	✓	✓	✓		✓		✓		7
Delay in resolving contractual conflicts	✓	✓	✓	✓	✓	✓		✓	✓	✓	9
Inaccurate cost estimates	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10

Identified Risks	**Inclusion Status**										
Discrepancies in contract documents (specifications, BOQ, drawings etc.)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
Inadequate site investigations	✓		✓	✓	✓		✓	✓	✓		7
Poor contract management	✓	✓	✓	✓		✓	✓	✓	✓		8
Claims and disputes	✓	✓	✓	✓	✓	✓	✓	✓		✓	9
Interest rate fluctuation	✓	✓	✓	✓	✓	✓	✓	✓		✓	9
Variations in tax regulations	✓	✓		✓	✓	✓			✓	✓	7
Fairness in construction laws and regulations	✓	✓		✓	✓	✓		✓	✓		7
Changes in government funding policies	✓	✓	✓		✓	✓	✓		✓		7
Statutory approvals and permits	✓	✓	✓		✓	✓	✓		✓		7
Industrial regulatory change	✓	✓		✓		✓	✓		✓	✓	7
Tariff changes	✓		✓	✓	✓	✓	✓		✓		7
Legal proceedings with government	✓		✓	✓	✓	✓	✓		✓	✓	8
Conflicts with government	✓	✓	✓	✓	✓	✓		✓	✓	✓	9
Inappropriate government policies	✓	✓	✓		✓	✓	✓	✓	✓		8
Poor international relations	✓	✓	✓	✓	✓	✓	✓	✓			8
Political instability*		✓	✓			✓		✓			4

Identified Risks	**Inclusion Status**										
Government transitions*								✓		✓	2
Corruption and bureaucracy*		✓			✓				✓		3
Source of funding*			✓				✓				2
Funding issues*	✓						✓				2
Lack of experience of local regulations*	✓			✓			✓		✓	✓	5
Energy saving uncertainties*			✓				✓		✓		3
Inflation in labor market	✓	✓	✓		✓	✓		✓	✓		7
Material price fluctuation	✓		✓		✓	✓	✓	✓	✓	✓	8
Financial condition of local market		✓	✓	✓		✓		✓		✓	6
Supply and demand in local market	✓	✓	✓		✓	✓	✓			✓	7
Unprecedented market situation	✓	✓			✓	✓	✓	✓		✓	7
International market trends	✓	✓			✓	✓	✓	✓	✓	✓	8
Flow of foreign direct investment	✓		✓	✓	✓		✓	✓		✓	7
Quality of materials available in local market	✓	✓	✓	✓	✓	✓	✓		✓	✓	9
Shortage of materials		✓	✓	✓	✓	✓	✓	✓	✓		8
Shortage of skilled labor		✓	✓		✓	✓	✓		✓	✓	7
Changes in economic indicators	✓	✓	✓	✓		✓	✓				6
Labor disputes*	✓					✓				✓	3
Project technical difficulties	✓	✓	✓	✓	✓	✓	✓		✓	✓	9

Identified Risks	**Inclusion Status**										
Equipment malfunctioning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
Additional cost of green materials	✓	✓	✓			✓	✓	✓	✓		7
High cost of machineries	✓	✓	✓	✓	✓	✓	✓	✓			8
Implementation of monitoring and control systems	✓	✓	✓		✓	✓	✓		✓		7
Unsuitable construction methods	✓	✓	✓	✓	✓	✓	✓		✓	✓	9
Complexity level of projects	✓	✓	✓	✓	✓	✓				✓	7
Inefficient equipment, tools, and plants	✓	✓	✓	✓	✓	✓	✓		✓	✓	9
Monopoly of technology access		✓	✓	✓		✓	✓		✓	✓	7
Acts of God	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
Bad weather	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10

Note: * factors excluded in second round of Delphi technique.

3.1.4.1 Response Measurement Scale

To gauge the impact, five-point scales were used in compliance with PMI, [51]. In order to achieve impact level in terms of risk criticality two factors has been studied:

1. **Likelihood of Occurrence**

   A risk's likelihood of occurrence scale lied between 0.0 (no probability) and 1.0 (certainty). Table 3.3 presents concerning scale.

Table 3.3: Likelihood measurement scale

Likelihood of Occurrence	
LO	Value
Very Low	0.1
Low	0.3
Moderate	0.5
High	0.7
Very High	0.9

2. **Magnitude of Impact**

   The risk's impact scale measures the level of consequence that risk pose on project objectives. Table 3.4 presents the scale values adopted for magnitude of impact.

Table 3.4: Impact scale

Magnitude of Impact	
MI	Term
0.05	Very Low
0.1	Low
0.2	Moderate
0.4	High
0.8	Very High

3.1.5 Data Acquisition

After development of instrument, a survey was conducted. Questionnaire was distributed among 170 industry professionals working in different public and private organizations.

3.1.6 Data Analysis

The gathered data was analyzed as detailed below:

3.1.6.1 Data Reliability

Reliability test is used to determine internal consistency of a research instrument. It is usually expressed in terms of Cronbach's alpha with a scale ranging from 0.0 to 1.0. A value 0.0 indicates lack of consistency whereas a value near 1.0 indicates high consistency in a set of data. Its value above 0.7 is considered acceptable and indicates that data acquired stands reliable for further analysis [39].

3.1.6.2 Normality Test

Normality test, usually named as Shapiro-Wilk test is used to assess either the collected data belongs to normal distributed or not. It is used when sample size is small, medium and up to 5000 [52]. For the data to be normally distributed (parametric data), the significance should be larger than 0.05 and value less than 0.05 specifies that the distribution pattern of data is not normal (non-parametric data).

3.1.6.3 Parametric and Non-parametric Analysis

While performing statistical tests, choosing between parametric and nonparametric tests occurs when data fail to meet assumptions of the test. It is very important to use valid tests according to data characteristics which includes data distribution, sample size, data measurement i.e. continuous, ordinal, and ranked. Parametric test perform well with continuous and normally distributed (specific pattern) and spread of each group is different in other words data is linear. While, non-parametric tests are used when data measured in ordinal and ranked scale, follows no specific distribution and shows a non-linear behavior.

3.1.6.4 Kruskal Wallis Test

Kruskal-Wallis is the statistical test used to measure if three or more separate groups (e.g. clients, consultants and contractors) have similar or varying perception concerning a non-normally distributed variable by ranking the variable of interest and comparing the ranks instead of means. For analyzing non-normally distributed data, Kruskal Wallis test is preferred and on the other hand for parametric data one-way ANOVA is suggested for better results. The results are tested against significance level of 0.05. If the value is more than 0.05 it specifies that all the groups have identical opinion regarding a variable and vice versa [53, 56].

3.1.6.5 Likelihood, Impact and Risk Criticality

1. **Likelihood (Probability)**

   Likelihood is the risk probability that a risk will occur, rated on five-point scale represented in Table 3.3; the LO of identified risks was computed using equation (1), [19].

   $$\mathbf{LO}^i = \frac{1}{n} \int_{j=1}^{n} \boldsymbol{LOij} \qquad \mathbf{(1)}$$

   Where,

   LO^i = the likelihood assessment of risk i.

   n = number of respondents.

   $LO^i{}_j$ = the weightage of likelihood of risk i given by respondent j.

2. **Magnitude of Impact**

   Magnitude of impact is the consequence of the risk on project objective, if the risk event occurs, rated on five-point scale indicated in table 3.4; MI of each risk calculated using equation (2).

   $$\mathbf{MI}^i = \frac{1}{n} \int_{j=1}^{n} \boldsymbol{MIij} \qquad \mathbf{(2)}$$

   Where,

MI^i = the impact weightage of risk i.

n = number of respondents i.e. 101 in this study.

$MI^i{}_j$ = the magnitude of impact weightage of risk I given by respondent j.

3. **Risk Criticality**

Analysis of risks using likelihood of occurrence and magnitude of impact assists in identifying those risks that should be managed on first priority. A risk criticality index (RCI) formula was adopted to obtain criticality of risks following the recommendations [34, 44]. The RC of a risk factor can be calculated using the equations (3) and (4)

$$\mathbf{RC^i{}_j = LO^i{}_j \ x \ MI^i{}_j \ (single)} \qquad \mathbf{(3)}$$

$$\mathbf{RC^i = \frac{1}{n} \int_{j=1}^{n} \boldsymbol{RCij} \ (multiple)} \qquad \mathbf{(4)}$$

Where,

$RC^i{}_j$= is the criticality weightage of risk i given by respondent j.

$LO^i{}_j$= is likelihood of occurrence rated by respondent j for risk i.

$MI^i{}_j$ = is magnitude of the impact respondent j valuated for the factor i.

RC^i= is the computed criticality of risk factor i.

n = number of respondents i.e. 101 in this case.

The scale of RC ranges from 0.05 to 0.72.

3.1.7 Risk Matrix Development

It is semi-quantitative method adopted for the assessment of risks associated to construction projects. A classical tool and common way agreed to combine the two dimensions of risk on a single view point. It demonstrates the multiplication of values designated to likelihood of occurrence and magnitude of impact in order to determine the category of risk for evaluation and mitigation, whether it is low, moderate or high category risk.

The standard risk matrix, used to ascertain the zonal distribution of identified factor bases upon the criticality values of risk has been adopted from PMBOK [51]. A 5 x 5 matrix has been used with impact scale ranges from Very low to Very high on the horizontal axis, figure 3.3. With the same range for likelihood of occurrence of risk factors is represented on the vertical axis of the matrix. In this matrix, three level with three colors have been used. The red color presented high risk critical importance and should be addressed first, yellow represents moderate risk can be coped with time or second in priority, and green for low risk may be ignored or addressed with least priority, [54, 55].

Risk Criticality for Specific Risk					
LO	Risk Criticality = LO x MI				
0.9 V.H	0.05	0.09	0.18	0.36	0.72
0.7 H	0.04	0.07	0.14	0.28	0.56
0.5 M	0.03	0.05	0.10	0.20	0.40
0.3 L	0.02	0.03	0.06	0.12	0.24
0.1 V.L	0.01	0.01	0.02	0.04	0.08
	0.05 VL	0.1 L	0.2 M	0.4 H	0.8 V.H
	Impact (MI)				

Figure 3.3: Risk Matrix [51]

Chapter 4

Results and Discussions

This chapter provides the details of the data gathered through survey, and its analysis adopting statistical tools. Results have been discussed in detail.

4.1 Questionnaire Survey

Detailed field survey was conducted through questionnaire. The questionnaire consisted of 66 economic risk factors, based upon the concerns of previous research works categorizing them into seven groups as detailed below, shortlisted through three rounds of Delphi technique.

1. Client.
2. Contractor.
3. Consultant.
4. Political and Government.
5. Market.
6. Technological limitations.
7. Natural causes.

Respondents were asked to rate the likelihood of occurrence and magnitude of impact for the risk factors on a scale provided. Total 170 questionnaires were distributed among various professionals working in different public and private construction organizations. 101 responses were received resulting a response rate of 59.41%. This number of responses have already been supported by study conducted by Dillman [58] and Lesser et al. [59]. When population size is unknown any sample size greater than 96 can be assumed as reasonable [60].

4.1.1 Characteristics of Respondents

As per the response data, out of 101 respondents 29% were from owner/ client, 33% from consultant and 39% from contractor. Grouping of respondents is shown in figure 4.1.

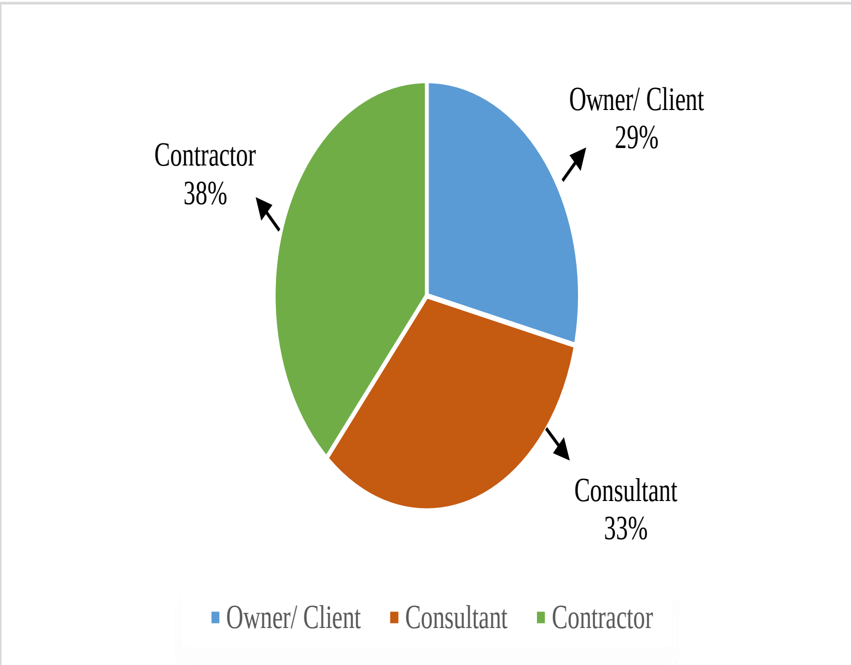

FIGURE 4.1: Respondents Grouping

The level of experience was also the variable being observed for the participating professionals. Approximately 34.66 % have an experience less than 5 years, 29.70

% with range of 5 to 10 year of experience, 23.77 % have 10 to 15 years, 8.91 % with 15 to 20 years of experience whereas 2.97 % of respondents possessed an experience of more than 20 years. Figure 4.2 depicts the experience level of respondents.

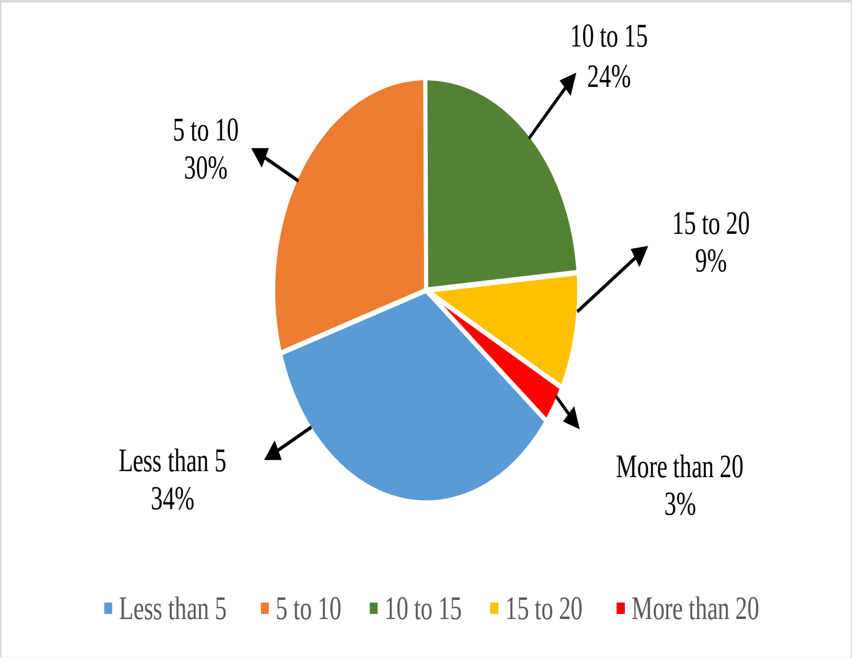

FIGURE 4.2: Experience of respondents

4.2 Statistical Analysis

The collected data was statistically analyzed step by step as follows.

4.2.1 Reliability of Sample

Reliability test known as Cronbachs alpha method frequently managed to measure internal consistency of collected data, especially when collected using Likert scale. A value of alpha greater than 0.7 specifies that data is consistent for further analysis. The results of reliability test performed on likelihood and impact data have been presented in table 4.1 and 4.2 respectively.

Table 4.1: Data reliability value of likelihood

Statistics		**Case Summary**			
Cronbach's Alpha	Number of Items	Cases		Number	%
.882	66		Valid	101	100
			Excluded [a]	0	.0
			Total	101	100
a. List wise deletion based on all variables in the procedure					

Table 4.2: Data reliability value of impact

Statistics		**Case Summary**			
Cronbach's Alpha	Number of Items	Cases		Number	%
.923	66		Valid	101	100
			Excluded [a]	0	.0
			Total	101	100
a. List wise deletion based on all variables in the procedure					

For the current study, Cronbach's alpha of 0.882 for likelihood data and 0.92 for magnitude of impact data was obtained. In both cases, the alpha observed higher value than 0.7 which confirmed the consistency of data achieved.

4.2.2 Normality Test

After the reliability of data, it was essential to examine the distribution pattern of the data. Shapiro-Wilk test was performed in this regard to assess whether the data was normally distributed (parametric) or not (non-parametric). The following hypothesis formulate the standard criteria for the test [52].

H_0: if p > alpha level retain H_o (Sample has normal distribution).

H_1: if $p <$ alpha level reject H_o (Sample has non-normal distribution).

Whereas, alpha level = 0.05. From the results of Shapiro-Wilk test, it was noted the significance value for both LO and MI of 0.000 were obtained, table 4.3.

Table 4.3: Shapiro-Wilk test results

Sr. No	**Factors Code**	**Likelihood of Occurrence (LO)**			**Magnitude of Impact (MI)**		
		Statistic	df	Sig.	Statistic	df	Sig.
1	CL1-DP	.897	101	.000	.784	101	.000
2	CL2-VR	.913	101	.000	.769	101	.000
3	CL3-IFA	.911	101	.000	.798	101	.000
4	CL4-UI	.905	101	.000	.786	101	.000
5	CL5- DAC	.901	101	.000	.776	101	.000
6	CL6-ADC	.913	101	.000	.832	101	.000
7	CL7-ISS	.884	101	.000	.807	101	.000
8	CL8-SDM	.896	101	.000	.810	101	.000
9	CL9-FC	.907	101	.000	.786	101	.000
10	CO1-BCO	.882	101	.000	.829	101	.000
11	CO2-NCS	.909	101	.000	.812	101	.000
12	CO3-MW	.892	101	.000	.764	101	.000
13	CO4-MDC	.905	101	.000	.811	101	.000
14	CO5-IFCS	.902	101	.000	.830	101	.000
15	CO6-CC	.903	101	.000	.794	101	.000
16	CO7-ISM	.913	101	.000	.807	101	.000
17	CO8-IRM	.894	101	.000	.788	101	.000
18	CO9-PAR	.907	101	.000	.755	101	.000
19	CO10-ISM	.895	101	.000	.771	101	.000
20	CO11-IDC	.896	101	.000	.821	101	.000
21	CO12-IMP	.911	101	.000	.795	101	.000
22	CN1-SIW	.914	101	.000	.792	101	.000
23	CN2-DSI	.887	101	.000	.825	101	.000

Sr. No	Factors Code	Likelihood of Occurrence (LO)			Magnitude of Impact (MI)		
24	CN3-ED	.900	101	.000	.822	101	.000
25	CN4-ITE	.898	101	.000	.781	101	.000
26	CN5-LR	.913	101	.000	.794	101	.000
27	CN6-LPT	.908	101	.000	.818	101	.000
28	CN7-DRC	.912	101	.000	.819	101	.000
29	CN8-ICE	.914	101	.000	.833	101	.000
30	CN9-DCD	.906	101	.000	.832	101	.000
31	CN10-ISI	.913	101	.000	.791	101	.000
32	CN11-PCM	.896	101	.000	.815	101	.000
33	CN12-CD	.897	101	.000	.817	101	.000
34	PG1-IRF	.903	101	.000	.827	101	.000
35	PG2-VTR	.894	101	.000	.770	101	.000
36	PG3-FCR	.914	101	.000	.786	101	.000
37	PG4-CGP	.887	101	.000	.788	101	.000
38	PG5-SAP	.912	101	.000	.763	101	.000
39	PG6-IRC	.890	101	.000	.787	101	.000
40	PG7-TC	.905	101	.000	.772	101	.000
41	PG8-LPG	.917	101	.000	.755	101	.000
42	PG9-CG	.891	101	.000	.808	101	.000
43	PG10-IGP	.914	101	.000	.814	101	.000
44	PG11-PIR	.913	101	.000	.798	101	.000
45	MR1-ILM	.909	101	.000	.778	101	.000
46	MR2-MPF	.913	101	.000	.781	101	.000
47	MR3-FCM	.905	101	.000	.828	101	.000
48	MR4-SDM	.910	101	.000	.821	101	.000
49	MR5-UMS	.906	101	.000	.795	101	.000
50	MR6-IMT	.906	101	.000	.768	101	.000
51	MR7-FFDI	.907	101	.000	.775	101	.000

Sr. No	**Factors Code**	**Likelihood of Occurrence (LO)**			**Magnitude of Impact (MI)**		
52	MR8-QMA	.910	101	.000	.775	101	.000
53	MR9-SM	.915	101	.000	.766	101	.000
54	MR10-SL	.916	101	.000	.798	101	.000
55	MR11-CEI	.892	101	.000	.778	101	.000
56	TL1-PTD	.898	101	.000	.768	101	.000
57	TL2-EM	.906	101	.000	.773	101	.000
58	TL3-ACM	.893	101	.000	.756	101	.000
59	TL4-HCM	.916	101	.000	.765	101	.000
60	TL5-IMC	.906	101	.000	.758	101	.000
61	TL6-UCM	.916	101	.000	.769	101	.000
62	TL7-CLP	.907	101	.000	.746	101	.000
63	TL8-IETP	.910	101	.000	.800	101	.000
64	TL9-MT	.905	101	.000	.747	101	.000
65	NC1-AOG	.902	101	.000	.819	101	.000
66	NC2-BW	.913	101	.000	.770	101	.000

The resulted significance value is less than the alpha level of 0.05, thus rejecting the null-hypothesis (H_o), it concludes to accept the alternative hypothesis. Therefore, data does not belongs to normal distribution. In other words, it belongs to non-parametric data, so further analysis will be performed by using non-parametric tests.

4.2.3 Kruskal Wallis Test

Since the data belonged to non-parametric category, so it was important to check the perception level of respondents. In this scenario, Kruskal Wallis test was performed to measure such level. This test checked whether respondents have similar or varying perception regarding each identified factor. The following hypothesis formulate the standard criteria to observe respondents perception [53] [56]:

H_0: if $p >$ alpha level retain H_o all median are equal (Same perception).

H_1: if $p <$ alpha level reject H_o at least one median is different (Variation in perception).

Whereas, alpha level = 0.05. Table 4.4 shows the output for perception level of respondents.

TABLE 4.4: Kruskal Wallis test results

Sr. No.	**Code**	**Likelihood of Occurrence (LO)**	**Magnitude of Impact (MI)**
		Sig.	Sig.
1	CL1-DP	.280	.101
2	CL2-VR	.554	.778
3	CL3-IFA	.810	.204
4	CL4-UI	.413	**.033**
5	CL5- DAC	.573	.316
6	CL6-ADC	.069	.943
7	CL7-ISS	.543	.879
8	CL8-SDM	.491	.308
9	CL9-FC	.994	.238
10	CO1-BCO	.101	.559
11	CO2-NCS	.270	.145
12	CO3-MW	.997	.567
13	CO4-MDC	.384	.385
14	CO5-IFCS	**.013**	.813
15	CO6-CC	.421	.984
16	CO7-ISM	.347	.252
17	CO8-IRM	.388	.978
18	CO9-PAR	.946	.690
19	CO10-ISM	.635	.431
20	CO11-IDC	.601	.195

Sr. No.	**Code**	**Likelihood of Occurrence (LO)**	**Magnitude of Impact (MI)**
		Sig.	Sig.
21	CO12-IMP	.687	.251
22	CN1-SIW	.544	.871
23	CN2-DSI	.758	.357
24	CN3-ED	.448	.506
25	CN4-ITE	.787	.840
26	CN5-LR	.358	.684
27	CN6-LPT	.157	.594
28	CN7-DRC	.073	.644
29	CN8-ICE	.059	.283
30	CN9-DCD	.436	.393
31	CN10-ISI	.975	**.040**
32	CN11-PCM	.180	.725
33	CN12-CD	.779	.383
34	PG1-IRF	.483	.241
35	PG2-VTR	.792	.995
36	PG3-FCR	.504	.989
37	PG4-CGP	**.030**	.332
38	PG5-SAP	.153	.730
39	PG6-IRC	.467	.154
40	PG7-TC	.343	.810
41	PG8-LPG	.102	.236
42	PG9-CG	.412	.118
43	PG10-IGP	.319	.119
44	PG11-PIR	.713	.633
45	MR1-ILM	.086	.642
46	MR2-MPF	**.026**	.631
47	MR3-FCM	.099	.228

Sr. No.	**Code**	**Likelihood of Occurrence (LO)**	**Magnitude of Impact (MI)**
		Sig.	Sig.
48	MR4-SDM	.633	.869
49	MR5-UMS	.455	.964
50	MR6-IMT	.994	.076
51	MR7-FFDI	.885	.338
52	MR8-QMA	.991	.804
53	MR9-SM	.852	.799
54	MR10-SL	.347	.179
55	MR11-CEI	.125	.202
56	TL1-PTD	**.017**	.370
57	TL2-EM	**.004**	.993
58	TL3-ACM	.226	.586
59	TL4-HCM	.483	.354
60	TL5-IMC	.492	.524
61	TL6-UCM	.903	.538
62	TL7-CLP	.678	.495
63	TL8-IETP	.978	.901
64	TL9-MTA	.056	.402
65	NC1-AOG	.546	.306
66	NC2-BW	.282	.229

The results suggested that the respondents had similar perceptions about probability of occurrence and impact level regarding most of the factors, except few factors that have been highlighted in table above. As most of the respondents agreed to same perceptions, so the data analysis can be further performed for risk indices.

4.2.4 Categorization of Factors

During analysis process, based upon the feedback, the shortlisted factors were categorized into groups keeping in view their source of origin/contribution. The factors were categorized into seven groups i.e. owner/client, contractor, consultant, political and government, market, technological limitations, and natural causes. Based upon the perceptions of stakeholders involved, risk indices were formulated to establish ranking for each of the identified risk factor.

4.3 Risk Indices

The data was analyzed to develop risk criticality of each factor using equation (3), which were further ranked on the bases of risk criticality values. Table 4.5 shows the LO, MI, RC and ranking of factors.

TABLE 4.5: LO, MI and RC Values

Group	**Factors Code**	**Likelihood (LO)**	**Impact (MI)**	**RC**	**Rank**
		Mean	Mean		
Owner / Client	CL1-DP	0.6	0.27	0.16	16
	CL2-VR	0.5	0.24	0.12	55
	CL3-IFA	0.55	0.27	0.15	23
	CL4-UI	0.5	0.25	0.13	46
	CL5- DAC	0.49	0.29	0.14	35
	CL6-ADC	0.47	0.34	0.16	16
	CL7-ISS	0.39	0.29	0.11	64
	CL8-SDM	0.47	0.33	0.16	16
	CL9-FC	0.52	0.29	0.15	23
Contractor	CO1-BCO	0.61	0.38	0.23	1
	CO2-NCS	0.56	0.38	0.21	2

Group	**Factors Code**	**Likelihood (LO)**	**Impact (MI)**	**RC**	**Rank**
		Mean	Mean		
	CO3-MW	0.54	0.25	0.14	35
	CO4-MDC	0.54	0.33	0.18	7
	CO5-IFCS	0.52	0.32	0.17	11
	CO6- CC	0.56	0.32	0.18	7
	CO7-ISM	0.52	0.32	0.17	11
	CO8-IRM	0.59	0.28	0.17	11
	CO9-PAR	0.55	0.27	0.15	23
	CO10-ISM	0.47	0.29	0.14	35
	CO11-IDC	0.56	0.33	0.19	4
	CO12-IMP	0.53	0.33	0.18	7
Consultant	CN1-SIW	0.49	0.28	0.14	35
	CN2-DSI	0.49	0.3	0.15	23
	CN3-ED	0.44	0.31	0.14	35
	CN4-ITE	0.46	0.28	0.13	46
	CN5-LR	0.52	0.29	0.15	23
	CN6-LPT	0.52	0.32	0.17	11
	CN7-DRC	0.45	0.31	0.14	35
	CN8-ICE	0.47	0.35	0.16	16
	CN9-DCD	0.45	0.33	0.15	23
	CN10-ISI	0.53	0.3	0.16	16
	CN11-PCM	0.48	0.31	0.15	23
	CN12-CD	0.56	0.33	0.19	4
Political and Government	PG1-IRF	0.55	0.36	0.2	3
	PG2-VTR	0.48	0.28	0.13	46
	PG3-FCR	0.5	0.25	0.13	46
	PG4-CGP	0.6	0.29	0.17	11

Group	**Factors Code**	**Likelihood (LO)**	**Impact (MI)**	**RC**	**Rank**
		Mean	Mean		
	PG5-SAP	0.46	0.25	0.12	55
	PG6-IRC	0.51	0.25	0.13	46
	PG7-TC	0.52	0.26	0.14	35
	PG8-LPG	0.49	0.24	0.12	55
	PG9-CG	0.51	0.31	0.16	16
	PG10-IGP	0.51	0.3	0.15	23
	PG11-PIR	0.48	0.26	0.13	46
Market	MR1-ILM	0.5	0.27	0.14	35
	MR2-MPF	0.5	0.29	0.15	23
	MR3-FCM	0.53	0.31	0.16	16
	MR4-SDM	0.51	0.3	0.15	23
	MR5-UMS	0.51	0.29	0.15	23
	MR6-IMT	0.48	0.25	0.12	55
	MR7-FFDI	0.53	0.26	0.14	35
	MR8-QMA	0.51	0.27	0.14	35
	MR9-SM	0.49	0.27	0.13	46
	MR10-SL	0.53	0.33	0.18	7
	MR11-CEI	0.46	0.27	0.12	55
Technology limitation	TL1-PTD	0.48	0.26	0.13	46
	TL2-EM	0.42	0.25	0.11	64
	TL3-ACM	0.5	0.24	0.12	55
	TL4-HCM	0.52	0.28	0.15	23
	TL5-IMC	0.47	0.25	0.12	55
	TL6-UCM	0.48	0.24	0.12	55
	TL7-CLP	0.56	0.25	0.14	35
	TL8-IETP	0.47	0.26	0.12	55
	TL9-MTA	0.44	0.25	0.11	64

Group	**Factors Code**	**Likelihood (LO)**	**Impact (MI)**	**RC**	**Rank**
		Mean	Mean		
Natural Causes	NC1-AOG	0.45	0.43	0.19	4
	NC2- BW	0.47	0.27	0.13	46

4.4 Risk Matrix

Economic risk factor matrix was developed for each group level and as well as overall basis for top 34 risk factors identified. Factor were categorized into three zones i.e. low, moderate, and high on the bases of their criticality.

4.4.1 Economic Risk Matrix at Individual Group Level

4.4.1.1 Owner/ Client Economic Risk Matrix

From the nine identified factors pertaining to client/ owner perspective, individual risk matrix based upon the values of risk criticality, figure 4.3.

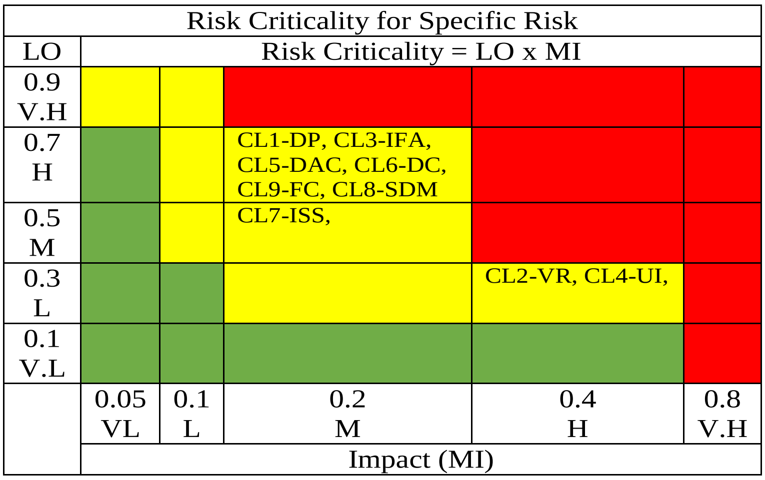

FIGURE 4.3: Owner/client risk matrix

It has been observed that all risk factors are in moderate zone and follow a pattern as:

1. Out of 9, 6 factors in this group lied in region of high likelihood and medium impact.

2. Improper site selection was the factor lied in medium likelihood and medium impact region of matrix.

3. Remaining two factors were observed in low likelihood and high impact region.

4.4.1.2 Contractor Economic Risk Matrix

Twelve risk factors were contributed to contractor's economic risk group. The developed matrix on the base of risk criticality value has been shown in figure 4.4.

Risk Criticality for Specific Risk					
LO	Risk Criticality = LO x MI				
0.9 V.H			CO4-MDC, CO6-CC, CO11-IDC, CO12-IMP		
0.7 H			CO5-IFCS, CO7-ISM, CO8-IRM, CO9-PAR, CO10-ISM, CO3-MW		
0.5 M				CO1-BCO, CO2-NCS	
0.3 L					
0.1 V.L					
	0.05 VL	0.1 L	0.2 M	0.4 H	0.8 V.H
	Impact (MI)				

FIGURE 4.4: Contractor risk matrix

Interestingly half of the factors out of 12 lied in critical zone whereas remaining lies in moderate zone. The zone wise distribution of risk factors is as follows.

1. Among 12 risk factors, 4 with high risk criticality were lied in very high likelihood and medium magnitude impact termed as high risk zone.

2. Half of the total risk factors were placed in high likelihood of occurrence and medium impact zone on the bases of their risk criticality.

3. Two risk factors lied in high risk zone having medium likelihood of occurrence and high magnitude of impact.

4.4.1.3 Consultant Economic Risk Matrix

This group consisted of twelve risk factors representing consultant economic risks, to study their likelihood and impact. The developed matrix on the base of risk criticality values has been shown in figure 4.5.

Risk Criticality for Specific Risk					
LO	Risk Criticality = LO x MI				
0.9 V.H			CN12-CD		
0.7 H			CN1-SIW, CN2-DSI, CN3-ED, CN5-LR, CN6-LPT, CN7-DRC,CN8-ICE, CN9-DCD, CN10-ISI, CN11-PCM		
0.5 M					
0.3 L				CN4-ITE,	
0.1 V.L					
	0.05 VL	0.1 L	0.2 M	0.4 H	0.8 V.H
	Impact (MI)				

FIGURE 4.5: Consultant risk matrix

However, in this case only one factor lied in high risk zone. The developed matrix depicts following zonal distribution of risk factors.

1. Claims and dispute was the only factor observed in Very high likelihood and medium impact, in other word high risk zone.

2. Majority of factors in this group, such as 10 out of 12 factors were observed in high likelihood and medium impact, moderate zone of risk matrix.

3. Inaccurate cost estimate with risk criticality 0.12 was placed in low likelihood and high impact zone.

4.4.1.4 Political and Government Economic Risk Matrix

The developed risk matrix for risk criticality in this group comprised of eleven risk factors, as shown in figure 4.6.

Risk Criticality for Specific Risk					
LO	Risk Criticality = LO x MI				
0.9 V.H					
0.7 H			PG4-CGP, PG7-TC, PG9-CG, PG10-IGP		
0.5 M			PG5-SAP,	PG1-IRF,	
0.3 L				PG2-VTR, PG3-FCR, PG6-IRC, PG11-PIR, PG8-LPG	
0.1 V.L					
	0.05 VL	0.1 L	0.2 M	0.4 H	0.8 V.H
	Impact (MI)				

FIGURE 4.6: Political and government risk matrix

Interestingly four pattern of zone wise distribution of factors have been observed in this case as detailed below.

1. 4 factors of this group were observed in high likelihood and medium impact region of matrix.
2. Interest rate fluctuation was only risk factor observed in high risk zone with medium likelihood and high impact.
3. Statutory approval and permits was the only factor with medium likelihood and medium impact.
4. 5 out of 11 factors were lied in low likelihood and high impact region.

4.4.1.5 Market Related Economic Risk Matrix

From identified factors, eleven factors representing market economic risks were also included for investigations. The developed matrix on the bases of risk criticality values of factor is shown in figure 4.7.

Risk Criticality for Specific Risk					
LO	Risk Criticality = LO x MI				
0.9 V.H			MR10-SL,		
0.7 H			MR1-ILM, MR2-MPF, MR3-FCM, MR4-SDM, MR5-UMS, MR7-FFDI, MR8-QMA,		
0.5 M					
0.3 L				MR6-IMT, MR9-SM, MR11-CEI	
0.1 V.L					
	0.05 VL	0.1 L	0.2 M	0.4 H	0.8 V.H
	Impact (MI)				

FIGURE 4.7: Market risk matrix

From the developed matrix the following pattern of zonal distribution of factors has been observed.

1. Skilled labor risk factor from this group with very high likelihood and medium impact was lied in high zone of matrix.
2. 7 risk factors with high likelihood and medium impact were observed in this case.
3. Remaining 3 risk factors with low likelihood and high impact were placed in moderate region of risk matrix.

4.4.1.6 Technological Limitations Economic Risk Matrix

Nine risk factors from identified factors covering the technological aspect of project economy were included in area of study. The developed matrix on the base of risk criticality values has been shown in figure 4.8.

Risk Criticality for Specific Risk					
LO	Risk Criticality = LO x MI				
0.9 V.H					
0.7 H			TL4-HCM, TL7-CLP		
0.5 M			TL2-EM, TL9-MTA		
0.3 L				TL1-PTD, TL3-ACM, TL5-IMC, TL8-IETP, TL6-UCM	
0.1 V.L					
	0.05 VL	0.1 L	0.2 M	0.4 H	0.8 V.H
	Impact (MI)				

FIGURE 4.8: Technological limitations risk matrix

It has been observed that all the risk factors lies in yellow zone but follows different pattern as

1. High cost of machineries and complexity level of project were factors of high likelihood and medium impact.
2. Equipment malfunctioning and monopoly of technology access were two risk factors with medium likelihood and medium impact.
3. Remaining five risk factors of this group were of low likelihood and high impact.

4.4.2 Overall Economic Risk Matrix

After development of economic matrix at individual level for each of the groups identified, a combined matrix was also developed. So in order to develop combined matrix, top 34 contribution factors, irrespective of group, were considered, table 4.6 details the top risks.

Table 4.6: Top 34 economic risk factors

Sr. No.	Code	Factor	RC	Rank	Group
1	CO1-BCO	Budgeted cost over-run	0.23	1	Contractor
2	CO2-NCS	Non-performance of contractor and sub-contractor	0.21	2	"
3	PG1-IRF	Interest rate fluctuation	0.20	3	Political & Gov.
4	CN12-CD	Claims and Disputes	0.19	4	Consultant
5	CO11-IDC	Inadequate duration of contract period	0.19	5	Contractor
6	NC1-AOG	Acts of God	0.19	6	Natural Causes
7	CO4- MDC	Mistakes during construction	0.18	7	Contractor
8	CO6- CC	Contractual claims i.e. time extension with cost	0.18	8	"
9	CO12-IMP	Inadequate man power	0.18	9	"
10	MR10-SL	Shortage of skilled labor	0.18	10	Market
11	CO5-IFCS	Inadequate financial control on site	0.17	11	Contractor
12	CO7-ISM	Inappropriate schedule management	0.17	12	"
13	CO8-IRM	Improper resource management	0.17	13	"

Sr. No.	**Code**	**Factor**	**RC**	**Rank**	**Group**
14	CN6-LPT	Lack of professional team	0.17	14	Consultant
15	PG4-CGP	Changes in government funding policies	0.17	15	Political & Gov.
16	CL1-DP	Delay in payments	0.16	16	Owner/ Client
17	CL6-ADC	Approved Design changes	0.16	17	“
18	CL8-SDM	Slow decision making	0.16	18	“
19	CN8-ICE	Inaccurate cost estimates	0.16	19	“
20	CN10-ISI	Inadequate site investigations	0.16	20	“
21	PG9-CG	Conflicts with government	0.16	21	Political & Gov.
22	MR3-FCM	Financial condition of local market	0.16	22	Market
23	CL3-IFA	Inadequate financial arrangements	0.15	23	Owner/ Client
24	CL9-FC	Funding capacity	0.15	24	“
25	CO9-PAR	Progress acceleration required	0.15	25	Contractor
26	MR2-MPF	Material price fluctuation	0.15	26	Market
27	MR4-SDM	Supply and demand in local market	0.15	27	“
28	MR5-UMS	Unprecedented market trends	0.15	28	“

Sr. No.	**Code**	**Factor**	**RC**	**Rank**	**Group**
29	CN2-DSI	Delay of site instructions	0.15	29	Consultant
30	CN5-LR	Lack of responsibility	0.15	30	"
31	CN9-DCD	Discrepancies in contract documents	0.15	31	"
32	CN11-PCM	Poor contract management	0.15	32	"
33	PG10-IGP	Inappropriate government policies	0.15	33	Political & Gov.
34	TL4-HCM	High cost of machineries	0.15	34	Tech. limitation

The developed matrix on the base of risk criticality of top 34 identified risk factors has been shown in figure 4.9.

Risk Criticality for Specific Risk					
LO	Risk Criticality = LO x MI				
0.9 V.H			CO4-MDC, CO6-CC, CO11-IDC, CO12-IMP, CN12- CD, NC1-AOG, MR10-SL,		
0.7 H			CL1-DP, CL3-IFA, CL6-DC, CL8-SDM CL9-FC, CO5-IFCS, CO7-ISM, CO8-IRM, CO9-PAR, CN2-DSI, CN5-LR, CN6-LPT, CN8-ICE, CN9-DCD, CN10-ISI, CN11-PCM, PG4-CGP, PG9-CG, PG10-IGP, TL4-HCM, MR3-FCM, MR2-MPF, MR4-SDM, MR5-UMS,		
0.5 M				CO1-BCO, CO2-NPCS, PG1-IRF,	
0.3 L					
0.1 V.L					
	0.05 VL	0.1 L	0.2 M	0.4 H	0.8 V.H
	Impact (MI)				

FIGURE 4.9: Overall risk matrix of top 34 risk factor

Based upon the top 34 factors, more than 50% of the factors, lied in moderate zone. The zone wise distribution of top factors remained as follows.

1. 7 factor among 34 were with very high likelihood and medium impact were laying in high risk category.
2. Majority of factors from critical risk were having high likelihood and medium impact, in other words 24 out of 34 factors in number.
3. 3 risk factor were also observed having medium likelihood but high impact, were lied in high risk zone.

However, the contribution of each groups identified in overall matrix is detailed in table 4.7.

Table 4.7: Group contribution in top factors

Sr. No.	**Group**	**No. of Contributing Factors**	**Ranks**
1	Owner / client	05	16, 17,18, 23, 24
2	Contractor	10	1, 2, 5, 7, 8, 9, 11, 12, 13, 25
3	Consultant	08	4, 14, 19 20, 29, 30, 31, 32
4	Market	05	10, 22, 26, 27, 28
5	Political and government	04	3, 15, 21, 33
6	Technological limitations	01	34
7	Natural causes	01	6

From the table 4.7, it was observed that the factors attributable to the contractor's group were the most contributing factors 30 % in top 34 economic risk factors followed by 24 % factors from consultant group. The contribution from owner / client and market related factors was the third contribution in the list with a share of 15 % each. Political and government group contributed 12 % in top risk factors. Whereas, the technological limitations and natural causes were the least contributing groups with an average of less than 3 %.

4.5 Scatter Analysis

The scatter analysis helped to observe the likelihood and impact ranges for each group, refer figure 4.10 to figure 4.15.

FIGURE 4.10: Owner / client scatter diagram

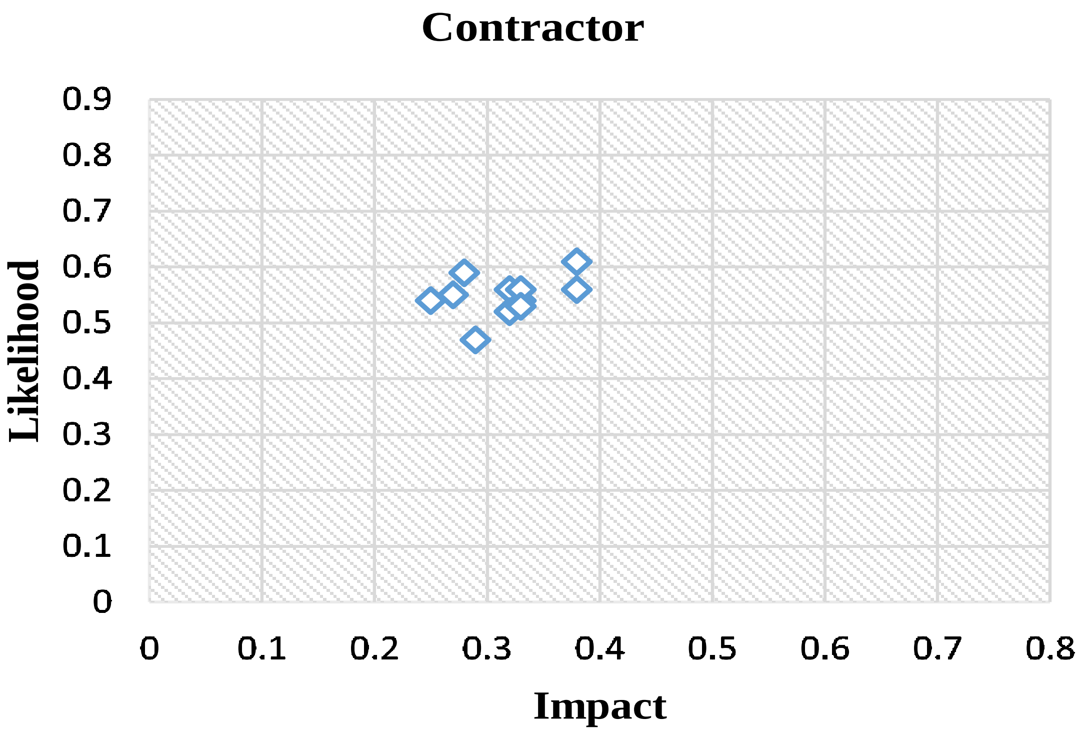

FIGURE 4.11: Contractor risk scatter diagram

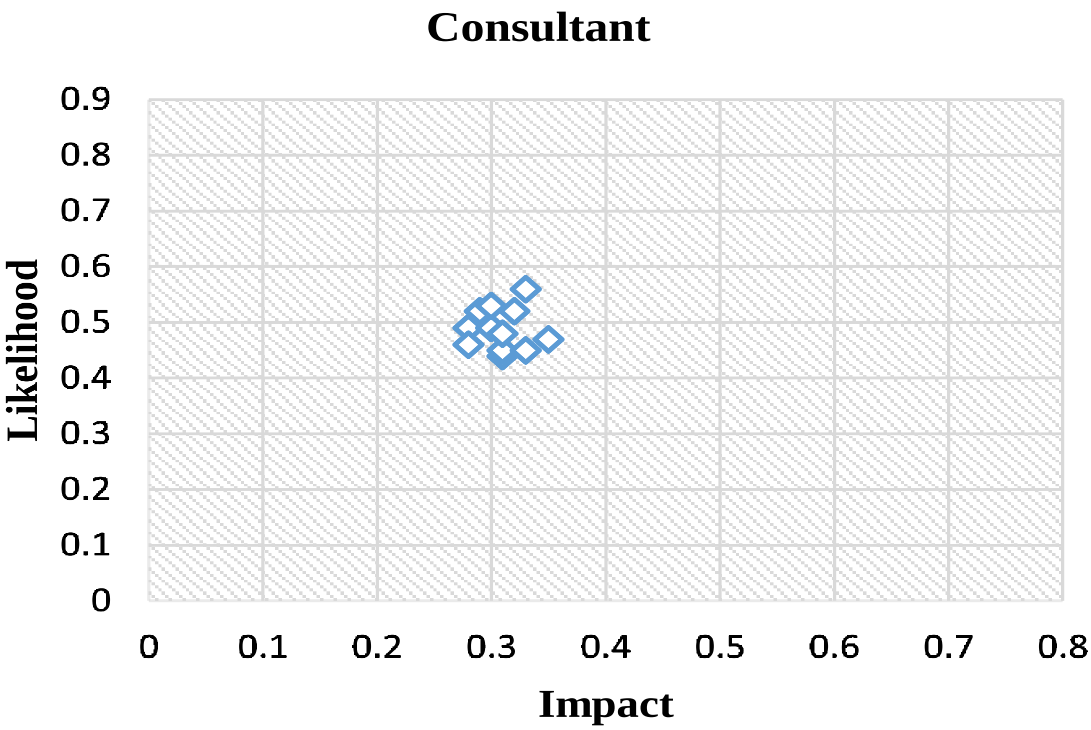

FIGURE 4.12: Consultant risk scatter diagram

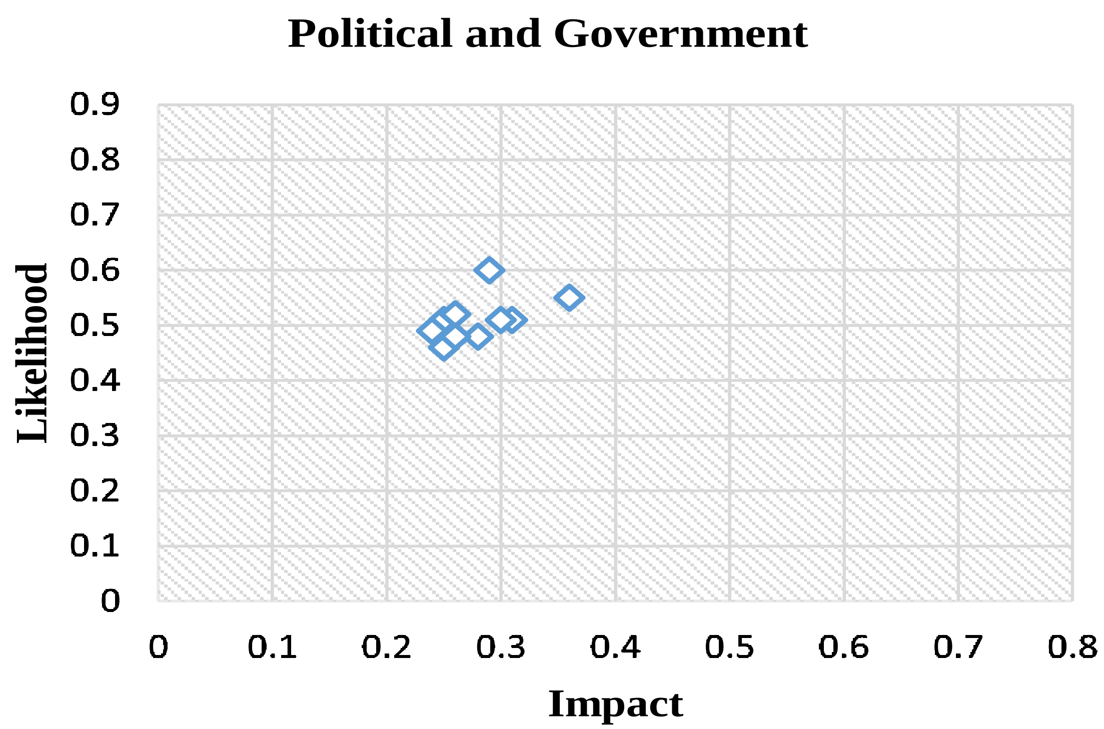

FIGURE 4.13: Political and government risks scatter diagram

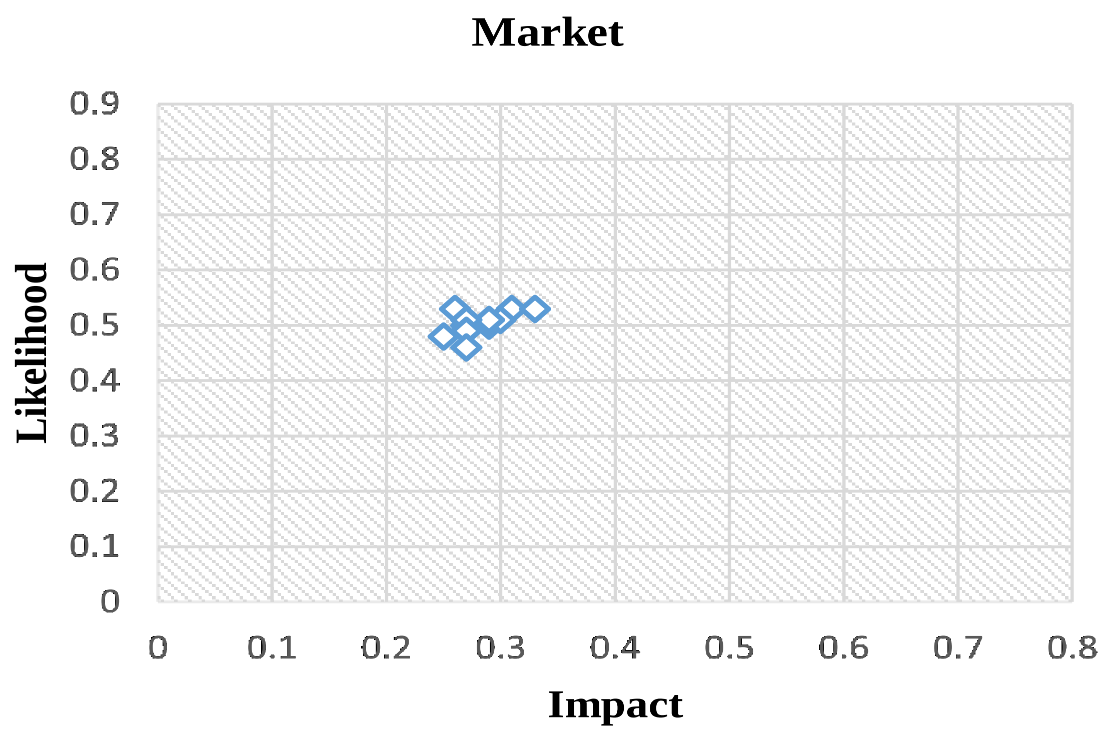

FIGURE 4.14: Market risks scatter diagram

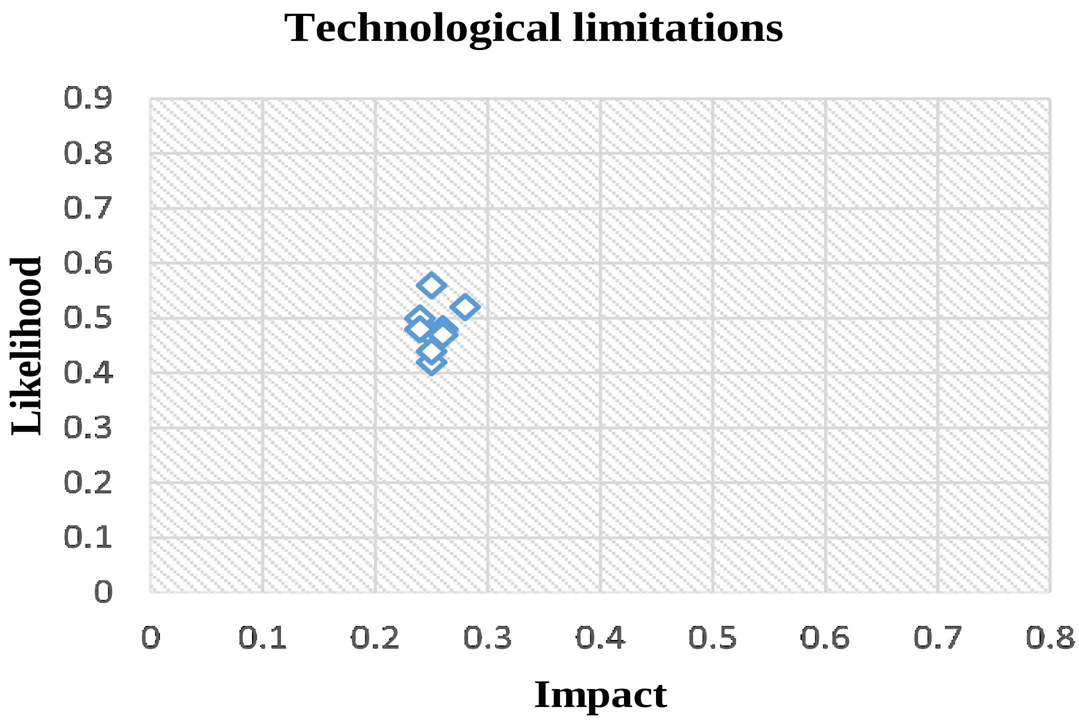

FIGURE 4.15: Technical limitations risk scatter diagram

In case of owner / client group, the cluster ranged from 0.35 to 0.61 for likelihood and 0.25 to 0.42. For group related to contractor it remained 0.45 to 6.5 and 0.25 to 0.40 respectively. For consultant it was 0.40 to 0.60 and 0.25 to 0.35 respectively. For the remaining groups like political and government, market related, and technological limitations it was observed as 0.45 to 0.62 and 0.22 to 0.37, 0.42 to 0.55 and 0.22 to 0.35, 0.40 to 0.56 and 0.22 to 0.30, respectively.

Chapter 5

Conclusion and Recommendations

This chapter presents summary of analysis, conclusions and some future recommendations are also presented. It comprises of two sections, the first one details the conclusions resulting from the current study, whereas second presents the recommendations for future works.

5.1 Conclusion

Scope of study in this research was limited to the development of economic risk matrix keeping in view the concept sustainability. The economic risk factors effect the economy of construction projects and pose a barrier in achieving economically sustainable construction. The first objective of the study comprises of identification economic risk factors which was achieved through critical literature review for identification of risk factors.A three-step Delphi technique process was applied to shortlist only significant factors and develop viable field survey instrument for further data collection. The second objective was to develop economic risk factor matrix for sustainable project construction. This objective was achieved through detailed field survey using questionnaire and analysis tools. The shortlisted significant factors were categorized into 7 groups according to their source of contribution and were presented in the form of questionnaire. A detailed field questionnaire survey was conducted, 101 filled questionnaires received back, which is acceptable as supported by Dillman [58] and Osborn [60] . Conclusions are summarized as below. The data was analyzed using statistical analysis and it has been observed that:

1. The reliability analysis results of likelihood data and impact data were 0.882 and 0.92, both values greater than 0.7. This justified that the data was reliable.

2. The likelihood data and impact data were analyzed for respondents perceptions regarding occurrence and impact of factors through Kruskal-Wallis test, the results highlighted that most of the factors were occurring significantly and had significant effect on the economy of construction projects.

As per Kruskal-Wallis test, according to respondents inadequate financial control on site (0.13), changes in government funding policies (0.03), material price fluctuation(0.026), project technical difficulties (0.017), equipment malfunctioning (0.004), were not significantly occurring. Whereas, unnecessary interventions (0.033), and inadequate site investigation (0.04), have no significant impact. The criticality score of each risk were obtained and observed that higher the risk criticality, higher be the effect of risk on project objectives.

According to analysis and risk criticality based ranking top 34 risk factors were budgeted cost overrun (0.23), non-performance of contractor and sub-contractor (0.21), interest rate fluctuation (0.20), claims and disputes (0.19), inadequate duration of contract period (0.19), acts of God (0.19) , mistakes during construction (0.18), contractual claims i.e. time extension with time (0.18), inadequate man power (0.18), shortage of skilled labor (0.18), inadequate financial control on site (0.17), inappropriate schedule management (0.17), improper resource management (0.17), lack of professional team (0.17), changes in government funding policies (0.17), delay in payments (0.16), design changes (0.16), slow decision making (0.16), inaccurate cost estimates (0.16), inadequate site investigations (0.16), conflicts with government (0.16), financial condition of local market (0.16), inadequate financial arrangements (0.15), funding capacity (0.15), progress acceleration required (0.15), material price fluctuation (0.15), supply and demand in local market (0.15), unprecedented market trends (0.15), delay of site instructions (0.15), lack of responsibility (0.15), discrepancies in contract documents (0.15), poor contract management (0.15), inappropriate government policies (0.15), high cost of machineries (0.15).

Based upon the received data, the risk matrix for individual group was developed and pattern of zone distribution was observed:

1. Owner / Client group, all factor lied in moderate zone. High likelihood of occurrence with high magnitude of impact was observed in the risk factors of this group.

2. For contractor group, six (6) risk factors lied in high zone and six six (6) factors lied in moderate zone with very high likelihood of occurrence and high impact.

3. In consultant group matrix, out of twelve six (12) factors one six (1) risk was in high zone whereas remaining were lied in moderate zone.

4. As in case of political and government related risks group one six (1) risk factor was observed in high zone with medium likelihood but high impact. Remaining risk were in moderate zone.

5. Market related risks group included one six (1) risk in high zone while remaining 10 risk factors were lied in moderate zone.

6. All risk factors of technological limitations related risk group were observed in moderate zone.

Risk matrix for last group was not developed as the group comprise of only two six (2) risk factors, but on the base of risk criticality, one six (1) risk factors of this group was included in top thirty four six (34) risk factors.

Scatter analysis was also performed for individual group. The following ranges for each group were observed:

1. In case of owner / client group, the range of likelihood of occurrence and magnitude of impact was 0.35 to 0.61 and 0.25 to 0.42, respectively. For contractor it remained 0.45 to 6.5 and 0.25 to 0.40. Whereas in case of consultant, it was 0.40 to 0.60 and 0.25 to 0.35 respectively.
2. For the remaining groups like political and government, market related, and technological limitations, it was observed as 0.45 to 0.62 and 0.22 to 0.37, 0.42 to 0.55 and 0.22 to 0.35, 0.40 to 0.56 and 0.22 to 0.30, respectively.

An overall matrix on the basis of top identified economic risk factors was formulated. The matrix achieved the following pattern:

1. Out of thirty four six (34), ten six (10) factors were observed in high zone and remaining twenty six (24) factors were in moderate zone.
2. Contractor group contributed 30%, followed by 24% from consultant, third major contribution in list was from owner/ client and market group with share of 15% each, political and government group contributed 12%, whereas technological limitations and natural causes group were the least contributing groups with 3% among these top economic risk factors.

This study helped in early, better understanding and awareness of economic risk factor. If these factors occur, they can affect the economy of construction projects and rise challenges in achieving economically sustainable construction project. The overall results of this study reveals that all identified factors are significantly occurring and have significant impact. The study has achieved a mile stone in development of economic risk matrix with risk criticality values which is expected to guide the project stakeholders in conducting economic risk analysis during feasibility study. Based upon these analysis, proper remedial measures would be possible for incorporation at planning and strategy level to improve and manage these barriers.

5.2 Recommendations

The current study was aimed to develop economic risk matrix to promote sustainable project developments. Based upon the results it is recommended that

1. Adoption of this study matrix at group level as well as overall basis can help to mitigate the risk impact, create better understanding and awareness of risk factors that would be likely to be managed by stakeholders at individual level as well as team level for successful completion of projects.
2. The study will help to perform economic risks analysis in a quantitative way at a very early stage of planning. This would act as a key to formulate a proper management strategy to be adopted at later stage of project implementation.
3. It would be easy to develop a risk response system keeping in view the pre-economic risk assessment. This is expected to reduce financial impact in developing efficient risk response system to be implemented during the project developments.

5.3 Future Study

Based upon the analysis, results and conclusion of the study, it is recommended that

1. The current study was limited to building projects, a further study can be progressed for other infrastructure development projects.

2. A further study can be managed by developing Analytic Network Process model for risk prioritization and mitigation measures.

3. A study can also be concluded to explore and observe in detail the other spheres of sustainability and its benefits, e.g. social and environmental sphere, in achieving sustainable construction developments.

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Annexure A

Questionnaire

Development of Economic Risk Factor Matrix For Sustainable Project Construction

Construction industry plays main role in economy and local development, it has direct effects on economy, ecology, biodiversity and considered being main consumer of natural resources. Therefore creating and implementing effective sustainable plans and risk identification for green economic status and their mitigation is vital.

However, the risks especially related to economics of construction projects are key factors in such sustainable developments as construction practices with economic management strategy is increasing day by day. An effective and efficient economic risk management directly affects project budget, performance and completion. The current study aims to investigate and develop an economic based risk matrix for sustainable construction.

As you will agree that the feedback from Industry Professionals would be the key to a successful achievement of developing economic risk factor matrix. Your kind cooperation is highly requested.

Part-I: Demographic Data

1. Type of Organization

o Owner/ Client o Consultant o Contractor other: ________

2. Profession

o Designer o Contractor o Civil Engineer o Client other: ________

3. Gender

o Male o Female

4. Working experience (years)

o less than 5 o 5-10 o 10-15 o 15-20 o More than 20

5. Educational Qualification

o Bachelor o Master o PhD other: ________

Part-II: Economic Risk factor Matrix Data:

This part focuses on the assessment of economic factors in terms of probability and impact. The probability is the measure of occurrence possibility level of factors. The impact is the measure of severity of such factors on project objectives (economy), with a scale i.e. very low = 0.05, Low=0.1, Moderate= 0.2, High=0.4, Very high = 0.8). Keeping in view the above criteria:

What do you think, what will be the probability and impact of factors detailed in four groups? Please mark one box for probability level and one for impact level.

1. Client Related Factors:

S. No	Factors	Probability					Impact				
		Very Low	Low	Moderate	High	Very High	0.05	0.1	0.2	0.4	0.8
1.	Delay in payments										
2.	Variations										
3.	Inadequate financial arrangements										
4.	Unnecessary interventions										
5.	Delays in approvals/change orders										
6.	Design changes										
7.	Improper site selection										
8.	Slow decision making										
9.	Funding capacity										

2. Contractor Related Factors:

S. No	Factors	Probability					Impact				
		Very Low	Low	Moderate	High	Very High	0.05	0.1	0.2	0.4	0.8
1.	Budgeted cost overrun										
2.	Non-performance of contractor and subcontractor										
3.	Material wastage										
4.	Mistakes during construction										

5.	Inadequate financial control on site										
6.	Contractual claims (i.e. time with cost claim)										
7.	Inappropriate schedule management										
8.	Improper resource management										
9.	Progress acceleration required										
10.	Inadequate site management										
11.	Inadequate duration of contract period										
12.	Inadequate man power										

3. Consultant Related Factors:

S. No	**Factors**	**Probability**					**Impact**				
		Very Low	Low	Moderate	High	Very High	0.05	0.1	0.2	0.4	0.8
1.	Slow inspection of completed work										
2.	Delay of site instructions										
3.	Errors in drawings										
4.	Inaccurate time estimates										
5.	Lack of responsibility										
6.	Lack of professional team										

7.	Delay in resolving contractual conflicts										
8.	Inaccurate cost estimates										
9.	Discrepancies in contract documents (specifications, BOQ, drawings, etc.)										
10.	Inadequate site investigations										
11.	Poor contract management										
12.	Claims and disputes										

4. External factors:

Stakeholders are not only the parties directly involved in project construction, any individual or entity which can directly or indirectly play its role for achievement of project objectives are also stakeholders. Definitely, these contributing factors will have possibility of occurrence and impact on / during project construction.

Please mark Probability level and impact level of detailed below factors.

5. Political and Government Related Factors:

S. No	**Factors**	**Probability**					**Impact**				
		Very Low	Low	Moderate	High	Very High	0.05	0.1	0.2	0.4	0.8
1.	Interest rate fluctuation										
2.	Variations in tax regulations										
3.	Fairness in Construction laws and regulations										

4.	Changes in government funding policies										
5.	Statutory approvals and permits										
6.	Industrial regulatory change										
7.	Tariff changes										
8.	Legal proceedings with government										
9.	Conflicts with government										
10.	Inappropriate government policies										
11.	Poor international relations										

6. Market Related Factors:

S. No	**Factors**	**Probability**					**Impact**				
		Very Low	Low	Moderate	High	Very High	0.05	0.1	0.2	0.4	0.8
1.	Inflation in labor market										
2.	Material price fluctuation										
3.	Financial condition of local market										
4.	Supply and demand in local market										
5.	Unprecedented market situation										

6.	International market trends										
7.	Flow of foreign direct investment										
8.	Quality of materials available in local market										
9.	Shortage of materials										
10.	Shortage of skilled labor										
11.	Changes in economic indicators										

7. Technological Limitations:

S. No	**Factors**	**Probability**					**Impact**				
		Very Low	Low	Moderate	High	Very High	0.05	0.1	0.2	0.4	0.8
1.	Project technical difficulties										
2.	Equipment malfunctioning										
3.	Additional costs of green materials and equipment's										
4.	High ost of machineries										
5.	Implementation of monitoring and control systems										
6.	Unsuitable construction methods										
7.	Complexity level of projects										

8.	Inefficient equipment, tools and plants										
9.	Monopoly of technology (access)										

8. Natural Causes:

S. No	**Factors**	**Probability**					**Impact**				
		Very Low	Low	Moderate	High	Very High	0.05	0.1	0.2	0.4	0.8
1.	Acts of God										
2.	Bad weather										