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**Addis Ababa University**

**Addis Ababa Institute of Technology**

**School of Civil and Environmental Engineering**

**Msc. Program in Construction Technology and Management Stream**

**STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK**

**FACTORS ON SELECTED SITES AROUND ADDIS ABABA: A CASE STUDY**

**Yonatane Tadesse Moche | GSR/4593/08**

A thesis submitted to the school of graduate studies of Addis Ababa University in partial fulfillment of the requirement of the degree of Master of Science in Civil Engineering (Construction Technology and Management)

**Advisor: - Dr.Abraham Assefa Tsehayae**



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**BY YONATANE TADESSE MOCHE**

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## **DECLARATION**

I **Yonatane Tadesse Moche**, declare that this paper is my own original work and has not been presented or will not be presented to any other university for a degree or any other qualification. I also declare that all material sources used for this thesis are referenced and recognized properly.

.....

**Yonatane Tadesse Moche**

## **ACKNOWLEDGMENT**

First of all my heartfelt gratitude goes to my advisor Dr. Abraham Assefa who gave me guidance and advise in order to make sure the research is academically meaningful.

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Finally, I would like to thank all the people that helped in the questionnaires and interviews conducted. I hope this paper shows the way forward in terms of responding to risk factors in high rise construction sites around Addis Ababa.

# **STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND ADDIS ABABA: A CASE STUDY**

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## **ABSTRACT**

The primary purpose of this research was to study the impact of major risk factors which are identified particularly in high rise building construction sites. 32 high rise buildings were evaluated using the questionnaire prepared and experts from 4 selected high rise building construction sites participated in the interview. The study revealed the major risk factors affecting the performance of the high rise building construction industry which is thriving in Addis Ababa, which are Inflation and Exchange rate fluctuation, Incorrect plan of work, cost, schedule and quality, poor use of advanced software, Importation, customs and visa issues, Permit requirements. Based on the DEMATEL assessment undertaken 16 of the risk factors were found to be cause factors while the remaining were effect groups.

**Key Words:** *-Risk, Risk management, High rise construction, DEMATEL assessment,*

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**ABBREVIATIONS**

**DEMATEL** .....Decision Making Trial and Evaluation Laboratory

**ME** .....Margin Of Error

**NEC** .....New Engineering Contract

**NFPA** .....National Fire Protection Association

**OSPMI** .....Office of Statewide Project Management Improvement

**PMBOK** ..... Project Management Body of Knowledge

**PMI** .....Project management institute

**PSE** ..... Pseudo Standard Error

**RF** .....Risk factors

**RII** .....Relative importance index

**RM** ..... Risk management

**RMP** .....Risk management processes

## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1. Research background**

An investment poured by different stakeholders contemplating to obtain a return is a key driver in high rise building construction (MPA, 2014). In addition, scarcity of land supply, increasing population density in certain areas of the world support and encourages the construction of high rise buildings (AGCS, 2014). Addis Ababa has seen increase in the construction of high rise building construction recently and these increase in the number of high rise buildings being constructed is seen as a positive matter while making sure that project management issues are resolved.

According to Divya et al. (2015), Project risk management is an integral part of the project management process which aims at identifying the potential risks associated with a project and responding to those risks. It includes activities which aim to maximize the consequences associated with positive events and to minimize the impact of negative events.

Even though risk management in its broader manner works to minimize the impact of negative or unwanted events so as to reduce the probable risk in high rise buildings. In addition, high-rises are usually built in cities where the sites can be very limited and logistics play a limiting role in the success of the project (Johanna, 2016). This risk factors need to be analyzed and responded to without delay.

High rise construction risks are generally classified as consultant related, contractor related, client related and due to external factors. This risks will influence the project's success in relation to

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time, cost and quality. These will impact the high rise construction project by adding overall cost, delaying the project, degrading the quality of the project output etc... These is significant because high rise building construction projects need more resources and capital flow.

The management of risks in high rise Construction Industry and improving contribution of the industry through focusing on the concept of risk and uncertainty is very important because it adds value to the construction industry. Therefore, this study aims to identify risk factors and to assess their impact in high rise building construction sites around Addis Ababa, Ethiopia.

## **1.2. Objective of the research**

### **1.3. General objectives**

The general objective of this research is to assess and categorize risk factors (RF) which occur on high rise building construction sites based on the research method employed. In addition, the impact of these risk factors was evaluated using the research tools.

### **1.4. Specific objectives**

The specific objectives of this study are generalized in to the following four main features.

1. To identify and to categorize key risk factors associated with building construction projects by reviewing literatures.
2. To rank the relative importance of these risk factors according to their relative importance index (RII) based on their impact on the selected high rise building projects.
3. To assess the severity and impact of these risk factors using the probability and impact matrix.
4. To recommend solutions based on construction risk management principles.

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## **1.5. Research questions**

This study will address the following questions.

- a. What are the major risk factors (RF) arising in high rise building construction sites around Addis Ababa?
- b. Which of the risk factors severely impact high rise building construction projects?
- c. What is the risk management strategy used by the project team to cope up with the risk factors in the projects studied?

## **1.6. Significance of the research**

This research is planned to evaluate the major risk factors in the high rise building construction industry, to assess their impact in projects success, project objectives and how these risk factors can be minimized. The significance of this research is to identify influential risk factors which result in high rise building projects being unsuccessful and to show their impact based on the research tools employed. And also, possible remedies are proposed on the basis of the findings that will come out as part of the final product of the research.

The findings help Clients, Designers, and Contractors to review their risk management strategies. It will also benefit government bodies by providing focus areas in terms of risk prevention in high rise building construction sites.

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## **1.7. Scope and limitation of the study**

The scope of the research is to investigate the impact of risk factors at Ethiopian high rise building construction sites during the construction phase particularly located at Addis Ababa and to categorize them based on their source, nature, impact on the particular project and the allocation of responsibilities to the particular stakeholders.

The research is limited to the high rise building construction industry in Addis Ababa and is based on theories of construction risk management literatures. In addition, the research is also limited to stakeholders in the high rise building construction sites (i.e. Consultants, contractors, and client) and literatures reviewed in relation to high rise building construction sites.

## **1.8. Organization of the research**

This research has five chapters described below;

- **Chapter 1** - Introduction and Background of the study
- **Chapter 2** - Literature review of the study
- **Chapter 3** – Research Design and methodology of the study
- **Chapter 4** – Results and Discussion of the study
- **Chapter 5** – Conclusion and Recommendation of the study

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1. Background**

This section tries to explore the major theories with regard to risk management, studies related to risks in the high rise construction industry of various countries, risk factors with respect to these countries and finally the overall summary of risk factors which are found through extensive research in to literatures and other data sources.

Building construction projects have been identified as one of the most dynamic, risky and complex endeavors (Kangari, 1995). OKEMA (2000), states that there is little evidence of application of risks and uncertainties management in construction in developing countries and yet it is apparent how they influence the course of construction projects and poses immerse challenges. This should be of particular concern in developing countries because they need to minimize cost and accelerate the projects progress.

Risk management (RM) in the construction project management context is a comprehensive and systematic way of identifying, analyzing and responding to risks to achieve the project objectives (PMI, 2007). Risk management (RM) has become a crucial area in the management of projects. Smart project managers employ risk management processes (RMP) to tackle challenges that impede their goals and objectives. They continually learn about effective RM practices by collaborating with project management professionals and risk management training (Kululanga, 2010).

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Although most CM firms acknowledge the need for managing risks, they instead prioritize time management, cost management, quality management, and safety management; in addition, most lack risk management departments or directors. For these reasons, risk factors are not being managed through systematical methods. This, in turn, causes problems such as decreased customer satisfaction, difficulty in providing early response to risks, uncertain accountability of risk factors, and difficulty in managing records of risk factors. (Kyungmo et al., 2017).

## **2.2. Definition of a high rise building**

Various definitions are given to describe what a high rise building is. According to Craighead, 2009, any structure where the height can have a serious impact on evacuation is classified to be a high rise building. Emporis (2000), defines a high rise as a multistory structure between 35-100 meters tall or a building of unknown height from 12-39 floors while NFPA (2016), states that a high rise only comprises of buildings higher than 23 meters or about 7 stories.

In Ethiopia, provisions in 1986, 2002 and 2010 were made for building height classification. The new regulation for building height classifies building heights based on building height zones. The zones are elaborated as follows (AACPPPO, 2017),

- ✓ Building Height Zone 1: - has 70m minimum height and adds no limit on the maximum height.
- ✓ Building Height Zone 2: - Maximum building height of 70m.
- ✓ Building Height Zone 3: - Maximum Building height is 35m.
- ✓ Building Height Zone 4: - Maximum Building height is 35m but the floor area ratio is different from zone 3.

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These research uses Building Height Zone 4 and above buildings which is similar to the Emporis standard definition of high rise. Therefore, the research evaluated and studied buildings with a height of more than 35 meters.

### **2.3.Ethiopia's economy and high rise construction in Addis Ababa**

With about 105 million people (2017), Ethiopia is the second most populous nation in Africa after Nigeria, and the fastest growing economy in the region. However, it is also one of the poorest, with a per capita income of \$783. Ethiopia aims to reach lower-middle-income status by 2025 (WorldBank, 2019).

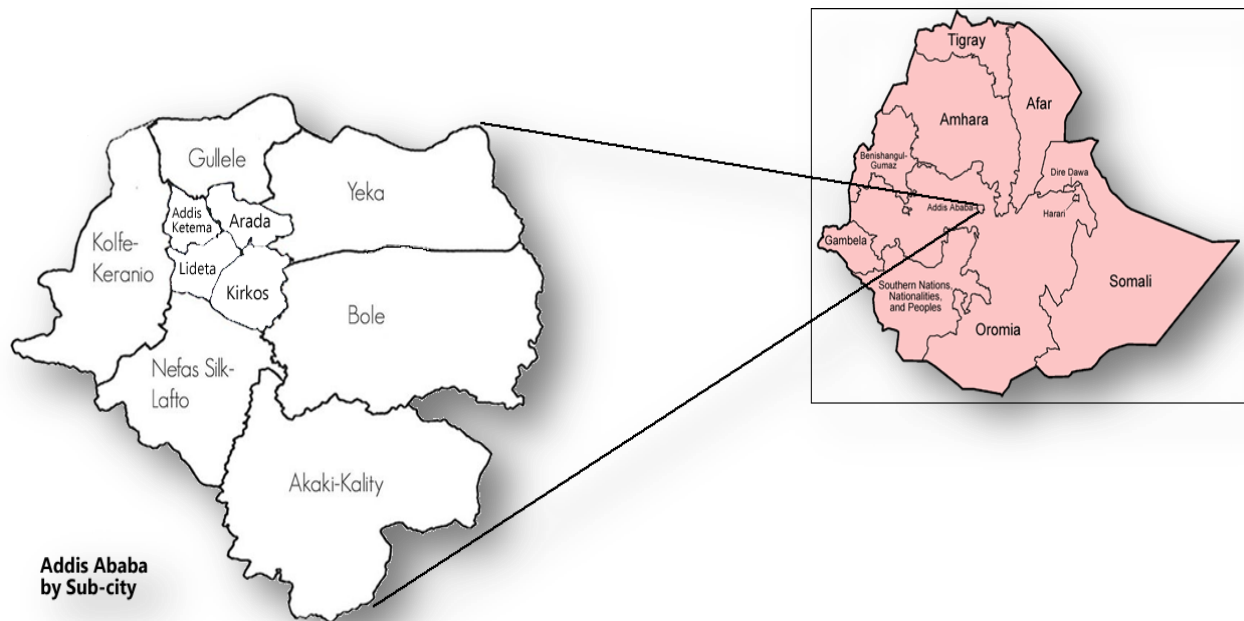
The Gross Domestic Product (GDP) in Ethiopia was worth 84.36 billion US dollars in 2018. The GDP value of Ethiopia represents 0.14 percent of the world economy. GDP in Ethiopia averaged 22.09 USD Billion from 1981 until 2018, reaching an all-time high of 84.36 USD Billion in 2018 and a record low of 6.93 USD Billion in 1994 (TradingEconomics, 2019)

With most of the global population and capital goods concentrated in urban areas, cities are key to social development and economic prosperity. They are drivers of national economic growth and innovation and act as cultural and creative centers (WorldBank, 2015) .

Addis Ababa is the capital city of Ethiopia. It is also the largest city in the country by population, with a total population of 3,384,569 according to the 2007 census. This capital city holds 527 square kilometers of area in Ethiopia. The population in the near future is expected to grow to exceed 6.5 million residents. The annual growth rate of the city has been estimated in recent years to be 3.8% (WorldPopulationReview, 2019).

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**Figure 1:- Location map of Addis Ababa (AACAA, 2017)**

Addis Ababa was established in the late 19th century and in comparison to other capital cities it is relatively young. Addis Ababa has evolved from a small rural settlement up to the 1950s into a vibrant modern metropolis today. Much of this urban transformation began during the period of Imperial Rule but accelerated in the post-1991 era (UNHabitat, 2017).

According to Emporis (2019), Addis Ababa currently has 101 Buildings which are considered to be high rise buildings. The compiled list of the buildings is listed in Appendix (C). The following table shows an outline of the high rise buildings which are currently under construction.

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**Table 1:- Some of the High-rise Buildings under Construction around Addis Ababa  
(Emporis, 2019)**

<b>Building name</b>	<b>Estimated height in meters</b>	<b>Floors</b>	<b>Type</b>	<b>Status</b>
1. Commercial bank of Ethiopia head quarters	198	48	Skyscraper	Under construction
2. Amhara Credit & Saving Institution HQ	135	36	High rise	Under construction
3. United Bank Headquarters	131	35	High rise	Under construction
4. NIB Bank Headquarters	131	35	High rise	Under construction
5. EEPCo Headquarters	127	34	High rise	Under construction
6. Four Points by Sheraton	120	32	High rise	Under construction
7. Zemen Bank Headquarters	112	30	High rise	Under construction
8. Red Cross Headquarters	112	30	High rise	Under construction
9. ORDA Headquarters	101	27	High rise	Under construction
10. Nile Insurance Company Headquarters	94	25	High rise	Under construction
11. Kebede Ketema Tower (KK Tower)	82	22	High rise	Under construction
12. Eleli building	79	21	High rise	Under construction

In addition to these high rise buildings being constructed new ones are being proposed and in progress. One of these is La Gare situated in the center of the city within proximity of the Addis Bole International Airport, with a rail line running along its northern edge. It has two tall residential towers, rising to their highest points of 34 stories in a ‘gateway’ configuration at the end of the central spine (EHE, 2019) .

## **2.4. Risk management conceptual framework**

### *2.4.1. Risk definition*

Risk is defined to be uncertain event or condition that, if it occurs, has a positive or negative effect on a project's objectives and it is the combination of the likelihood of occurrence of an event or exposure (PMI, 2013 ; OHSAS, 2007). Uncertainties include events (which may or may not happen) and uncertainties caused by ambiguity or a lack of information. It also includes both negative and positive impacts on objectives (ISO, 2009). Risk is proportional to the expected losses which can be caused by a risky event and to the probability of this event (Jayasudha et al., 2014).

According to Putu & Stephen (2005), in construction projects, risks play a significant part in decision making and may affect the performance of a project. If they are not dealt with sensibly, they may cause cost overruns, delays on schedule and even poor quality. Each project has a different level and combination of risks and sites will adopt different strategies to minimize them because the characteristics of projects are unique and dynamic.

### *2.4.2. Risk Management Process*

Risk management helps the key project participant's client, contractor or developer, consultant, and supplier to meet their commitments and minimize negative impacts on construction project performance in relation to cost, time and quality objectives (Nerija & Audrius, 2012). When performing risk management in construction, conditions may involve unique situations regarding stakeholders, international law, or international financial institutions (PMI, 2007).

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Building projects must consider the environmental impact of the job, the successful scheduling, budgeting, site safety, availability of materials, logistics, inconvenience to the public caused by construction delays, preparing delivery system documents, etc. From the perspective of risk management, given building projects featuring high risk and complex risk structure, clients normally seek to lower risk by adapting some kind of risk strategies, such as project delivery system, to transfer risk or share risk to other project entities (James & Zur, 1987). A construction project is plagued with various risks in all the stages of the life cycle of the project.

Project risk management is an integrated process which includes activities to identify project uncertainty, estimates their impact, analyze their interactions, control them in the execution stage, and even provide feedback to the maintenance of collective knowledge asset (Williams, 1995). It has the task of identifying risks, measuring the probability and the likely impact of events, and treating risks, eradicating or minimizing their impact with the minimum investment of resources (Berenger & Justus, 2016). In addition, it also generates response strategies in the light of expected outcomes and risks emerged, carrying out identification analysis and response generation steps repetitively throughout the lifecycle of an object to ensure the project objectives are met (Edmundas et al., 2009).

Managing risks involves identifying, assessing and prioritizing risks by monitoring, controlling and applying managerial resources with a coordinated and economical effort so as to minimize the probability and/or impact of unfortunate events and so as to maximize the realization of project objectives (Douglas, 2009).

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A typical risk management process includes the following key steps (Robert, 2009):



Figure 2:- The risk management process (Robert, 2009)

### 2.4.2.1. Risk Identification

Risk identification involves identifying potential project risks. Risk identification plays a key role in the success of managing risk. Failure in the identification of risks can cause inadequacy in the whole process of risk management which led to non-achievement of organizational objectives. Tools and techniques facilitate the process of identification, and need to be adopted on the basis of firms' characteristics (Ali, 2016). In addition risk identification is the process that is used to find, recognize, and describe the risks that could affect the achievement of objectives (ISO, 2009). Risk identification includes all risks, either under the control of the organization or not. It is useful for knowing which risks might affect the project and to document its characteristics. Risk identification is a continuous process, as there may be new risks to be discovered throughout the project (Imayanti, 2017).

Risk Identification produces a deliverable to the project Risk Register where risks are identified that may affect the project's ability to achieve its objectives. Risk Identification documents which risks might affect the project and documents their characteristics. The Risk Register is subsequently amended with the results from qualitative risk analysis and risk response planning, and is reviewed and updated throughout the project (OSPMI, 2007).

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According to Ewelina & Mikaela (2011), risk identification techniques are classified in relation to information gathering, documentation and research. These risk identification techniques are shown in the following table.

Table 2:- Risk identification techniques (Ewelina & Mikaela, 2011)

<b>Information gathering methods</b>	Workshops
	Brainstorming
	Interviews
	Questionnaires
	Benchmarking
	Consulting experts
	Past experience
	Delphi technique
	Risk breakdown structure
	Visit locations
<b>Documentation</b>	Databases, historical data from similar projects
	Templates
	Checklists
	Study project documentation (plan, files etc.)
	Study specialist literature
<b>Research</b>	Stakeholder analysis
	Research assumptions
	Research interfaces

In order to find all potential risks which might impact a specific project, different techniques can be applied. Risk identification typically involves the comprehensive identification of risks that might affect the project throughout its lifecycle by using expertise input where required (Craig, 2013). According to Agnieszka & Mariusz (2015), at the risk identification stage the statement of the factors which occur in the whole cycle of the project should be found. Identification of risk factors is fundamental requirement. Risk identification can be done by following approaches such as standard checklists, expert interviews, Delphi technique, comparing to other projects and facilitated brainstorming sessions (Muhammad et al., 2011).

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The main methods used for risk identification are stated as follows

- I. **Brain storming:** This is one of the most popular techniques which is used for idea generation. It is also very useful for risk identification in which all relevant persons associated with project gather at one place. There is one facilitator who is briefing about various aspects with the participants and then after note down the factors (Sakthiniveditha, 2015 ; Odimabo, 2016).
- II. **Delphi technique:** This technique is similar to brainstorming but the participants in this do not know each other and they are not at the same place. They will identify the factors without consulting other participants. The facilitator like in brain storming sums up the identified factors (Sakthiniveditha, 2015). This technique is more time consuming and expensive compared to the brainstorming technique (Chapman, 1997).
- III. **Interview/Expert opinion:** Experts or personnel with sufficient experience in a project can be a great help in avoiding/solving similar problems over and over again. All the participants or the relevant persons in the project can be interviewed for the identification of factors affecting risk (Sakthiniveditha, 2015). Due to time limitations the questions must be properly structured in order to effectively gather the required information (Chapman, 2001).
- IV. **Past experience:** Past experience from the same kind of project, the analogy can be formed for identification of the factors (Sakthiniveditha, 2015). It is important to be note that in this kind of process, knowledge based information acquired must be relevant and applicable to the existing building construction project (Odimabo, 2016).

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### *2.4.2.2. Risk Assessment/Analysis*

Risk Assessment/analysis enables the estimation and evaluation of all potential risks that may arise during implementation. The risk analysis of the project is an effective way of ensuring that the strategies used to control potential risks of the project are profitable (Ungureanu & Braicu, 2015).

Risk assessment methods have ranged from simple classical methods to fuzzy approach mathematical models. Many construction project risk assessment techniques currently used are comparatively mature tools (Zeng et al., 2007). It comprises the establishment of probabilities of occurrence of adverse events; the setting of assumptive bounds to associated uncertainties; and the measurement of the potential impact of risk event outcomes in a qualitative or in a quantitative way (Edwards, 2005).

Owing to several quantitative and qualitative factors, some of which may be in conflict with the others, the risk assessment technique selection is complicated. The results of this process will become the input to the determination of the optimum decision. With a better quantification measuring result, the managers can recognize which risks are more important and then deploy more resources on it to eliminate or mitigate the expected consequences (Amir et al., 2010).

According to Ungureanu & Braicu (2015), risk Assessment/ analysis consists of three coherent activities which are the identification of threats, assessment of their probability of occurrence and estimation of the risks impact on the project in terms of working time.

Risks of different types are placed in different categories by considering their predetermined characteristics (Aleshin, 1999). Risk assessment provides decision-makers and responsible parties with an improved understanding of risks that could affect achievement of objectives and the adequacy and effectiveness of controls already in place. This provides a basis for decisions about

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the most appropriate approach to be used to treat the risks. The output of risk assessment is an input to the decision-making processes of the organization (David, 2009).

Risk assessment should be documented in a way which records the stages of the process. Documenting risk assessment creates a risk profile for the organization which facilitates identification of risk priorities, captures the reasons for decisions made about what is and is not tolerable exposure, facilitates recording of the way in which it is decided to address risk, allows all those concerned with risk management to see the overall risk profile and how their areas of particular responsibility fit into it and facilitates review and monitoring of risks (HMT, 2004).

### *2.4.2.2.1. Qualitative Risk Analysis*

Qualitative assessment is very important to determine the importance of risks and knowing which needs to be treated before the other; this assessment depends on some Computational and graphical tools (Ahmed et al., 2018). Qualitative risk analysis typically involves assessing the priority of identified risks, and these assessments are preferably informed by factual information. Matrices specify combinations of likelihood and impact that lead to ratings risks as low, moderate and high priority. Descriptive terms or numeric values are used, depending on preference. Organizational thresholds are considered and inform the matrix (Craig, 2013).

Qualitative risk analysis is one process of assessing the impact and likelihood on the identified risks. This process prioritizes the risks according to their potential effect on the project objectives and is one way to determine the importance of addressing specific risks and guiding appropriate risk responses. An evaluation of the available information on a regular basis can also help to modify the assessment of the risk (Rathna, 2018).

The qualitative risk analysis involves but is not limited to these (Shrivastava, 2012):

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- ✓ **Performing root-cause analysis**, which will help figure out the source of the risk and other the attributes (such as impact and response strategy) of the risk.
- ✓ **Determining the probability of occurrence for the risk event.** The probability should range between 0 and 1. If the probability is zero then this event is not likely to happen. If the probability is one, then this event has already occurred and there may be a need for an issue resolution plan rather than a risk response plan.
- ✓ **Estimating the impact if the event did occur.** The impact can be in terms of time or money or both. The time impact may most likely result in altering the schedule whereas cost impact may most likely increase/decrease the project's bottom line in relation to retaining or preserving the projects profitability.

The tools and Techniques for Qualitative Risk Analysis are stated as follows (Said et al., 2016): -

- I. Risk Probability and Impact:** Risk probability and risk impact may be described in qualitative terms such as very high, high, moderate, low and very low. The risk probability is the likelihood that a risk will occur and the risk impact is the effect on project objectives if the risk occurs.
- II. Probability / Impact Risk Rating Matrix:** A matrix may be constructed that assigns risk ratings (very low, low, moderate, high and very high) to risks or conditions based on combining probability and impact scales. Risks with high probability and high impact will require further analysis, including quantification, and possibly aggressive risk management. The risk rating is identified using a matrix and risk scales for each risk type or condition.

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### *2.4.2.2.2. Quantitative Risk Analysis*

Quantitative risk analysis is mostly used on large and complex construction projects in support of significant project management and financial decisions. The need for, and the viability of, developing a quantitative risk analysis should be assessed through expert judgment and may depend on the project size, the project team level of experience in risk management, the information and data available to develop appropriate models, and the resources assigned to risk management activities (PMI, 2007).

It can be appropriate to employ quantitative analysis for the more significant risks, especially when there is doubt over the initial assessment. However, where risks are themselves combinations of other risks, or are likely to be affected by other risks, quantitative methods can be difficult to apply with any certainty as to the value of the analysis. If the analysis is undertaken at an early stage it is sometimes possible to minimize risk at very little cost (BSI, 2000). According to Craig (2013), numerical values are assigned to the risk event and used to make decisions under uncertainty.

Quantitative analysis uses techniques such as Expected Value, Decision Tree Analysis, Sensitivity Analysis, Monte Carlo Simulation etc.

- **Decision Tree** is one of approved graphical methods of quantitative analysis of a risk, it contains decision points and normal cases points, Decision points represent options or available strategies, while normal cases points represent the external conditions that can occur. The value of each branch of the decision tree can be calculated, the right decision is made based on these calculations (Ahmed et al., 2018).

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- **Simulation:** - quantitative risk analysis uses a process that simulates the combined effect of individual project risks and other sources of uncertainty to evaluate their potential impact on achieving project objectives. Simulations are usually performed by Monte Carlo simulation. Monte Carlo simulation is a stochastic form of simulation where the probability of project outcome is obtained by carrying out a number of iterations, depending on the degree of confidence required (PMI, 2017) (Akintoye & MacLeod, 1997).
- **Sensitivity analysis:** - Sensitivity analysis helps to determine which individual project risks or other sources of uncertainty have the most potential impact on project outcomes. It correlates variations in project outcome with variations in elements of the quantitative risk model (PMI, 2017).
- **Influence diagram:** - this are graphical aids to decision making under uncertainty and it represents a project or situation within the project as a set of entities, outcomes and influences together with the relationships and effects between them (PMI, 2017).

### *2.4.2.3. Risk Mitigation*

Risk mitigation is any action that can be taken to reduce the likelihood of a risk materializing or to reduce the consequences to the contracting party taking the risk, if it does materialize. Mitigation practices vary depending on the risks being considered and whether the party concerned is a private or public one. (Addis, 2014).

Four strategies to mitigate negative risks in the Practice Standard for Project Risk Management are to avoid, transfer, mitigate, and accept: -

- ✓ **Avoid:** - Risk avoidance is more effective during early project phases and contract negotiation. After a contract is signed, some of the major risks regarding performance

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of plants linked to critical project activities and penalties related to these activities cannot be avoided. An exemption clause can be included in the contract to avoid those risks (PMI, 2007). This strategy is based on changing the project plan to eliminate risk, or to unwanted circumstance or to protect the objectives of the project from its effects. Of course, not all risks can be avoided, but some risks have proven experience in many of projects could be avoided (Ahmed, Ibrahim, & Ysory, 2018).

- ✓ **Transfer:** - Transferring the risk simply gives another party responsibility for its management; it does not eliminate the risk. Risk should be transferred to the party best able to manage it, for example, to subcontractors or insurance companies (PMI, 2007).
- ✓ **Mitigate:** - Risk mitigation is a risk response strategy whereby the project team acts to reduce the probability of occurrence or impact of a risk for example, the risk of losing key personnel in the late stages of construction projects can be mitigated by providing completion bonuses. Another way to reduce risk impact is by sharing it with other parties that may have the appropriate knowledge and resources to manage it (PMI, 2007).
- ✓ **Acceptance:** - implies potential time and cost impacts, which should be included in the contingency reserve. For example, an ambiguity in a contract clause about who is responsible for providing water for hydrostatic tests could be accepted if the volume (and cost) is small and the availability is high (PMI, 2007).

#### *2.4.2.4. Risk Monitoring*

The last process which is risk monitoring deals with keeping track of the identified risks, residual risks, and new risks. It also monitors the execution of planned strategies on the identified risks and evaluates their effectiveness. Risk monitoring and control continues for the life of the

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project. The list of project risks changes as the project matures, new risks develop, or anticipated risks disappear. Periodic project risk reviews repeat the process of identification, analysis, and response planning.

Berenger and Justus (2016), forwarded corrective measures in handling risks associated with construction projects which are to adjust the scope of work, monitor risks regularly, evolve alternate plans to manage predictable risks, make appropriate decisions and keep all concerned informed about possible risks.

One of the fundamental philosophies behind Project Risk Management is that the information which is generated through its use is applied within the project. To allow this, a Risk Register tool is generally used as a means of recording and documenting the information generated through the use of Project Risk Management (Fiona & Kevin, 2002).

### **2.5.Ranking Strategies for High Rise Building Construction Risks**

Risk management in the construction project management context is a comprehensive and systematic way of identifying, analyzing and responding to risks to achieve the project objectives (ICE, 2005). An effective risk management process encourages the construction company to identify and quantify risks and to consider risk containment and risk reduction policies (Nerija & Audrius, 2012).

The environment in which the project is executed is becoming ever more complex. In complex environment projects, both the number of risks increases, along with the number of interrelationships between them. This increase in the number and interrelationships of risks creates a need for a systematic integrated approach to risk assessment (Babak & Farzad, 2012). Because of

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these complexities in projects; prioritizing these risks can help achieve more effective and efficient projects risks through ranking those using different methods (Amin & Ali, 2012).

Risks, based on individual views can be categorized in different ways; some are classified based on their probability of occurring while others are classified as a consequence of the impact they may have on construction activities, their types and sources. Despite these various classifications, they are meant to attain a common objective, that is, they are an important aid in risk management and assist in forming risk lists that are used when detecting a risk (Babak & Farzad, 2012).

### *2.5.1. The Probability and Impact Matrix*

The probability and impact matrix illustrates a risk rating assignment for individual risk factors in the identified risks categories. The risk matrix shows the combination of impact and probability that in turn yield a risk priority (shown by the red, yellow, and green color) (Juneja, 2018).

A matrix is constructed that assigns risk ratings (very low, low, moderate, high and very high) to risks or conditions based on combining probability and impact scales. Risks with high probability and high impact will require further analysis, including quantification, and possibly aggressive risk management. The risk rating is identified using a matrix and risk scales for each risk type or condition (Said et al., 2016).

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A sample for the probability/impact risk rating matrix is shown in the following table: -

Impact	0.9	0.9	1.8	2.7	3.6	4.5	Very high
	0.5	0.7	1.4	2.1	2.8	3.5	High
	0.5	0.5	1.0	1.5	2.0	2.5	Medium
	0.3	0.3	0.6	0.9	1.2	1.5	Low
	0.1	0.1	0.2	0.3	0.4	0.5	Very low
		1	2	3	4	5	
		Very low	Low	Medium	High	Very high	
		Probability					

**Figure 3:- P-I Qualitative risk analysis matrix sample (John & Herman, 2011)**

The steps used to prepare the probability and impact matrix are as follows (Juneja, 2018):

- I. List down the Risks:** - The first step in the process begins with the listing down of all the risks that the participants can think of. This is usually done in a brainstorming session. Participants are typically given a list which contains common categories of risks. The participants are then advised to think of whatever risk they can foresee in the project category by category. This is done over and over again to ensure that the list is exhaustive.
- II. Rate for Probability and Impact:** -Once the list of the possible risks that a project may face is available, the next step is to rate the risks. The risks are rated on two parameters viz. probability of occurring and impact of occurring. In both cases the score is given out of 5, with 5 being certainty that the risk will occur or have a very high impact if they do occur. The scores are then multiplied and then arranged in a descending order.
- III. Classify the Risks:** - Risks need to be classified and efforts need to be focused only on the ones that are priority.

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An illustrated project risk impact values on project parameters is illustrated as follows according to (John & Herman, 2011):-

**Table 3:- An illustrated project risk impact values on project parameters(John & Herman, 2011)**

Impact Value	Impact		
	Quality performance	Cost overruns (percentage)	Time delays (months)
<b>0.1 (low)</b>	Minimal	Within budget	Negligible
<b>0.3 (minor)</b>	Small	1-10%	Minor slip (<1)
<b>0.5 (moderate)</b>	Moderate	10-25%	Moderate slip (1-3)
<b>0.7 (significant)</b>	Significant	25-50%	Significant (>3)
<b>0.9 (high)</b>	Goals not achievable	>50%	Large slip

**IV. Decide on Mitigation Planning:** -There are three basic strategies which help mitigate risks successfully.

- ✓ **Prevention:** These plans try to ensure that the risk event cannot take place. This is advisable for the high impact risks.
- ✓ **Correction:** These plans try to catch the risks early before too much damage has been done and the characteristic difference is the attempt to minimize the impact.
- ✓ **Warning:** Here too the emphasis is on detecting the risk as early as possible but the element of correction is not present.

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### *2.5.2. Introduction to Decision Making Trial and Evaluation Laboratory (DEMATEL)*

Decision Making Trial and Evaluation Laboratory (DEMATEL), is a decision making method based on a pair-wise comparison using experts' judgment. This method originated from the Geneva Research Center of Battelle Memorial Institute by Fontela & Gabus in 1976. They developed the DEMATEL method to find integrated solutions for the fragmented and antagonistic phenomena of world societies (Babak & Farzad, 2012).

The DEMATEL method assumes a system contains a set of components  $C = \{C_1, C_2 \dots C_n\}$ , with pair wise relations that can be evaluated. The methodology, according to the properties of objective affairs, can confirm the interdependence among the variables/attributes and restrict the relation that reflects the properties with an essential system and development trend. The end product of the DEMATEL process is a visual representation an individual map of the mind by which the respondent organizes his or her own action in the world (Davood, 2012).

This technique can facilitate an understanding of the complex structure of a specific problem under consideration, and identifying relationships between factors in a form of hierarchical structure (Tzeng, Chiang, & Li, 2007). DEMATEL was applied to explore complex relationships, construct an impact-relation map, and moreover, obtain the impacts of each element over others. This approach is mostly applied to support a decision making process, assisting analyzers in prioritizing alternatives, and deriving important factors for analysis (Junseok et al., 2018).

According to Lin (2013), Cause factors have impact on the entire system; their performance can influence the overall goal. Moreover, the criteria belong to the cause group should be paid more attention. Effect factors are tended to be easily impacted by others which causes factors in effect group inappropriate to be a critical success factor.

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In addition, the strength of the relation of the impact of once object on another within a pair is evaluated using an ordinal, discrete scale consisting of 0 -N levels. The creators of the method adopted scale values of  $N = 4$ , where different levels have the following meaning (Elzbieta, 2018):

- 0 - no impact,
- 1 - little impact,
- 2 - medium impact,
- 3 - large impact
- 4 - Very large impact.

The procedure of applying the DEMATEL technique can be summarized by the following four steps (Amin et al., 2016; Junseok et al., 2018)

**STEP 1:** - The initial direct-relation matrix is used to calculate an average perception matrix. The matrix ( $An \times n$ ) can be achieved by pair-wise comparisons between criteria that are carried out by expert team and each element of this matrix ( $a_{ij}$ ) denotes the influence value of criterion  $i$  on criterion  $j$ . The influence of criterion (factor)  $i$  on a criterion (factor)  $j$  means how increase/decrease in  $i$  can increase/decrease  $j$ .

**STEP 2:** - Normalizing the average perception matrix. The  $A$  of Equation (1) is a matrix before normalization, and  $X$  means a normalized direct-relation matrix. The  $a_{ij}$  of Equation (2) is the degree to which a factor  $i$  affects the other factor  $j$ .

$$X = k \times A \dots \dots \dots \text{Equation 1}$$

$$k = \frac{1}{\max \sum_{j=1}^n a_{ij}} \dots \dots \dots \text{Equation 2}$$

**STEP 3:** - Derive the total relation matrix ( $T$ ) by

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$$T = X(I - X)^{-1} \dots\dots\dots \text{Equation 3}$$

**STEP 4:** - Summation of rows (*D*) and summation of columns (*R*) are calculated according to matrix *T*. *D* Value of a factor is its influential impact on others. *R* Value is an impact the factor receives from others (5) & (6).

$$D = (\sum_{j=1}^n t_{ij})_{n \times 1} \dots\dots\dots \text{Equation 4}$$

$$R = (\sum_{j=1}^n t_{ij})_{1 \times n} = [t_{.j}]_{n \times 1} \dots\dots\dots \text{Equation 5}$$

Where (*D + R*) represents the horizontal axis vector which is called prominence and indicates the relative importance of each criterion, (*D - R*) is named relation. In general, if (*D - R*) > 0, then the criterion is a member of cause group; and if (*D - R*) < 0, then the criterion is a member of effect group.

After finding the horizontal axis (*D+R*) and the relation axis (*D-R*) four types of attributes can be found (Svetla & Lilo, 2017)

- I. If (D-R) is positive and axis (D+R) is large:** - indicates that the criteria are causes and they are also a driver for problem solving.
- II. If (D-R) is positive and axis (D+R) is small:** - indicates that the criteria are independent and can only influence a few other factors.
- III. If (D-R) is negative and axis (D+R) is large:** - indicates that the criteria are the core problems that must be solved. I.e. they are effect type criteria with indirect impact and cannot be improved directly.
- IV. If (D-R) is negative and (D+R) is small:** - indicates that the factors are independent and can be influenced by a few other attributes.

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**STEP 5:** - Setting the threshold value ( $\alpha$ ). The threshold value will be calculated by using the Lenth's principle of distinguishing effect significance in order to filter out main risk factors for the cause and effect relationship diagram. Lenth's method is an objective method for deciding which effects are active in the analysis of unreplicated experiments, when the model is saturated and hence there are no degrees of freedom for estimating the error variance. (Russell, 2006).

The computation involves two stages. Assuming that  $C_1, C_2, \dots, C_m$  denotes the  $m$  contrast estimates. First, Calculating  $S_0$  which is the initial value of  $\tau$

$$S_0 = 1.5 \cdot \text{median} \{|c_j|\} \dots \dots \dots \text{Equation 6}$$

Then, calculating PSE which is the pseudo standard error by exceeding 2.5 times  $S_0$

$$PSE = 1.5 \cdot \text{median} \{|c_j| : |c_j| \leq 2.5S_0\} \dots \dots \dots \text{Equation 7}$$

The second step is just like the first, except that those effects that exceed  $2.5 S_0$  in absolute value are excluded. PSE is termed the pseudo standard error, and it is an estimate of  $\tau$ . Once the PSE is obtained, one can multiply it by a factor from Table 1 to obtain a margin of error (ME) for the contrasts. Contrasts that exceed the ME in absolute value are deemed active at the 5% significance level. ME calculated by the following formula

$$ME = t_1 - \frac{\alpha}{2}; \frac{m}{3} \times PSE \dots \dots \dots \text{Equation 8}$$

**STEP 6:** - Building a cause and effect relationship diagram. The cause and effect diagram is constructed by mapping all coordinate sets of (D+R) and (D-R) to visualize the complex interrelationship between and provide information for judgment (Sheih et al., 2010).

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The factors in which  $t_{ij}$  is greater than  $\alpha$  are shown in the cause and effect diagram (Yang et al., 2008). The overall DEMATEL process is shown in the following diagram

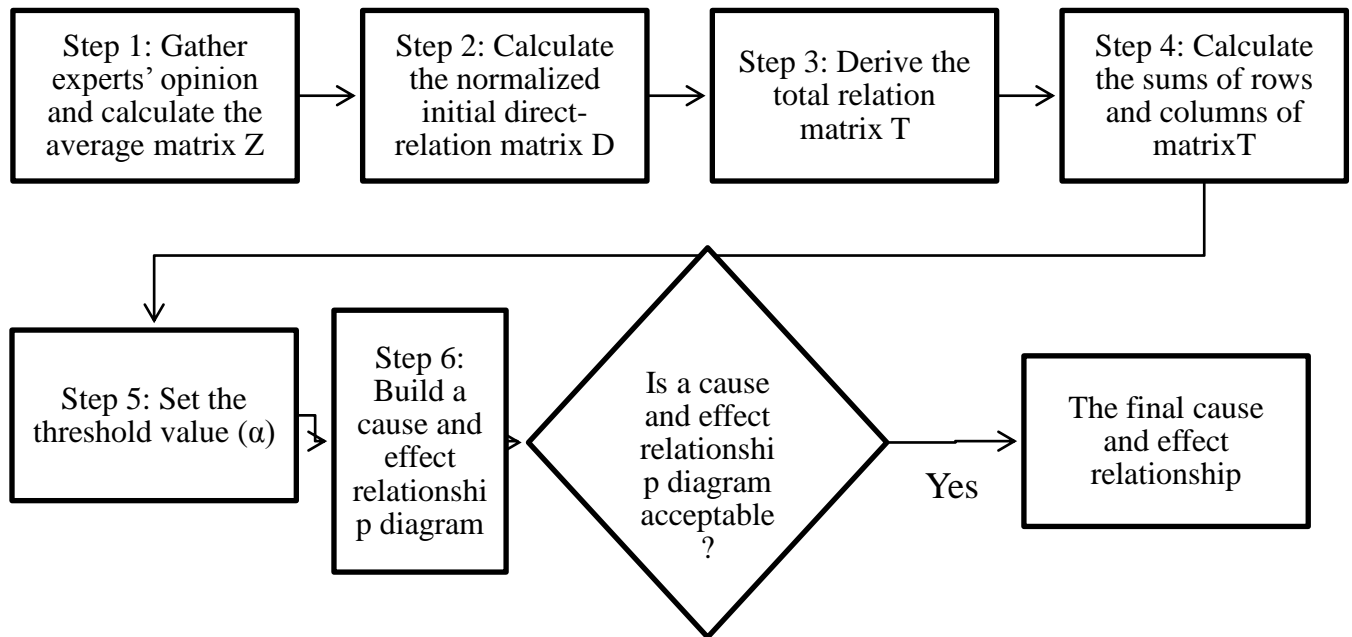


Figure 4:- The process of DEMATEL method (Detcharat & Pongpun, 2013)

## **2.6.Past Studies related to High Rise Building Construction Risk Factors**

### *2.6.1. An Overview of General Issues Related to High Rise Building Construction*

The major issues that need consideration in the execution of a high rise building are compiled as follows.

#### **I. Project planning**

- ✓ **Logistics planning;** - In a construction project, a logistics plan has a far reaching influence on cost, time and quality. Logistics planning works to minimize material shortages, implements control over long haulage distances, overlooks temporary facility planning and ensures adaptability to changing site conditions (Pankaj, 2016 ; O-Kyung & Jong-Hoon, 2004).
- ✓ **Vertical delivery of materials:-** The vertical delivery of materials and labor on construction sites has a significant effect on the overall performance of the schedule. Pumping and placing concrete at extreme heights, vertical movement of operatives and materials, good performance in incoming logistics laying down and storage area were the most important drivers for good performance in the high rise building construction industry with regard to delivery of resources (CCIP, 2014 ; Yufeng et al., 2015; Ling-Zhen et al., 2009).

#### **II. Construction planning**

- ✓ **Construction implementation plan;** - In order to make sure the project management is productive a smooth information flow, project should be managed in each project phase in detail, future events must be forecasted including uncertain factors, a thorough review and verification of risks with their response strategy, timely decision making. In terms of particular issues methods should be laid out to maintain good site management,

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verticality of the structure should be repeatedly evaluated, standardization of structural elements in order to make repetitive work items I.e. components leading to repeatability in formworks, formwork systems need to be integrated with crainage and logistics and management of labor productivity, the use of innovative equipment solutions, safety issues in relation to tower cranes obstacles, congested sites, power lines and the length of work shift (CCIP, 2014 ; Maria, 2000 ; O-Kyung & Jong-Hoon, 2004).

- ✓ **Design coordination and cycle time management:** - Designing with high constructability, minimizing design changes, speed of decision making and information flow between stakeholders (Maria, 2000 ; O-Kyung & Jong-Hoon, 2004).

### *2.6.2. Studies Related to High Rise Building Construction Risk Factors in Addis Ababa*

Various researchers studied problems in the Ethiopian construction industry especially in Addis Ababa where the majority were related to safety risk factors particularly in the high rise building construction industry which is booming.

With regard to safety risk factors in the local high rise construction projects numerous researches were made in Addis Ababa. Fasil (2017), studied construction safety and health management in high rise building construction projects in Addis Ababa and the study tried to assess 5 Chinese and 15 local grade one contractors. As a result of the study a high percentage of the respondents believed that objects falling from a height, workers falling from scaffolding during construction, un shored protection of excavation followed by noise, tools & machinery, stairway & ladder, electricity power accident, and then construction elevators & hazardous substances cause injuries & fatalities in a high rate in decreasing order. In addition, stairways and ladders, scaffolding, fire,

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followed by tools & machinery, objects falling from a height, and then construction hoists & elevators, excavations and electricity causes injuries & fatalities in medium rate in decreasing order.

Girma (2018), raised major risk issues while studying the safety practice in high rise building construction around Addis Ababa and this were that companies had no written safety policy, warning signs with foreign language description were observed, emergency exit systems were not available, medical professionals were not available for first aid, the sites did not use proper cover for the buildings and lastly standards, rules regulations and directives of the country are not well known by the professionals on project sites.

Derebe (2018), tried to study the norm of planning and scheduling of CBE head quarter construction. The research inferred the need for good planning and scheduling, the importance of vertical transport mechanisms including concrete pumping mechanism and the critical use of scheduling. It recommended a continual safety follow up, a detailed schedule preparation, the involvement of local contractors and finally local workforce expulsion should be minimized.

A general review of risk analysis practices in local grade one contractors was researched by Hana (2017), in which the major risks in general were found to be price inflation of materials, payment delay, unrealistic project duration, inadequate scheduling, shortage of fund, discrepancies in design documents, delay in sub contract work, shortage of material in the market, inadequate design team experience and exchange rate fluctuation.

In relation to logistics management practices and their impacts Woyesa (2017), forwarded the major impacts such as increase in project time, cost overrun, late material arrival, fraudulent activities, poor construction quality and material loss.

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Factors affecting labor productivity were studied by Mekdes (2016), and the critical factors were found to be shortage of material, decision making delay, incomplete and inaccurate drawings, lack of project progress follow up, financial difficulties of owner/payment delay, incomplete facilities, inspection and construction delay, lack of motivation, frequent damage of equipment's and changes of work/variation.

Addis (2014), tried to study the practice of using construction contract risk management techniques in Ethiopian building projects and to emphasize the importance of such practice in achieving project objectives. The research concluded that projects are aware of the concept of risk management but most parties involved in Ethiopian building construction projects don't use risk management techniques in their projects. Financial difficulty and poor contract management were identified to be the most important causes of risk with a very high level of occurrence and a high level of impact on project objectives in the Ethiopian building construction projects.

Mitike et al. (2017), tried to assess the impact of risk in Ethiopian construction industry. It identified risks which have very high level of influence on project costs. The major risks are found to be equipment/material failure, labor poor productivity and equipment scarcity. The quality of the project which is affected by labor poor productivity is very high. The others like equipment/material failure, managerial inadequacy, and lack of training, lack of communication and departures of qualified staff have high risk level in term of quality. Generally, the risks with very high risks rating based on the analysis undertaken were equipment/material failure, the labor poor productivity and equipment and material non-availability. The assessment revealed that construction project industry in general has no routine practices employed to manage risks. Although construction risks management literature is very rich in its conceptual frame.

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Sileshi (2018), tried to assess construction project risk management practices of Chinese Construction Companies in Ethiopia towards typical construction project risks. Participants in the study indicated that they apply these practices especially risk identification, and risk management techniques, the overall rating on the application of risk management techniques is not high and qualitative techniques obtained much higher ratings than quantitative techniques. The survey results also showed that for risk identification, the most common techniques used were checklists, risk register, past experience and expert judgment; for risk analysis, the preferred tools used were risk matrix that defines probability/likelihood and impact exist in the company's and assess the probability of achieving specific project objectives. For Risk response, respondents stated that tools were used to avoid the occurrence of risks through a proactive way and risks were transferred to third parties. For risk monitoring, it was found that the majority of the respondents indicated the project team holds periodic meetings specifically for risk discussions as predominant technique. The predominant risk mitigation technique used in the companies was risk transfer strategy.

Shewaferahu (2016), Studied major causes of delays on building projects in the Ethiopian Construction Industry particularly the principal factors responsible for delays in the Addis Ababa University Educational Building Projects, their effect on the progress as well as timely delivery. The research identified factors such as discrepancies in design documents, frequent design change and variation order during construction, unclear and inadequate details in drawings, slow response and inspection, poor contract management, inaccurate site investigation and change in material type during construction as consultants' responsibility. Delay in material delivery, inefficient planning and scheduling, late procurement of materials, low labor productivity, inappropriate cost estimation and improper construction method as contractor's responsibility. Finance arrangement and inadequate fund allocation, change and variation order during construction, delays to effect

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progress payment, unrealistic project duration and slow decision making as the client's responsibility.

Hailemeskel (2013), tried to identify management control problems of construction industry in Ethiopia and stated that the major problems related to the construction industry as Shortage of finance, equipment, machinery and skilled and unskilled human resources. In addition, weak performance due to wastage which is more than 20 %, Poor control and management capacity, Low productivity level in terms of manpower, machine, and materials utilization, absence of modern Scheduling techniques for planning and evaluation practice at project level.

Feysal (2018), Compared Factors Affecting Performance of Local and International Contractors in Building Projects in Ethiopia particularly focusing on identification and comparison of performance differences of local and international contractors; while giving much emphasis on time and stated that major factors affecting both groups of contractors is found out to be cost related factors. In addition, it has been observed that the unavailability of personnel and recruitment of highly experienced and qualified employees and also the competence development is a major problem for the construction industry.

The current situation of managing and minimizing wastage of construction materials on selected public building construction projects in Addis Ababa was studied by (Asmara, 2015). The most significant factors causing construction waste on building construction projects are Site supervision factors, Materials handling and storage factors, Design and documentation factors, Site management and practices factors and Operations factors.(Dawud, 2015), tried to assess performance measures for material management on building projects in Addis Ababa and the

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conclusions were that there is rare practice of material management and thus the construction companies should practice it more.

Bedru (2016), investigated different types, causes, effects of construction defects in Public building projects and at the end tried to forward construction defect reducing measures in building projects. From the results of the thesis a total of 8 effects of construction defect were recorded. Project delay ranked as the highest effect of construction defects. The next effect was construction cost overrun. The analysis ranked high maintenance cost as the 3rd highest effects of construction defects. Construction defect negatively affect contractor and/or consultant reputation and decreases the value of project were the remaining effects of construction defect in top five list respectively.

Mulualem (2017), tried to study problems related to schedule preparation and control in high rise, medium and complex projects with a project cost of 500 million Birr or more by selecting public building projects in Addis Ababa. The study found two categories of factors which were contractor and consultant/client initiated. The contractor initiated factors were poor project management, low qualification and limited staff experience, subcontractor and supplier non-performance. The consultant/client initiated factors were incompleteness of design information, incompetent supervision (lack of experience), late approval of shop drawings, and change in initial design with late decision making process.

These different researches done by various researchers have shown risk factors in relation to cost, time and quality in general. Despite some other researches related to building construction around Addis Ababa, no particular and wide-ranging research has been found with respect to high rise building construction risks in Ethiopia. The only particular researches directly touching high rise building construction risk issues were (Fasil, 2017 ; Girma, 2018) related to safety and health

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management in high rising building in Addis Ababa city administration and (Muluaem, 2017) who studied problems related to schedule preparation and control in high rise, medium and complex projects.

### *2.6.3. International Studies Related to High Rise Building Construction Risk Factors*

This section tries to explore the researches undertaken by various researchers with regard to high rise building construction in the world stage and their implications. In addition, the main risk factors studied will be compiled so as to make a basis for the risk factors to be studied by this research.

#### *A. Asia*

Bhangale (2017), studied the causes for high rise building construction delay in the city of Pune, India as a case study and attempted to classify factors in to consultant related, contractor related, client related and due to external factors. The major factors from these four classifications being errors made by designers, inadequate site investigation, interim payment delays, poor communication between parties, Insufficient estimation of original contract duration, Poor use of advanced design software, Inadequate contractor experience, Incompetent project team, Poor site management and supervision, slow decision making, unexpected issues on the project site, material price escalation, poor quality of materials and issues related to labor including inexperience, low productivity and poor quality of work.

Amitabh and Amit (2011), tried to assess the construction challenges in the case of the SKY towers construction in Mumbai. The observations were that Challenges were encountered while erecting equipment's due to space constraints. Therefore, in order to respond to these issue

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planning was made for the right equipment, formwork system, concrete planning, construction sequence and placement in strategic location.

The nature of critical factors affecting project performance in Indonesian Building contracts were studied by (Putu & Stephen, 2005). High inflation/ increased price was perceived as the top rank risk factor affecting both project time and cost. Design change by owner and defective design were assessed as the second and third most important factors affecting project time respectively, but were in third and second place respectively when their impact on project cost was considered. For delayed payments on contract, this was ranked in the fifth position with respect to project time and in fourth position for project cost. The two risk factors that were not identified in the top-5 critical risk factors affecting both project time and project cost were weather condition (4th position for time) and defective construction work (5th position for cost).

The investigation of possible risk factors affecting in high-rise construction projects through a structured questionnaire distributed in Surat city of Gujarat was done by (Gamit et al., 2019). The top ten risk factors affecting the high-rise construction projects considering all responses are financial failure of the contractor, delayed payments on contract, material management, natural calamities (floods, earthquakes, fire, etc.), high competition in bids, defective design, improper planning, poor communication between involved parties, poor communication between the site and head office and finally difficulty to access the site.

Ming-Fung et al. (2018) tried to study project risks commonly occurring in Hong Kong NEC projects and categorized them as ground and utilities, design information, structures, and workmanship. Modification of design information may incur during the construction stage owing to changes in site condition, law regulation and the owner's requirement. In Hong Kong, most

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construction sites are located near existing buildings and infrastructure. Damage to existing structures or subsidence may incur during the construction stage. The Contractor may spend extra time and cost to carry out remedial works.

Yadi et al. (2018), identified the critical success factors (CSFs) for safety management of high-rise building construction projects and exploring interactions among such CSFs. Study data were sourced from semi structured interviews and a questionnaire survey administered in China. The study established six third-order Critical success factors including management measures, management organization, technical and management plan, worker safety behavior, safety environment and worker safety quality.

Kim et al. (2016), calculated the importance of high-rise building construction risks in Korea using by PROMETHEE technique. The high degree risk factors are 'Operation plan of material lifting', 'Outrigger & Belt Truss Construction', 'Foundation work plan of high-rise building' and 'Considering a Structure concept of high-rise building.

### *B. Middle East and Africa*

Bhatti (2018), identified 56 factors causing delay & top most common factors in different parts of the world causing delay in construction projects are recognized keeping in mind the environment of Dubai, United Arab Emirates. After compiling this risk factors, the research tried to list the 10 most common factors causing delay in high rise construction projects which are time overrun, Cost overrun, disputes, project abandonment, bankruptcy, lawsuits, litigation and arbitration.

Hezekiah (2000), tried to study risk management in the building construction Industry in Kenya by analyzing time and cost risks. The research found that extra work, change in design, delay in

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preparation of detailed drawings and late instructions to be the four most important sources of cost and time risks in Kenya.

Symon (2016), investigated causes of delay in large construction projects according to the respondents were erratic payment, slow decision making, bureaucracy in client organization, design changes, labor shortages, low skill levels, plant equipment related problems, environmental concerns and restrictions, management problems, material changes and low design team experience.

A survey for the evaluation of risk factors impacting construction projects in Ghana yielded responses from 34 contractors, 46 consultants, and 23 clients or owners (private and public) within the Ghanaian construction industry. Results of this study indicate a disparity of the ranking of the degree of occurrence and impact among the groups. There was a statistical difference at the  $p < 0.05$  level significant for five out of 25 risk factors occurrences as follows: “construction methods”, “inflation”, “weather condition”, “ground conditions and contaminant conditions” and “poor communication amongst project team” and only one for the degree of impact scores for “price fluctuation”. Based on the composite risk factors, the financial and economic factors were found to be the most likely to occur and have the most impact on projects, whereas legal risk factor was found to be a low weighted risk, as it had the least likelihood to occur and the least impact score (Chileshe & Boadua, 2012).

Khatleli (2017), tries to show the pertinent risks (managerial, technical and financial) encountered in the Zambian building sector. Most of these risks are consultant and contractor related, mainly resulting from imperfect planning and monitoring in the pre-construction and construction phases of the project, respectively. Furthermore, the results show that 80% of the pertinent risks point to

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deficiency or imperfect application of knowledge in cost management, procurement management, integration management, communication management, and scope management.

### *2.6.4. Summary of Risk Factors Compiled from Various Sources*

As the above sub chapters tried to show different researchers tried to classify high rise building construction risk factors within the scope of their study element. Because projects are unique in their own way due to the unique risk factors they encounter on their execution stage numerous factors were found. After analyzing the above researches related to building construction risk factors particularly in the high rise construction industry in the international and local the risk factors were grouped and the following table was compiled using the risk factors explored in the numerous literatures found.

As the above sub chapters tried to show different researchers tried to classify building construction risk factors within the scope of their study element. After analyzing the above researches related to building construction risk factors particularly in the high rise construction industry in the international and local (around Addis Ababa), the following table is compiled for further analysis.

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**Table 4:- Compiled Categories of Risks Associated With High Rise Buildings**

Risk factors		References	
		Particular papers related to high rise Building construction	Papers related to Building construction in general
<b>Finance</b>	F1- Inflation and Exchange rate fluctuation F2- Inappropriate advance payment use F3- interim payment delay	(Bhangale, 2017),(Arati & Ashish, 2015),(Vichian et al.,2018)(Anik et al., 2018)(Hana, 2017)	(Imayanti, 2017)(Putu & Stephen, 2005)(Calvert, 1995)(Leenu & Annie, 2018)(Addis, 2014)(Hailemeskel, 2013)(Shewaferahu, 2016)(Feysal, 2018)(Bedru, 2016) (Chileshe & Boadua, 2012), (Khatleli, 2017).(Mekdes, 2016)
<b>Management</b>	M1 - Change in top management M2 - Type of delivery method selected M3- Poor contract and site management M4- Poor communication between stakeholders M5- Material handling and storage factors	(Anik et al., 2018)(Vichian et al., 2018)(Arati & Ashish, 2015) (Mulualem, 2017) (Bhangale, 2017) (Amitabh & Amit, 2011)(Symon, 2016)(Derebe, 2018)	(Asmara, 2015)(Hailemeskel, 2013)(Shewaferahu, 2016)(Addis, 2014) (Mitike et al., 2017) (Feysal, 2018)(Dawud, 2015)(Mekdes, 2016)
<b>Design</b>	D1- Inadequate site investigation D2- Poor detailing and design change delay D3- poor use of advanced software	(Anik et al., 2018)(Vichian et al., 2018)(Arati & Ashish, 2015)(Bhangale, 2017) (Maria, 2000)(Hana, 2017)	(Mohamad & Donald, 2015)(Asmara, 2015)(Hailemeskel, 2013)(Shewaferahu, 2016)(Leenu & Annie, 2018) (Khatleli, 2017) (Hezekiah, 2000)

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Risk factors		References	
		Particular papers related to high rise Building construction	Papers related to Building construction in general
<b>Construction</b>	<p>C1- Incorrect plan of work, cost, schedule and quality</p> <p>C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials</p> <p>C3- Loss of time by traffic control and restriction</p> <p>C4- Low labor productivity and labor shortage</p> <p>C5- Improper choice of curtain wall systems and deficient field installation</p> <p>C6- Changes and variation order</p>	<p>(Anik et al., 2018)(Vichian et al., 2018)(Arati &amp; Ashish, 2015)(Mohamad &amp; Donald, 2015) (Imayanti B. , 2017)(Amitabh &amp; Amit, 2011) (Ming-Fung et al., 2018) (Pankaj, 2016) (O-Kyung &amp; Jong-Hoon, 2004) (CCIP, 2014) (Maria, 2000)(Symon, 2016) (Kim et al., 2016)(Derebe, 2018)</p>	<p>(Bedru, 2016)(Feysal, 2018)(Hailemeskel, 2013)(Shewaferahu, 2016)(Leenu &amp; Annie, 2018) (Mitike et al., 2017) (Asmara, 2015)(Putu &amp; Stephen, 2005)(Mekdes, 2016)</p>
<b>Legal</b>	<p>L1- Permit requirements.</p> <p>L2- Bribery/ Corruption</p>	<p>(Vichian et al., 2018)(Arati &amp; Ashish, 2015) (Ming-Fung et al., 2018) (Bhatti, 2018)(Symon, 2016)</p>	<p>(Feysal, 2018)(Hailemeskel, 2013)(Shewaferahu, 2016)(Leenu &amp; Annie, 2018)(Fasil, 2017) (Adnan &amp; Jaser, 2008)(Woyesa, 2017)</p>
<b>Safety</b>	<p>S1- No appointed safety personnel</p> <p>S2- Labor Injuries</p> <p>S3- Fire/ Theft of material and Equipment</p>	<p>(Fasil, 2017) (Girma, 2018) (CCIP, 2014) (Maria, 2000) (Yadi et al., 2018) (Ming-Fung et al., 2018)</p>	<p>(Leenu &amp; Annie, 2018)</p>
<b>Procurement</b>	<p>P1 – Late material Procurement</p> <p>P2- Defective material supply and price escalation</p> <p>P3 Unavailability of material, labor and Equipment</p> <p>P4- Utility service delay</p> <p>P5- Importation, customs and visa issues</p>	<p>(Arati &amp; Ashish, 2015)(Mohamad &amp; Donald, 2015)(Vichian et al., 2018) (Bhangale, 2017)(Hana, 2017)</p>	<p>(Bedru, 2016)(Feysal, 2018)(Hailemeskel, 2013)(Shewaferahu, 2016)(Leenu &amp; Annie, 2018) (Mitike et al., 2017) (Khatleli, 2017)(Mekdes, 2016)(Woyesa, 2017)</p>

### **2.7. Gaps Observed in Existing Literature in Ethiopia**

The literature review explored various researches in relation to high risk construction risk factors. These literatures tried to show the basic risk factors in their respective study areas. Numerous researches exist in relation to the risk factors in high rise building construction in the international arena. The researchers particularly related to high rise building construction in Ethiopia are very few and the ones that occur are mostly related to safety issues as we can see in the above review.

This shows the need for a wide-ranging study in terms of high rise building construction risk factors in Ethiopia. In addition, it is evident that although the major risk factors are similar in the overall sense of construction industry, the prevalence, interconnection and the influence of these risk factors were not particularly studied. This makes a clear indication for the need to study the interdependency, impact of these risk factors in relation to high rise building construction.

As stated earlier risks related to safety management were studied and other factors such as finance, management, design, construction, legal and procurement factors were not studied particularly and in relation to high rise building construction. Since the high rise building construction industry in Ethiopia is booming the study of risk factors benefits the parties involved in the particular projects for better planning and execution of the project work. This research tried to add credible understanding to the existing body of knowledge by marking out and analyzing the critical risk factors while showing their impact on project progress. In addition, the interrelationships between the risk factors, how they influence each other, evaluation of key factors for problem solving and those with little influence over others were explored.

## **CHAPTER THREE**

### **RESEARCH DESIGN AND METHODOLOGY**

#### **3.1.Introduction**

This section of the research explains and justifies the methods and means in which the objectives of the study are met. The study considered both quantitative and qualitative research approaches based on the nature of the research problem to enable understanding of the current situation. In general primary and secondary sources were used to collect data for the research. The methodologies to be used in this research include literature review, data collection using questionnaire and a structured interview, analysis of respondent's response, discussion of the phenomenon based on the response of the research population and finally a conclusion was drafted including the recommendations that come out as part of the research output.

#### **3.2.Research Design, Methodology and Approach**

Research methodology is the method by which research can be carried out and it lies at the heart of any research. It is vital to give careful consideration to the research methodology at the outset of the research in order to adopt most appropriate approaches and research methods (Amaratunga et al., 2002). Since mixed-methods research improves the validity and reliability of the resulting data and strengthens causal inferences by providing the opportunity to observe data convergence or divergence in hypothesis testing (Abowitz & Toole, 2009).

Therefore, this research used a mixed method in which questionnaire is used as a quantitative instrument and a case study was used as a qualitative instrument in order to achieve the research goals. The timing of the research was concurrent. Concurrent means that the researcher

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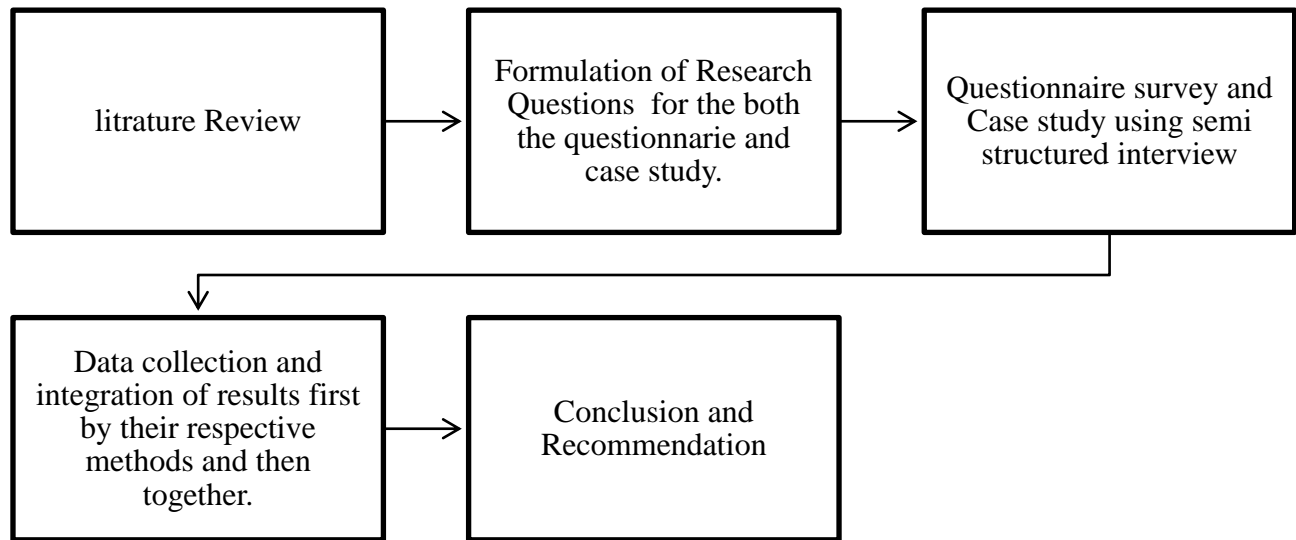
implements both quantitative and qualitative methods during a single phase of the research study. This means that the quantitative and qualitative data are collected, analyzed, and interpreted at (approximately) the same time (Creswell, 2003)

Morgan (1998 ), advised that the weighting in a study be based on the strength of which data collection method (quantitative over qualitative) is best suited to address the study's goals or purpose. In our case the quantitative method particularly the questionnaire is given more weight.

The mixing decision for this study is to merge the two data sets which come from the qualitative and quantitative study. Merging means that researcher takes the two data sets and explicitly brings them together or integrates them. Researchers can merge the two data sets during the interpretation (by analyzing them separately in a results section and then merging the two sets of results together during the interpretation or discussion phase) or during the analysis of the data (by transforming one data type into the other type or consolidating the data into new variables) (Creswell, 2003). The following research method was used in order to achieve the research objectives specified. These steps were instrumental in achieving the objectives since they add value to the next step specified.

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**Figure 5:- Research methodology**

### 3.3. Study Area and research population

The study was undertaken in Addis Ababa, Ethiopia. This area is selected since major high rise construction is currently being implemented in the area and it can show us the real picture in-terms of high rise construction risk factors in the country at large. High rises currently being constructed in Addis Ababa were explored by making sure the research found the representative samples it needed.

The populations for this research were high rise building construction sites i.e. those more than 35 meters in Addis Ababa using building height zone 4 and above from the building height regulation. The data for the number of high rise building construction sites was found from the Building permit and construction supervision office of Addis Ababa which was 20 high rise buildings and in addition 12 buildings located mainly in the financial zone of Addis Ababa found from (Emporis, 2000) were used.

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Therefore, our total population was 32 high rise buildings which are under construction in various parts of Addis Ababa.

### **3.4. Selected Research Methods**

In order to meet the research objectives a mixed method is selected so as to make sure these objectives are met. The case study is used for the analysis of risk factors in the high rise construction industry, while the questionnaire is used to assess and categorize risk factors (RF) which occur on high rise building construction sites studied.

#### *3.4.1. Case Studies (Qualitative Instrument)*

The case study method “explores a real-life, contemporary bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in- depth data collection involving multiple sources of information and reports a case description and case themes (Creswell, 2003). The researcher therefore have to consider if it is wisely to make a single case study or if it is more wisely to make a multiple case study for the understanding of the phenomenon (Gustafsson, 2017).

Multiple case studies can be used to either give out contrasting results for expected reasons or similar results in the studies (Yin, 2003) . In addition, multiple case study methodology is more powerful than single-case designs as it provides more extensive descriptions and explanations of the phenomenon or issue. Therefore, this study used multiple case studies to study risk factors in high rise building construction projects located in Addis Ababa in order to understand the phenomenon more deeply.

The case study in this research is designed so as to evaluate and analyze responses from professionals in high rise building construction sites using the data collection method selected.

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Cross case evaluation summaries were prepared so as to show the big picture. The following figure shows the case study process design to be followed by this research.

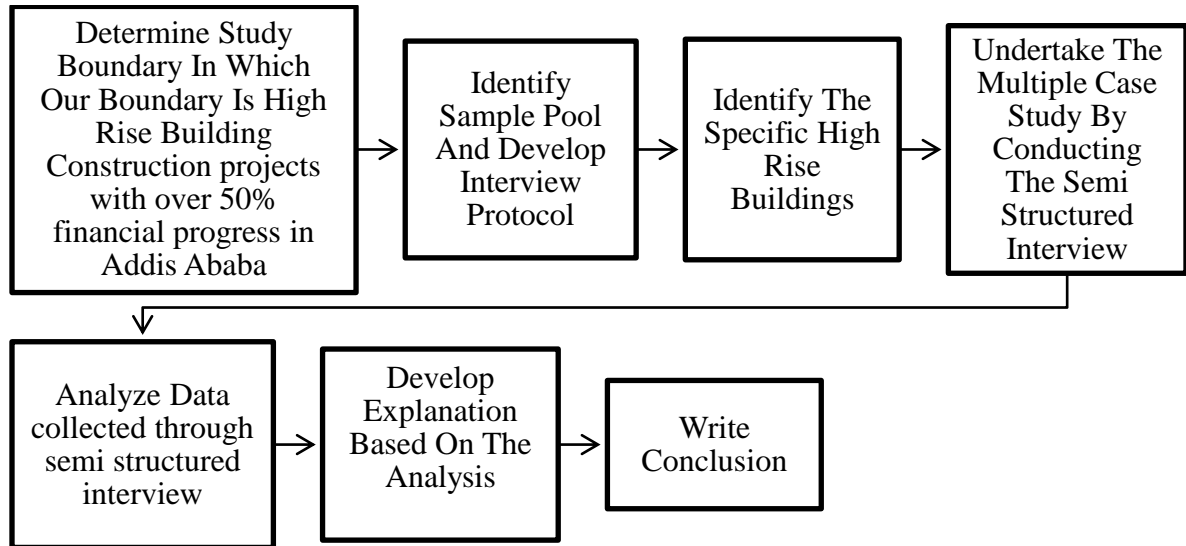


Figure 6:- The basic flow to be followed for the case study

### 3.4.1.1. Selection of Case Study

The method used for selecting high rise building construction site for these case study was based on purposive sampling. According to (Neuman & Robson, 2009), purposive or judgmental sampling uses the judgment of an expert in selecting cases or the researcher selects cases with a specific purpose in mind. Purposive sampling is useful for case study in three situations: (1) when a researcher wants to select unique cases that are especially informative, (2) when a researcher would like to select members of a difficult-to-reach, specialized population, and (3) when a researcher wants to identify particular types of cases for in-depth investigation. The purpose is to gain deeper understanding of those particular types of cases.

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In order to be selected for the case study the high rise building construction sites

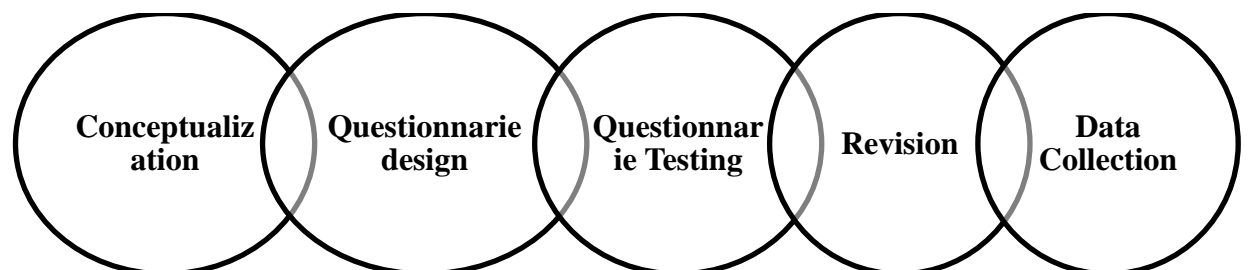
- ✓ Willingness of the companies and their staff.
- ✓ High rises located around the city of Addis Ababa were studied.
- ✓ High rises with a minimum height of 35 meters or greater were considered

Based on these qualifications the following cases were selected and studied for the case study. The case study tried include government owned project cases and private owned projects. The buildings assessed using the case study were

- ✓ Case one: - Zemen Bank HQ Construction project
- ✓ Case Two: - Nile insurance Sc. HQ construction site
- ✓ Case Three: -National Archive and library Construction site
- ✓ Case Four: -CMC Apartments Construction site

### *3.4.2. Questionnaire (Quantitative Instrument)*

The questionnaire as a quantitative research instruments was formulated after gathering and analyzing the literatures regarding risk factors in building construction. A questionnaire survey was used to examine the degree of importance of each risk factor in the particular projects and other stakeholders to be studied. The process used for the questionnaire part of this study will use the following process proposed by (Brancato, et al., 2006)



**Figure 7:- Questionnaire development process (Brancato, et al., 2006)**

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Simple random sampling where every member of the population has a known and equal chance of being selected was used as a sampling technique for the questionnaire. The questionnaire interviews were conducted among stake holders in the construction project by means of the Likert scale so respondents can give the rank to their answers. The Likert scale was selected to obtain the probability of the risk factors in building construction project that are identified in the literature review. A 5 - point Likert scale will be adopted, where 1 represented “rare”, 2 “occasional”, 3 “somewhat frequent”, 4 “frequent”, and 5 “very frequent”. Likewise, the Likert scale was selected to obtain the impact of the risk factors in the project that are identified in the literature review. A 5-point Likert scale was adopted, where 1 represented “very low”, 2 “low”, 3 “moderate”, 4 “high”, and 5 “very high”. The questionnaire will have the following parts

1. Respondents background
2. High rise Building Project information
3. Table for the probability and impact matrix
4. Table for DEMATEL analysis
5. Risk management strategies and tools used in the project

### *3.4.2.1. Methods Used in the Design of the Questionnaire*

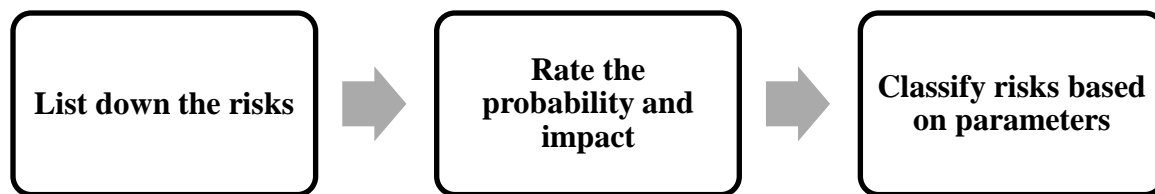
The interdependence of the risk factors was confirmed using the DEMATEL method by a visual representation. Probability impact matrix is used to rank the most influential factors in the high rise building construction sites to be studied around Addis Ababa. In addition, the background of respondents was collected. The process to be followed by the Probability impact matrix and the DEMATEL method are illustrated as follows.

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### *I. The Probability and Impact Matrix*

The probability and impact matrix was used as an instrument because it presents stakeholders' views that are essential for prioritizing project risks qualitatively (John & Herman, 2011). The matrix was prepared using the probability and impact data collected using the questionnaire. The probability and impact matrix illustrates a risk rating assignment for individual risk factors in the identified risks categories. The risk matrix shows the combination of impact and probability that in turn yield a risk priority (shown by the red, yellow, and green color). The process to be used in the preparation of the PI matrix is shown as follows



**Figure 8:- Probability impact matrix preparation process (Juneja, 2018)**

### *II. Decision Making Trial and Evaluation Laboratory (DEMATEL)*

The DEMATEL method was also used to construct an impact-relation map, and obtain the impacts of each element over others. The network relation map (NRM) was used to present a structural relationship between the different influence factors to visualize the relationship between the risk factors. The process followed by the method will be as follows

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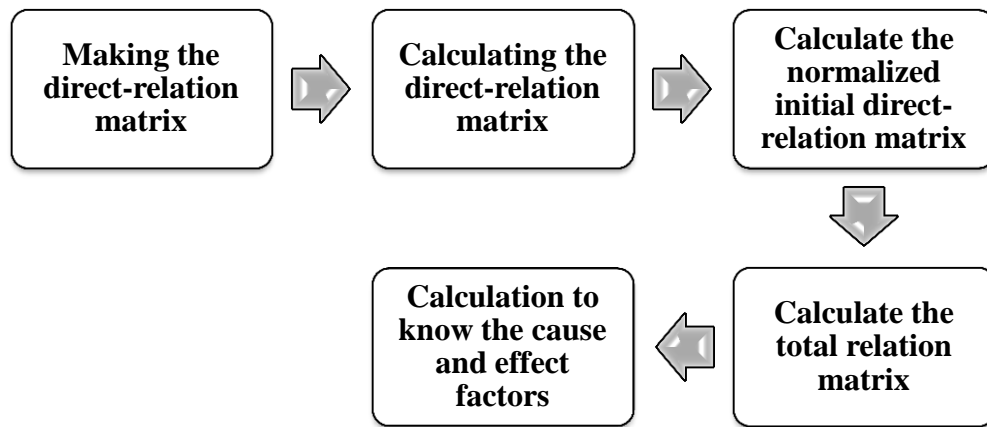


Figure 9:- DEMATEL processes to be followed

### 3.5.Data Collection

#### 3.5.1. Primary Data

The sources of primary data are stakeholders in the high rise building construction sites (i.e. Consultants, contractors and client). The data was used to infer conclusions with regard to the impact of risk factors based on the response of these parties.

#### 3.5.2. Secondary Data

Academics periodicals, research journals, government publications, past dissertations and Internet resources were used as secondary data sources to help identify with and emphasize the phenomenon at hand.

### 3.6. Data Analysis

In the design of the questionnaire, particular attention was given to the numerical data in order to facilitate the proper analysis that will follow and to finally make a clear and unambiguous representation of what was found in the research. The tools for data analysis are relative

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importance index method, Kendall's coefficient of concordance and the probability and impact matrix. In the case study using a structured interview the cases were analyzed separately and then merged with the questionnaire results in order to get the big picture.

*3.6.1. The Relative Importance Index Method (RII)*

The relative importance index method (RII) was used to determine owners', consultants', and contractors' perceptions of the relative importance of the identified risk factors. Stakeholders who are actively working in the building construction industry were approached to participate in this research. The relative importance index method (RII) was computed as follows (Cheung, Suen, & Cheung, 2004).

$$RII = \frac{\sum W}{A \times N} \dots \dots \dots \text{Equation 9}$$

Where

- ✓ W is the weight given to each factor by the respondents and ranges from 1 to 5;
- ✓ A is the highest weight = 5;
- ✓ N is the total number of respondents.

*3.6.2. Kendall's Coefficient of Concordance*

To determine whether there is a significant degree of agreement among the 3 groups of respondents (owners, contractors and consultants) Kendall's coefficient of concordance is used. It is used as a measure of agreement among raters. Kendall's coefficient of concordance indicates the degree of agreement on a zero to one scale, and is computed by the following equation (Moore et al., 2003).

$$W = \frac{12U - 3m^2n(n+1)^2}{m^2n(n^2-1)} \dots \dots \dots \text{Equation 10}$$

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Where

$$U = \sum_{j=1}^n (\sum_{k=1}^m R_{Kj})^2 \dots\dots\dots \text{Equation 11}$$

- ✓ n is the number of factors;
- ✓ m is the number of groups;
- ✓ j is the factors 1, 2, ..., N.
- ✓  $R_K$  is the sum of ranks in all groups for each factor
- ✓ W is the coefficient of concordance

In order to check the significance test for the null hypothesis for the agreement or disagreement among the 3 groups of respondents (owners, contractors and consultants), the chi square ( $X^2$ ) test approximation was used for (n-1) degrees of freedom (Kendal & Gibbons, 1990). A significance level of 0.05 was used for the calculation meaning that there will be a 5% probability of concluding that a difference exists.

$$X^2 = m(n - 1)W \dots\dots\dots \text{Equation 12}$$

The hypothesis is therefore

- ✓ Null hypothesis ( $H_0$ ) There is insignificant degree of agreement among owners, contractors and consultants.
- ✓ Alternative hypothesis ( $H_1$ ) There is a statistically significant degree of agreement among owners, contractors and consultants.

If the computed value of  $X^2$  is greater than the tabulated value of  $X^2$ ,  $H_0$  is rejected, otherwise accepted.

### **3.7. Reliability and validity**

Reliability and validity are the two most important and fundamental features in the evaluation of any instrument or tool for a good research (Haradhan, 2017). According to (Golafshani, 2003), whatever research methodology is adopted for research reliability and validity issues have to be considered as they are tests for trustworthiness of the measurement instrument used in the research. Therefore, this research tried to make sure these three tests are complied with while achieving the research objectives outlined. In order to guarantee the validity of the research data the questionnaire prepared was first piloted to a few professionals working in the high rise building construction projects ensuring that the contents consistency and relevancy of the questions asked is preserved.

### **3.8. Summary of the Research Process**

As a summary, we can see that this research used both quantitative by using questionnaire and qualitative method using a case study method particularly structured interview as a mixed method. In order to logically reflect on the effectiveness of the mixed- method for achieving the particular research objectives of this research numerous literatures were presented.

Analysis procedures were set out before exploring the subject matter and the research procedures outlined made sure the outcomes of the research are valid in terms of scientific research procedures. Both the questionnaire and the case study followed the steps prepared and the integration of the result also followed the research process outlined.

## **CHAPTER FOUR**

### **RESULTS AND DISCUSSION**

#### **3.1. Introduction**

This chapter will show the data collected in different forms and the analysis of the respondent's opinion with regard to the specific questions of the research. Tabular presentation, percentage of respondents who agree or disagree with the idea discussed and other issues were shown as per the response given by the research population. In general, the data presented will follow the research methodology presented in the previous chapter in order to achieve the research objective proposed.

#### **3.2. Quantitative Data Presentation and Analysis from Questionnaire**

The objectives of the research were to assess, categorize and show the impact of these risk factors risk factors (RF) which occur on building construction sites based on the research method employed. In order to achieve the objective of the research this study administered a mixed strategy for data collection. First 23 potential risk factors were extracted from various literatures as illustrated in the literature review section and some 4 Risk factors were added to the list after testing the questionnaire with 3 industry experts with many years of experience in building construction including high rise buildings.

As per the research methodology used a semi structured interview and a questionnaire was developed and used. For the semi structured interview an interview protocol was prepared, it included questions related to respondent background, project information of the current high rise construction project the respondent is working on, risk factors are provided to be evaluated

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whether or not they are evident in the high rise building construction project they are currently engaged in, the responsible parties for the risk factors and their consequences. In addition, respondents were asked whether or not they use risk management as a core process and the tools they use in order to achieve the risk management process outlined.

*3.2.1. Response Rate*

Slovin's formula was used to calculate the sample size as follows.

$$n = \frac{N}{1+Ne^2} \dots \dots \dots \text{Equation 13}$$

where

n = Number of samples,

N = Total population and

e = Error tolerance.

Using a total population of 32 high rise buildings, with a 95% confidence level giving an error tolerance of 0.05 the number of samples n is calculated to be 30

$$n = \frac{32}{1+32(0.05^2)} = \underline{\underline{30}}$$

Even though the sample size was calculated to be 30 the number of samples distributed was 60 in order to add more trustworthiness to the research. From the 60 questionnaires distributed in various sub cities in Addis Ababa high rise building construction sites, only 56 were returned. In addition, from the returned questionnaires 2 were eliminated because they were incomplete. From these we can calculate that the response rate is 90%.

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### 3.2.2. Respondents Profile

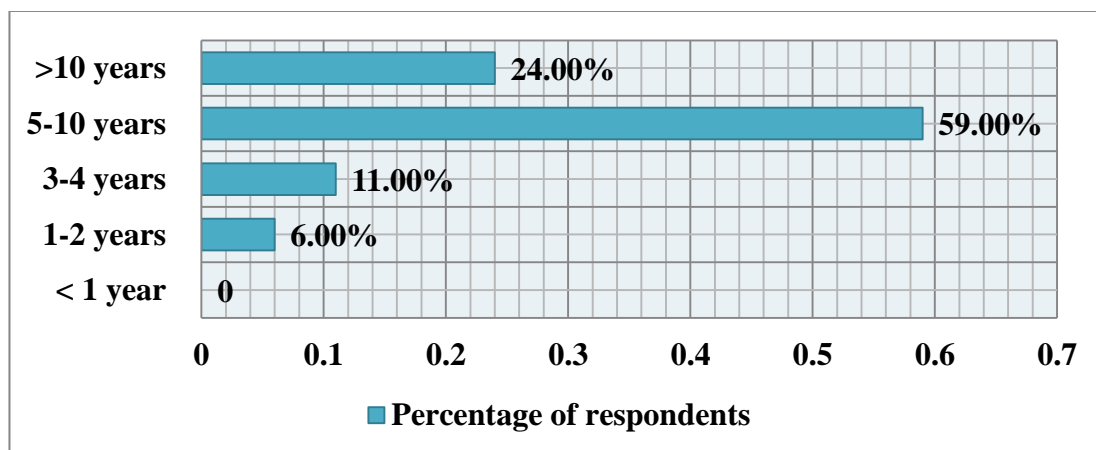
After collecting the response of the population an analysis was done in order to tabulate the results so that the result is shown more clearly. In addition, the analysis follows the questions flow pursued by the questionnaire the respondents filled.

The majority of the respondents about 50% worked for the main contractor in their respective projects followed by owner which takes about 30 %, sub-contractors 11% and finally consultants 9%.

**Table 5:- Stakeholder Profile of Respondents**

Profile	Frequency	Percentage
Main contractor	20	37%
Sub-Contractor	8	15%
Consultant	12	22%
Owner	14	26%
Total	54	100%

In terms of experience most of the respondents have 5-10 years of experience with a percentage of 59% and the remaining respondents with more than 10 years' experience 24%, 3-4 years' experience 11% and finally 1-2 years' experience with 6%.



**Figure 10:- Experience Of the Questionnaire Respondents**

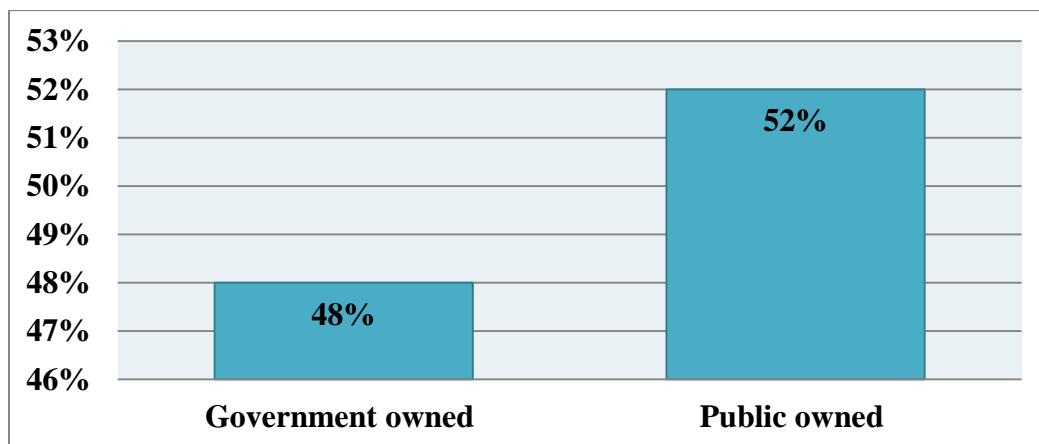
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As for the Education Qualification of respondents, the majority of respondents which take 33% have a Bsc. Degree and the remaining ones having Msc. Degree taking the remaining 39%.

**Table 6:- Education Qualification of Respondents**

Profile	Frequency	Percentage
Diploma	-	-
B.Sc.	33	61%
M.Sc.	21	39%
PHD	-	-
Other	-	-
Total	54	100%

From the surveyed projects using the questionnaire prepared 48% of the projects were government owned while the remaining 52% are public owned.



**Figure 11:- Ownership of the Projects surveyed**

In terms of delivery method, the projects used the Design Bid Build (DBB) delivery method.

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**Table 7:- The delivery method used by the projects studied**

Profile	Frequency	%
Design Build (DB)	-	-
Design bid build (DBB)	54	100%
Construction management consultancy (CM)	-	-
Others	-	-
Total	54	100%

The current stage for the majority of the projects was between 30% - 70% which takes about 89% and the remaining projects have 70%-95% executed percentage.

The following table shows the current stage of construction of the surveyed high rise buildings.

**Table 8:- Current progress rate of high rise construction projects studied**

Profile	Frequency	%
10% - 30%	-	-
30% - 70%	48	89%
70% - 95%	6	11%
Total	54	100%

The major risk management tools pointed out by the respondent's in terms of use by the building construction sites were only checklists, expert system which uses experts in relation to the particular risk item, interviews and some questionnaires. In addition to these ones some of the companies have a process for risk management and they also use past experience through document review in order to manage risks that arise in their particular sites.

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### **3.3. Risk Severity and Impact Assessment for high rise building construction risks**

Using the questionnaire as a tool respondents were asked to fill out both the likelihood and impact of the risk factors identified. The table used in the questionnaire embraced Likert scale for the respondents to write their opinions in numerical forms. For the analysis of the project risk severity and impact assessment table first the risks were listed down from various sources and were compiled, then their probability and impact was rated using the questionnaire prepared, finally analysis was done using the relative importance index (RII) to examine and rank the factors as indicated in the research method. After all this process a risk matrix was prepared by first calculating the response of the population for the probability and impact of each risk factor respectively.

To determine whether there is a significant degree of agreement among the 3 groups of respondents (main contractor, sub-contractor, consultant and owner) Kendall's coefficient of concordance was used. In addition, the response of these stakeholders was first analyzed separately based on their response to the particular risk probabilities and impact. The coefficient was calculated for the probability of occurrence and for the impact separately using the values gathered from respondents and first by calculating the RII and then ranking the factors separately for the main contractor, sub-contractor, consultant and owner in order to make sure the significant degree of agreement between these stakeholders is known.

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*3.3.1. Response given by the stakeholders in terms of probability of risk factor occurrence*

Importation, customs and visa issues, poor detailing and design change delay and inflation and Exchange rate fluctuation were found to be the three risk factors with the highest probability of occurrence. The response of the research population for the probability of the risk factors occurring with their respective stakeholders is shown as follows.

**Table 9:- Probability of the Risk Factor Occurrence**

Risk factors	Main contractor		Sub-contractor		Consultant		Owner		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank
F1- Inflation and Exchange rate fluctuation	0.80	3	0.78	4	0.87	2	0.74	6	0.80	3
F2- Inappropriate advance payment use	0.49	24	0.55	19	0.55	17	0.41	3	0.49	23
F3- interim payment delay	0.52	20	0.53	22	0.53	18	0.44	2	0.50	20
M1 - Change in top management	0.38	27	0.30	27	0.33	26	0.36	5	0.35	27
M2 - Type of delivery method selected	0.62	11	0.58	16	0.60	14	0.59	2	0.60	11
M3- Poor contract and site management	0.57	17	0.65	12	0.60	14	0.56	3	0.59	15
M4- Poor communication between stakeholders	0.46	26	0.58	16	0.48	22	0.54	4	0.50	20
M5- Material handling and storage factors	0.68	8	0.70	9	0.72	8	0.69	1	0.69	8
D1- Inadequate site investigation	0.64	10	0.75	5	0.63	10	0.74	3	0.68	9
D2- Poor detailing and design change delay	0.84	2	0.95	1	0.78	6	0.76	2	0.82	2
D3- poor use of advanced software	0.77	5	0.85	3	0.80	4	0.79	1	0.79	4
C1- Incorrect plan of work, cost, schedule and quality	0.77	5	0.75	5	0.80	4	0.81	1	0.79	5
C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	0.59	14	0.50	24	0.62	12	0.61	3	0.59	14

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Risk factors	Main contractor		Sub-contractor		Consultant		Owner		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank
C3- Loss of time by traffic control and restriction	0.57	17	0.73	8	0.57	16	0.60	4	0.60	11
C4- Low labor productivity and labor shortage	0.59	14	0.50	24	0.63	10	0.53	5	0.57	16
C5- Shortage of engineers and specialists	0.50	21	0.58	16	0.47	24	0.53	5	0.51	19
C6- Changes and variation order	0.78	4	0.75	5	0.77	7	0.73	2	0.76	6
L1- Permit requirements.	0.70	7	0.70	9	0.85	3	0.76	1	0.75	7
L2- Bribery/ Corruption	0.61	12	0.53	22	0.62	12	0.41	2	0.55	17
S1- No appointed safety personnel	0.58	16	0.50	24	0.53	18	0.47	2	0.53	18
S2- Labor Injuries	0.53	19	0.55	19	0.48	22	0.43	3	0.50	22
S3- Fire/ Theft of material and Equipment	0.50	21	0.60	14	0.32	27	0.54	1	0.49	25
P1 – Late material Procurement	0.66	9	0.70	9	0.67	9	0.71	2	0.68	9
P2- Defective material supply and price escalation	0.47	25	0.55	19	0.45	25	0.47	4	0.48	26
P3 Unavailability of material, labor and Equipment	0.50	21	0.60	14	0.50	21	0.41	5	0.49	23
P4- Utility service delay	0.61	12	0.63	13	0.52	20	0.64	3	0.60	11
P5- Importation, customs and visa issues	0.85	1	0.90	2	0.92	1	0.91	1	0.89	1

As per the process out lined in the research methods the Kendall's coefficient of concordance was tabulated in order to know the agreement of respondents in terms of probability of occurrence. A significance level of 0.05 was be used as per the methodology stated.

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Table 10:- Kendall's coefficient of concordance for probability of occurrence

<b>Factors</b>	<b>Finance</b>	<b>Management</b>	<b>Design</b>	<b>Construction</b>	<b>Legal</b>	<b>Safety</b>	<b>Procurement</b>
Kendall's Coefficient	3.625	5.66	6.13	4.54	6.5	6.06	5.76
Computed chi square value	29	90.6	49	90.857	26	48.5	92.2
Tabulated chi square value with p=0.005	5.99	9.49	5.99	11.05	3.84	5.99	9.49
df= (n-1)	2	4	2	5	1	2	4
Implication	(H <sub>0</sub> ) is rejected.	(H <sub>0</sub> ) is rejected.	(H <sub>0</sub> ) is rejected.	(H <sub>0</sub> ) is rejected.	(H <sub>0</sub> ) is rejected.	(H <sub>0</sub> ) is rejected.	(H <sub>0</sub> ) is rejected.

From the result the computed value of  $X^2$  is greater than the tabulated value of  $X^2$  implying that the null hypothesis ( $H_0$ ) is rejected.

*3.3.2. Response given by the stakeholders in terms of overall impact of the risk factors*

The overall impact of the risk factors was also examined after the collection of the response data. From the collected data we can see that incorrect plan of work, cost, schedule and quality, inflation and Exchange rate fluctuation and loss of time by traffic control and restriction were the major risk factors with the highest RII in terms of overall impact.

**Table 11 :- overall impact of the Risk Factor s**

<b>Risk factors</b>	<b>Main contractor</b>		<b>Sub-contractor</b>		<b>Consultant</b>		<b>Owner</b>		<b>Overall</b>	
	<b>RII</b>	<b>Rank</b>	<b>RII</b>	<b>Rank</b>	<b>RII</b>	<b>Rank</b>	<b>RII</b>	<b>Rank</b>	<b>RII</b>	<b>Rank</b>
F1- Inflation and Exchange rate fluctuation	0.90	2	0.93	1	0.90	2	0.90	2	0.90	2
F2- Inappropriate advance payment use	0.37	27	0.40	26	0.35	27	0.36	27	0.37	27
F3- interim payment delay	0.59	21	0.60	13	0.68	9	0.56	20	0.60	18
M1 - Change in top management	0.55	22	0.50	20	0.77	5	0.64	12	0.61	15

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Risk factors	Main contractor		Sub-contractor		Consultant		Owner		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank
M2 - Type of delivery method selected	0.66	14	0.78	4	0.50	22	0.66	10	0.64	13
M3- Poor contract and site management	0.67	13	0.70	8	0.60	16	0.61	14	0.64	12
M4- Poor communication between stakeholders	0.63	16	0.53	19	0.58	17	0.70	7	0.62	14
M5- Material handling and storage factors	0.69	11	0.45	23	0.62	14	0.53	21	0.60	19
D1- Inadequate site investigation	0.55	22	0.70	8	0.48	23	0.63	13	0.58	22
D2- Poor detailing and design change delay	0.75	7	0.50	20	0.52	21	0.49	25	0.59	20
D3- poor use of advanced software	0.79	3	0.65	11	0.57	19	0.69	9	0.69	11
C1- Incorrect plan of work, cost, schedule and quality	0.91	1	0.90	2	0.92	1	0.93	1	0.91	1
C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	0.43	25	0.43	24	0.45	24	0.39	26	0.42	26
C3- Loss of time by traffic control and restriction	0.68	12	0.73	5	0.80	3	0.74	5	0.73	3
C4- Low labor productivity and labor shortage	0.77	5	0.80	3	0.72	8	0.60	16	0.72	5
C5- Shortage of engineers and specialists	0.46	24	0.35	27	0.42	25	0.50	24	0.44	25
C6- Changes and variation order	0.70	10	0.63	12	0.75	6	0.74	5	0.71	7
L1- Permit requirements.	0.71	9	0.70	8	0.68	9	0.79	4	0.72	4
L2- Bribery/ Corruption	0.79	3	0.60	13	0.75	6	0.59	17	0.70	9
S1- No appointed safety personnel	0.60	19	0.60	13	0.65	12	0.61	14	0.61	15
S2- Labor Injuries	0.61	18	0.73	5	0.68	9	0.83	3	0.70	9
S3- Fire/ Theft of material and Equipment	0.74	8	0.58	17	0.78	4	0.70	7	0.71	6
P1 – Late material Procurement	0.76	6	0.73	5	0.65	12	0.66	10	0.70	8
P2- Defective material supply and price escalation	0.43	25	0.43	24	0.42	25	0.53	21	0.45	24
P3 Unavailability of material, labor and Equipment	0.62	17	0.58	17	0.55	20	0.57	19	0.59	21
P4- Utility service delay	0.60	19	0.50	20	0.62	14	0.51	23	0.57	23

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P5- Importation, customs and visa issues	0.66	14	0.60	13	0.58	17	0.59	17	0.61	15
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As for the impact of risk factors significance degree of agreement, no agreement was found between the stakeholders for risk factors categorized under management, design, legal and safety risks because as seen in the table the Computed chi square value is less than the Tabulated chi square value with  $p=0.005$ , while the remaining three risk factors have a strong agreement among the stakeholders. The following table shows the result obtained from the analysis calculated for the impact of risk factors.

**Table 12 Kendall's coefficient of concordance for the impact of risk factors**

Factors	Finance	Management	Design	Construction	Legal	Safety	Procurement
Kendall's Coefficient	1	0.03	0.44	0.87	0	0.44	0.83
Computed chi square value	8	0.4	3.5	17.48	0	3.5	13.20
Tabulated chi square value with $p=0.005$	5.99	9.49	5.99	11.07	3.84	5.99	9.49
df= (n-1)	2	4	2	5	1	2	4
Implication	(H <sub>0</sub> ) is rejected.	(H <sub>0</sub> ) is Accepted	(H <sub>0</sub> ) is Accepted.	(H <sub>0</sub> ) is rejected.	(H <sub>0</sub> ) is Accepted.	(H <sub>0</sub> ) is Accepted.	(H <sub>0</sub> ) is rejected.

*3.3.3. Probability Impact matrix results*

As for the rank using the relative importance index (RII) it was found that F1 (Inflation and Exchange rate fluctuation), (C1- Incorrect plan of work, cost, schedule and quality), D3 (poor use of advanced software), P-5 (Importation, customs and visa issues), L1 (Permit requirements), C6

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(Changes and variation order), D2 (Poor detailing and design change delay), P1 (Late material Procurement), C3 (Loss of time by traffic control and restriction) and M5 (Material handling and storage factors) were the top ten risk factors.

The table was developed using the overall RII calculated ranking was prepared for the risk factors is outlined in the following table

**Table 13:- Probability Impact matrix results using RII**

	<b>Risk factors</b>	<b>Probability</b>	<b>Impact</b>	<b>Matrix</b>	<b>Risk Ranking (RII)</b>
<b>Finance</b>	F1- Inflation and Exchange rate fluctuation	0.7963	0.9037	0.7196	1
	F2- Inappropriate advance payment use	0.4926	0.3667	0.1806	27
	F3- interim payment delay	0.5037	0.6037	0.3041	21
<b>Management</b>	M1 - Change in top management	0.3519	0.6148	0.2163	25
	M2 - Type of delivery method selected	0.6000	0.6407	0.3844	13
	M3- Poor contract and site management	0.5852	0.6444	0.3771	15
	M4- Poor communication between stakeholders	0.5037	0.6222	0.3134	20
	M5- Material handling and storage factors	0.6926	0.5963	0.4130	10
<b>Design</b>	D1- Inadequate site investigation	0.6815	0.5778	0.3937	12
	D2- Poor detailing and design change delay	0.8222	0.5926	0.4872	7
	D3- poor use of advanced software	0.7926	0.6926	0.5489	3
<b>Construction</b>	C1- Incorrect plan of work, cost, schedule and quality	0.7852	0.9148	0.7183	2
	C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	0.5889	0.4222	0.2486	23
	C3- Loss of time by traffic control and restriction	0.6000	0.7296	0.4378	9
	C4- Low labor productivity and labor shortage	0.5704	0.7185	0.4098	11
	C5- Improper choice of curtain wall systems and deficient field installation	0.5111	0.4444	0.2272	24
	C6- Changes and variation order	0.7593	0.7111	0.5399	6
<b>Legal</b>	L1- Permit requirements.	0.7481	0.7222	0.5403	5
	L2- Bribery/ Corruption	0.5481	0.7000	0.3837	14
<b>Safety</b>	S1- No appointed safety personnel	0.5296	0.6148	0.3256	19
	S2- Labor Injuries	0.4963	0.7000	0.3474	16

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<b>Procurement</b>	S3- Fire/ Theft of material and Equipment	0.4852	0.7148	0.3468	17
	P1 – Late material Procurement	0.6815	0.7037	0.4796	8
	P2- Defective material supply and price escalation	0.4778	0.4519	0.2159	26
	P3 Unavailability of material, labor and Equipment	0.4926	0.5852	0.2883	22
	P4- Utility service delay	0.6000	0.5667	0.3400	18
	P5- Importation, customs and visa issues	0.8889	0.6148	0.5465	4

The risk matrix was prepared using the data collected for the impact and probability and was first calculated i.e. the average response given by the respondents for each risk factor. The following table illustrates the average probability and impact calculated from the response given by the research participants. Using this matrix, the impact and probability of the risk factors can be seen in a detailed manner.

**Table 14 : - Risk matrix for high rise building construction risk factors**

		probability					
		1	2	3	4	5	
		Rare(0.1)	Occasional (0.3)	somewhat frequent (0.5)	Frequent (0.7)	very frequent (0.9)	
<b>Impact</b>	5	Very High(0.8)	-	-	-	F1,C1	-
		Risk score	-	-	---	0.56	-
	4	High(0.4)	-	S2,S3	C3,C4,L2,P1	C6,L1	-
		Risk score	-	0.12	0.2	0.28	-
	3	Moderate(0.2)	-	M1,P3	F3,M2,M3,M4 ,M5,D1,S1,P4	D2,D3,P5	-
		Risk score	-	0.06	0.1	0.14	-
	2	Low(0.1)	-	F2,P2	C2,C5	-	-
		Risk score	-	0.03	0.05	-	-
	1	Very Low(0.05)	-	-	-	-	-
		Risk score	-	-	-	-	-

### **3.4. DEMATEL Assessment**

#### *3.4.1. DEMATEL Result*

As discussed in the research method the DEMATEL analysis is used in order to understand the cause- effect relationship between the risk factors identified. As per the steps used by DEMATEL which are explained by the literature review the DEMATEL procedure was done as follows.

#### **STEP ONE: - Finding the Average Matrix**

After inputting the response of the questionnaire participants the average matrix which is the initial direct relation matrix was calculated from the respondent's response compiled in excel. The following table shows the Initial direct relation matrix which was calculate from the response given

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**Table 15:- Initial direct relation matrix which was calculate from the response given**

	F1	F2	F3	M1	M2	M3	M4	M5	D1	D2	D3	C1	C2	C3	C4	C5	C6	L1	L2	S1	S2	S3	P1	P2	P3	P4	P5
F1	0	1	2	2.1	2.2	0.4	0.4	0.7	0.4	0.5	0.6	0.5	0.1	0.6	0.6	0.6	0.5	0	0	1	0	0	2.46	0	3	0	2.39
F2	0	0	1	1.8	2	1.7	0.4	1.1	0.3	0.4	0.5	0.5	0	0.5	0.5	0.5	0.5	1	1	1	1	1	2.61	0	1	0	0.52
F3	0	2	0	2.3	2.1	1.9	0.5	1	0.4	0.5	0.5	0.5	0.5	0.5	0.6	0.4	0.5	1	0	0	1	1	2.44	1	1	0	0.41
M1	1	2	2	0	2.2	1.8	0.6	1.1	0.5	2	0.4	0.6	0.6	0.5	0.6	0.5	0.3	1	0	1	1	1	1.02	1	1	0	0.56
M2	1	2	2	1.1	0	2	0.5	1	0.5	2	0.4	2.3	0.5	0.5	0.5	0.5	2.2	1	1	1	0	0	2.7	1	1	0	0.50
M3	0	2	2	1.2	2.3	0	0.6	1.1	1.6	1.9	0.5	2.5	0.5	0.5	1.4	2.7	2.7	0	2	2	2	2	2.54	1	1	0	0.37
M4	3	2	2	1	2.1	1.7	0	1.2	1.4	2.1	0.5	2.4	0.6	0.5	0.5	0.5	2.6	3	2	2	2	2	0.83	3	3	3	2.41
M5	0	2	2	1	2	2.1	2.1	0	1.7	2	0.6	2.8	0.5	0.5	0.6	2.9	2.2	1	2	2	2	2	1.11	3	0	0	0.46
D1	0	2	2	1.1	2.3	1.9	1.7	1.8	0	1.9	0.5	2.5	0.5	0.6	0.5	3	2.6	1	1	1	1	1	1.04	0	1	0	0.50
D2	0	2	2	0.9	2	2.1	2	2.1	1.2	0	3.1	2.1	0.4	0.5	0.6	3	2.8	1	0	1	2	2	2.7	3	1	0	2.39
D3	1	2	2	1.1	1.6	2.3	2	1.8	0.9	3.1	0	2.7	0.5	0.6	0.5	3	2.7	1	1	2	0	0	2.72	1	1	0	0.59
C1	1	2	2	0.9	1.8	2.1	1.7	2.1	0.9	2.9	2.9	0	0.5	3	0.4	3	2.4	1	1	2	2	2	2.57	0	1	0	0.61
C2	0	2	2	1.1	1.9	1.9	1.8	2.5	0.9	2.9	0.4	2	0	0.5	0.5	3	1	1	1	0	0	0	1.07	0	1	0	0.44
C3	1	2	2	0.9	1.9	2.1	2.1	2.2	0.9	1.1	0.4	1.9	0	0	0.6	0.5	1	2	1	1	2	2	1.04	1	0	0	0.57
C4	1	2	2	1.2	2.1	2	1.8	2.2	1	1	0.6	2	0.4	0.4	0	0.4	1	0	0	1	1	1	1.09	1	0	0	0.52
C5	0	2	2	1	2	1.9	1.8	2.1	1.1	1.2	1.4	1.9	1.4	0.6	0.5	0	1.1	0	1	1	1	1	1.04	2	1	0	0.46
C6	2	2	2	0.9	2	1.8	1.9	2	1.1	3	1.9	2.1	0.4	0.5	0.6	2.9	0	0	1	1	1	1	2.41	1	3	0	0.54
L1	1	2	2	1	2.3	1.9	2	2	1.1	1.1	1.6	2.1	0.4	3.2	0.4	0.5	0.8	0	1	0	0	0	2.67	0	1	3	2.76
L2	1	2	2	0.9	2.2	1.9	1.8	1.9	1	0.9	1.5	1.8	0.6	0.6	0.5	0.6	1.2	2	0	1	0	0	1.15	2	1	3	0.50
S1	1	2	2	0.7	2.1	1.7	2.2	2.1	1.1	1.1	1.6	1.9	0.6	0.5	0.6	0.5	1	1	0	0	2	2	0.91	1	1	0	0.59
S2	0	2	2	1	2.2	2.1	2	2	0.9	1.1	1.3	1.7	0.5	0.5	0.5	0.5	1.1	1	1	3	0	0	0.93	1	0	0	0.50
S3	0	2	2	1.1	2	1.8	2.1	2	1.1	1.1	1.6	2	0.6	0.4	0.5	0.6	0.9	1	1	0	1	1	0.93	0	1	0	0.50
P1	3	2	2	1.1	2.3	1.7	2.4	1.9	1.1	0.9	1.3	2.3	0.5	0.5	0.4	0.6	0.8	0	1	0	1	1	0	0	3	0	2.50
P2	3	2	2	0.9	2.1	2.1	2.4	2.3	0.9	0.7	1.6	2.1	0.5	0.5	0.5	0.5	0.8	0	0	0	1	1	1.02	0	0	0	0.46
P3	3	2	2	1.1	2	1.9	1.9	2.2	1	1.1	1.8	2.1	3.5	0.4	0.6	0.6	1	0	0	1	0	0	2.39	1	0	0	2.33
P4	1	2	2	1.1	1.9	2.4	1.9	2.3	1.1	0.8	1.3	2.2	0.4	0.4	0.4	0.6	1.1	1	1	1	0	0	0.94	0	1	0	0.44
P5	3	2	2	1	2	2.1	2	2.2	1	0.9	1.5	2.1	3.2	0.5	0.5	0.4	0.9	0	0	0	1	1	2.43	1	3	0	26.50

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### **STEP TWO: - Normalizing the Average Perception Matrix**

First the k is calculated using equation (2). In order to calculate k the row sums and the column sum should be known. Therefore, the following table shows the row and the column sum in order to know the maximum.

**Table 16:- Result for row and column sum**

<b>Risk Factor</b>	<b>Row Sum</b>	<b>Column Sum</b>
F1	22.5	26.09
F2	19.76	50.30
F3	21.63	50.57
M1	22.69	29.46
M2	25.41	53.61
M3	36.78	49.11
M4	46.28	42.52
M5	39.78	46.78
D1	30.11	25.17
D2	40.74	38.02
D3	36.37	30.41
C1	40.7	49.94
C2	29.8	18.19
C3	30.57	18.20
C4	26.15	14.17
C5	29.11	32.80
C6	36.13	35.72
L1	35.87	20.54
L2	33.28	18.02
S1	29.59	23.35
S2	28.39	23.30
S3	27.93	23.30
P1	33.15	44.76
P2	28.81	22.35
P3	35.15	28.44
P4	27.61	9.19
P5	61.35	51.33

After summing up the row and column separately for each risk factor our maximum was found to be 61.35. Thus, k is found using equation (2)

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$$k = \frac{1}{61.35} = \underline{\underline{0.0163}}$$

After finding our k the normalized direct-relation matrix X was calculated using equation (1)

**Table 17:- Normalized direct relation matrix**

	F1	F2	F3	M1	M2	M3	M4	M5	D1	D2	D3	C1	C2	C3	C4	C5	C6
F1	0.00	0.02	0.02	0.03	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01
F2	0.01	0.00	0.02	0.03	0.03	0.03	0.01	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01
F3	0.01	0.03	0.00	0.04	0.03	0.03	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
M1	0.01	0.04	0.03	0.00	0.04	0.03	0.01	0.02	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01
M2	0.01	0.03	0.03	0.02	0.00	0.03	0.01	0.02	0.01	0.03	0.01	0.04	0.01	0.01	0.01	0.01	0.04
M3	0.01	0.03	0.03	0.02	0.04	0.00	0.01	0.02	0.03	0.03	0.01	0.04	0.01	0.01	0.02	0.04	0.04
M4	0.04	0.03	0.03	0.02	0.03	0.03	0.00	0.02	0.02	0.03	0.01	0.04	0.01	0.01	0.01	0.01	0.04
M5	0.01	0.03	0.03	0.02	0.03	0.03	0.03	0.00	0.03	0.03	0.01	0.05	0.01	0.01	0.01	0.05	0.04
D1	0.01	0.03	0.03	0.02	0.04	0.03	0.03	0.03	0.00	0.03	0.01	0.04	0.01	0.01	0.01	0.05	0.04
D2	0.01	0.03	0.03	0.01	0.03	0.03	0.03	0.03	0.02	0.00	0.05	0.03	0.01	0.01	0.01	0.05	0.05
D3	0.01	0.03	0.03	0.02	0.03	0.04	0.03	0.03	0.01	0.05	0.00	0.04	0.01	0.01	0.01	0.05	0.04
C1	0.01	0.03	0.03	0.01	0.03	0.03	0.03	0.03	0.01	0.05	0.05	0.00	0.01	0.05	0.01	0.05	0.04
C2	0.01	0.03	0.03	0.02	0.03	0.03	0.03	0.04	0.01	0.05	0.01	0.03	0.00	0.01	0.01	0.05	0.02
C3	0.01	0.03	0.03	0.01	0.03	0.03	0.03	0.04	0.02	0.02	0.01	0.03	0.00	0.00	0.01	0.01	0.02
C4	0.01	0.04	0.03	0.02	0.03	0.03	0.03	0.04	0.02	0.02	0.01	0.03	0.01	0.01	0.00	0.01	0.02
C5	0.01	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.02	0.01	0.01	0.00	0.02
C6	0.04	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.02	0.05	0.03	0.03	0.01	0.01	0.01	0.05	0.00
L1	0.01	0.03	0.03	0.02	0.04	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.01	0.05	0.01	0.01	0.01
L2	0.02	0.03	0.04	0.01	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.01	0.01	0.01	0.01	0.02
S1	0.01	0.03	0.04	0.01	0.03	0.03	0.04	0.03	0.02	0.02	0.03	0.03	0.01	0.01	0.01	0.01	0.02
S2	0.01	0.03	0.03	0.02	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.01	0.01	0.01	0.01	0.02
S3	0.01	0.04	0.03	0.02	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.01	0.01	0.01	0.01	0.02
P1	0.04	0.03	0.03	0.02	0.04	0.03	0.04	0.03	0.02	0.01	0.02	0.04	0.01	0.01	0.01	0.01	0.01
P2	0.04	0.03	0.03	0.02	0.03	0.03	0.04	0.04	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.01	0.01
P3	0.04	0.03	0.03	0.02	0.03	0.03	0.03	0.04	0.02	0.02	0.03	0.03	0.06	0.01	0.01	0.01	0.02
P4	0.01	0.04	0.03	0.02	0.03	0.04	0.03	0.04	0.02	0.01	0.02	0.04	0.01	0.01	0.01	0.01	0.02
P5	0.04	0.03	0.03	0.02	0.03	0.03	0.03	0.04	0.02	0.02	0.03	0.03	0.05	0.01	0.01	0.01	0.02

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**Table 17: - Normalized direct relation matrix (Continued)**

	L1	L2	S1	S2	S3	P1	P2	P3	P4	P5
F1	0.01	0.01	0.01	0.00	0.00	0.04	0.00	0.05	0.00	0.04
F2	0.01	0.01	0.01	0.01	0.01	0.04	0.01	0.02	0.00	0.01
F3	0.01	0.01	0.01	0.01	0.01	0.04	0.01	0.02	0.00	0.01
M1	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.01
M2	0.01	0.01	0.01	0.01	0.01	0.04	0.01	0.02	0.00	0.01
M3	0.01	0.03	0.03	0.04	0.04	0.04	0.01	0.01	0.00	0.01
M4	0.05	0.03	0.03	0.03	0.03	0.01	0.04	0.05	0.05	0.04
M5	0.02	0.03	0.04	0.04	0.04	0.02	0.04	0.01	0.00	0.01
D1	0.02	0.01	0.01	0.01	0.01	0.02	0.00	0.01	0.00	0.01
D2	0.02	0.01	0.01	0.03	0.03	0.04	0.04	0.01	0.00	0.04
D3	0.02	0.01	0.04	0.01	0.01	0.04	0.01	0.01	0.00	0.01
C1	0.02	0.01	0.03	0.03	0.03	0.04	0.01	0.01	0.00	0.01
C2	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.01
C3	0.04	0.01	0.01	0.03	0.03	0.02	0.01	0.01	0.00	0.01
C4	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.01
C5	0.00	0.01	0.01	0.01	0.01	0.02	0.04	0.01	0.00	0.01
C6	0.00	0.01	0.01	0.01	0.01	0.04	0.01	0.05	0.00	0.01
L1	0.00	0.01	0.01	0.01	0.01	0.04	0.01	0.01	0.05	0.04
L2	0.03	0.00	0.01	0.01	0.01	0.02	0.04	0.01	0.05	0.01
S1	0.01	0.01	0.00	0.03	0.03	0.01	0.01	0.01	0.00	0.01
S2	0.01	0.01	0.05	0.00	0.00	0.02	0.01	0.01	0.00	0.01
S3	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.01
P1	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.05	0.00	0.04
P2	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.01
P3	0.01	0.01	0.01	0.01	0.01	0.04	0.01	0.00	0.00	0.04
P4	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.01
P5	0.01	0.01	0.01	0.01	0.01	0.04	0.01	0.05	0.00	0.43

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**STEP THREE: - Derive the Total Relation Matrix (T) By Applying Equation (3)**

**Table 18:- Total relation matrix based on DEMATEL survey in high rise buildings**

	F1	F2	F3	M1	M2	M3	M4	M5	D1	D2	D3	C1	C2	C3	C4	C5	C6
F1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F2	0.02	0.02	0.04	0.04	0.05	0.05	0.02	0.04	0.02	0.02	0.02	0.03	0.01	0.02	0.01	0.02	0.02
F3	0.02	0.05	0.02	0.05	0.06	0.05	0.02	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02
M1	0.02	0.06	0.06	0.01	0.06	0.05	0.03	0.04	0.02	0.05	0.02	0.03	0.02	0.02	0.02	0.02	0.02
M2	0.03	0.06	0.05	0.03	0.03	0.06	0.03	0.04	0.02	0.05	0.02	0.06	0.02	0.02	0.02	0.03	0.06
M3	0.03	0.07	0.07	0.04	0.08	0.04	0.04	0.05	0.04	0.06	0.03	0.08	0.02	0.02	0.03	0.07	0.07
M4	0.07	0.07	0.08	0.04	0.08	0.07	0.04	0.06	0.05	0.07	0.04	0.08	0.03	0.03	0.02	0.04	0.08
M5	0.03	0.07	0.07	0.04	0.07	0.07	0.07	0.04	0.05	0.06	0.04	0.08	0.02	0.02	0.02	0.08	0.07
D1	0.02	0.06	0.06	0.04	0.07	0.06	0.05	0.06	0.02	0.06	0.03	0.07	0.02	0.02	0.02	0.07	0.07
D2	0.03	0.07	0.08	0.04	0.08	0.08	0.07	0.07	0.04	0.04	0.08	0.08	0.02	0.02	0.02	0.08	0.08
D3	0.03	0.07	0.07	0.04	0.07	0.07	0.06	0.06	0.03	0.08	0.03	0.08	0.02	0.02	0.02	0.08	0.07
C1	0.03	0.07	0.07	0.04	0.07	0.08	0.06	0.07	0.04	0.08	0.07	0.04	0.02	0.06	0.02	0.08	0.07
C2	0.02	0.06	0.06	0.04	0.06	0.06	0.05	0.07	0.03	0.07	0.03	0.06	0.01	0.02	0.02	0.07	0.04
C3	0.03	0.07	0.06	0.03	0.06	0.06	0.06	0.06	0.03	0.04	0.03	0.06	0.01	0.01	0.02	0.03	0.04
C4	0.02	0.06	0.06	0.03	0.06	0.06	0.05	0.06	0.03	0.04	0.03	0.06	0.02	0.02	0.01	0.03	0.04
C5	0.02	0.06	0.06	0.03	0.06	0.06	0.05	0.06	0.03	0.04	0.04	0.06	0.03	0.02	0.02	0.02	0.04
C6	0.06	0.06	0.07	0.04	0.07	0.06	0.06	0.06	0.04	0.08	0.05	0.07	0.02	0.02	0.02	0.07	0.03
L1	0.03	0.07	0.07	0.04	0.08	0.07	0.06	0.07	0.04	0.05	0.05	0.07	0.02	0.07	0.02	0.03	0.04
L2	0.04	0.06	0.07	0.03	0.07	0.06	0.06	0.06	0.03	0.04	0.04	0.06	0.02	0.02	0.02	0.03	0.05
S1	0.03	0.06	0.07	0.03	0.07	0.06	0.06	0.06	0.03	0.04	0.04	0.06	0.02	0.02	0.02	0.03	0.04
S2	0.02	0.06	0.06	0.03	0.07	0.06	0.06	0.06	0.03	0.04	0.04	0.06	0.02	0.02	0.02	0.03	0.04
S3	0.02	0.06	0.06	0.04	0.06	0.06	0.06	0.06	0.03	0.04	0.04	0.06	0.02	0.02	0.02	0.03	0.04
P1	0.06	0.06	0.07	0.04	0.07	0.06	0.06	0.06	0.04	0.04	0.04	0.07	0.03	0.02	0.02	0.03	0.04
P2	0.06	0.06	0.06	0.03	0.06	0.06	0.06	0.06	0.03	0.03	0.04	0.06	0.02	0.02	0.02	0.03	0.04
P3	0.06	0.06	0.07	0.04	0.07	0.07	0.06	0.07	0.03	0.05	0.05	0.07	0.07	0.02	0.02	0.04	0.04
P4	0.02	0.06	0.06	0.03	0.06	0.07	0.05	0.06	0.03	0.04	0.04	0.06	0.02	0.02	0.02	0.03	0.04
P5	0.11	0.11	0.11	0.06	0.12	0.12	0.10	0.11	0.06	0.08	0.08	0.12	0.11	0.04	0.03	0.06	0.07

\*Mat lab was used to drive the total relation matrix.

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**Table19: - Total relation matrix based on DEMATEL survey in high rise buildings (Continued)**

	L1	L2	S1	S2	S3	P1	P2	P3	P4	P5
F1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F2	0.02	0.02	0.02	0.02	0.02	0.06	0.02	0.03	0.00	0.03
F3	0.02	0.02	0.02	0.02	0.02	0.06	0.02	0.03	0.00	0.03
M1	0.02	0.02	0.02	0.02	0.02	0.04	0.02	0.03	0.00	0.04
M2	0.02	0.02	0.02	0.02	0.02	0.07	0.02	0.04	0.00	0.04
M3	0.02	0.05	0.05	0.05	0.05	0.07	0.03	0.04	0.01	0.04
M4	0.07	0.05	0.05	0.06	0.06	0.06	0.06	0.08	0.06	0.11
M5	0.03	0.05	0.06	0.06	0.06	0.06	0.06	0.03	0.01	0.05
D1	0.03	0.02	0.03	0.03	0.03	0.05	0.02	0.03	0.01	0.04
D2	0.03	0.02	0.03	0.05	0.05	0.08	0.06	0.04	0.01	0.10
D3	0.03	0.02	0.05	0.03	0.03	0.08	0.03	0.03	0.01	0.05
C1	0.03	0.03	0.05	0.06	0.06	0.08	0.03	0.03	0.01	0.05
C2	0.03	0.02	0.02	0.02	0.02	0.05	0.02	0.03	0.01	0.04
C3	0.05	0.02	0.03	0.05	0.05	0.05	0.02	0.03	0.01	0.04
C4	0.01	0.02	0.02	0.02	0.02	0.04	0.02	0.02	0.00	0.04
C5	0.02	0.02	0.02	0.03	0.03	0.05	0.05	0.03	0.00	0.04
C6	0.02	0.02	0.03	0.03	0.03	0.07	0.03	0.07	0.01	0.05
L1	0.02	0.03	0.03	0.03	0.03	0.08	0.02	0.03	0.05	0.11
L2	0.04	0.01	0.03	0.02	0.02	0.05	0.05	0.03	0.05	0.04
S1	0.02	0.02	0.02	0.05	0.05	0.04	0.02	0.03	0.01	0.04
S2	0.02	0.02	0.06	0.02	0.02	0.04	0.02	0.02	0.01	0.04
S3	0.02	0.02	0.02	0.03	0.03	0.04	0.02	0.03	0.01	0.04
P1	0.02	0.02	0.03	0.03	0.03	0.03	0.02	0.07	0.01	0.10
P2	0.02	0.02	0.02	0.02	0.02	0.04	0.02	0.02	0.01	0.04
P3	0.02	0.02	0.03	0.03	0.03	0.07	0.03	0.02	0.01	0.09
P4	0.02	0.02	0.02	0.02	0.02	0.04	0.02	0.03	0.00	0.04
P5	0.04	0.04	0.04	0.05	0.05	0.12	0.04	0.12	0.01	0.81

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**STEP FOUR: - Summation Of Rows (D) And Summation Of Columns (R) Are Calculated According To Matrix T.**

**Table 19:- Total influence and relation matrix based on DEMATEL survey**

Risk factors		D	R	D-R	D+R
Finance	F1	0	0.94256	-0.9426	0.94256
	F2	0.67754	1.66284	-0.9853	2.34038
	F3	0.72856	1.66195	-0.9334	2.39051
Management	M1	0.77252	0.96705	-0.1945	1.73957
	M2	0.88619	1.75996	-0.8738	2.64615
	M3	1.24616	1.66453	-0.4184	2.91069
	M4	1.59905	1.40298	0.19607	3.00203
	M5	1.36277	1.53965	-0.1769	2.90243
Design	D1	1.05059	0.85676	0.19383	1.90735
	D2	1.45604	1.31655	0.13948	2.77259
	D3	1.27476	1.03708	0.23768	2.31183
Construction	C1	1.40764	1.68443	-0.2768	3.09207
	C2	1.03965	0.66713	0.37252	1.70678
	C3	1.06111	0.62003	0.44107	1.68114
	C4	0.90247	0.48359	0.41888	1.38605
	C5	1.0055	1.15093	-0.1454	2.15643
	C6	1.23089	1.26109	-0.0302	2.49198
Legal	L1	1.29647	0.68903	0.60744	1.98549
	L2	1.1277	0.64166	0.48604	1.76936
Safety	S1	1.02412	0.82045	0.20367	1.84457
	S2	0.9838	0.84231	0.14149	1.82612
	S3	0.96819	0.84231	0.12588	1.8105
Procurement	P1	1.17175	1.54239	-0.3706	2.71414
	P2	0.96828	0.79502	0.17327	1.7633
	P3	1.23163	0.97115	0.26048	2.20277
	P4	0.95741	0.28801	0.66939	1.24542
	P5	2.80406	2.12341	0.68065	4.92747

Based on the D-R result the risk factors were classified as cause and effect groups. In addition the horizontal axis vector which is (D+R) which shows prominence and relative importance of

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each criterion was calculated. In terms of the degree of influence the following analysis was found.

**Table 20:- Normalized degree of influence for the risk factors studied**

Risk factors		D-R	D+R	Normalized degree of influence
Finance	F1	-0.9426	0.94256	1.56%
	F2	-0.9853	2.34038	3.87%
	F3	-0.9334	2.39051	3.95%
Management	M1	-0.1945	1.73957	2.88%
	M2	-0.8738	2.64615	4.38%
	M3	-0.4184	2.91069	4.81%
	M4	0.19607	3.00203	4.96%
	M5	-0.1769	2.90243	4.80%
Design	D1	0.19383	1.90735	3.15%
	D2	0.13948	2.77259	4.59%
	D3	0.23768	2.31183	3.82%
Construction	C1	-0.2768	3.09207	5.11%
	C2	0.37252	1.70678	2.82%
	C3	0.44107	1.68114	2.78%
	C4	0.41888	1.38605	2.29%
	C5	-0.1454	2.15643	3.57%
	C6	-0.0302	2.49198	4.12%
Legal	L1	0.60744	1.98549	3.28%
	L2	0.48604	1.76936	2.93%
Safety	S1	0.20367	1.84457	3.05%
	S2	0.14149	1.82612	3.02%
	S3	0.12588	1.8105	2.99%
Procurement	P1	-0.3706	2.71414	4.49%
	P2	0.17327	1.7633	2.92%
	P3	0.26048	2.20277	3.64%
	P4	0.66939	1.24542	2.06%
	P5	0.68065	4.92747	8.15%

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### **STEP 5: - Setting the Threshold Value ( $\alpha$ )**

First, Calculating  $S_0$  which is the initial value of  $\tau$  using equation (6)

$$S_0 = 1.5 \times 0.036$$

$$\underline{\underline{S_0 = 0.0535}}$$

Then, Calculating PSE which is the pseudo standard error using equation (7)

$$PSE = 1.5 \times 0.0357$$

$$\underline{\underline{PSE = 0.0535}}$$

Using the Multipliers to obtain the ME at  $\alpha = 0.05$  level from the table given by (Ye K, 2000),

ME was calculated using  $m = 27$ . Therefore,  $ME = 2.077 \times 0.0535 = \underline{\underline{0.1112}}$

Thus our threshold value was found to be 0.1112

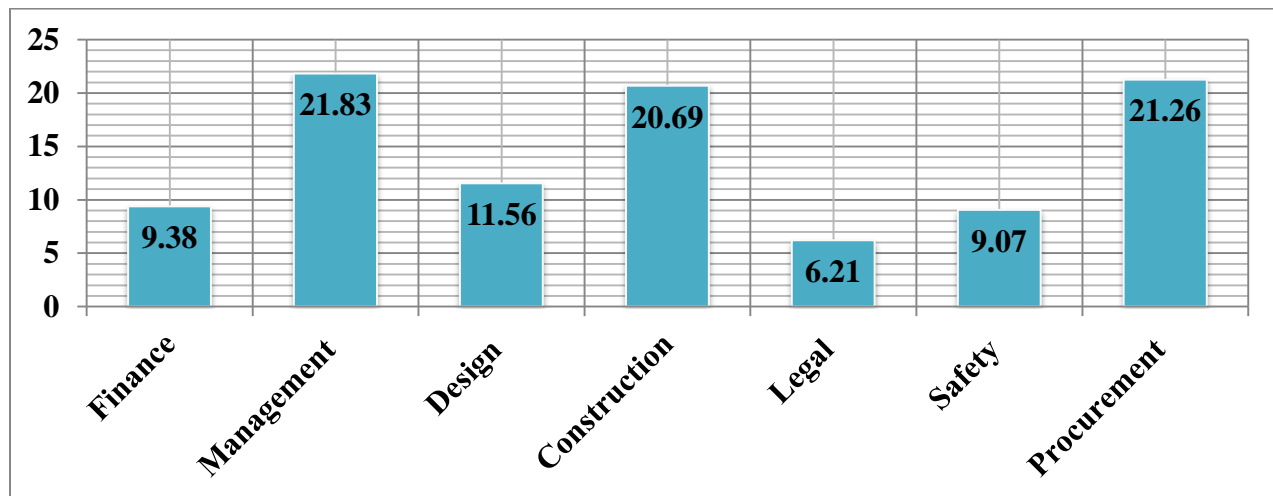
**STEP 6: - Building a Cause and Effect Relationship Diagram.** The overall causal diagram of the criteria was produced using the results above in which the D+R was plotted in the x – axis and D- R in the Y- axis and only using values greater than our threshold value which was found to be 0.1112.



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### ✓ Based on D-R values obtained

From the literature review it is stated that if  $(D - R) > 0$ , then the criterion is a member of cause group; and if  $(D - R) < 0$ , then the criterion is a member of effect group. As a result of the DEMATEL analysis 16 of the risk factors were found to be a cause group and the remaining 11 risk factors were found to be an effect group.



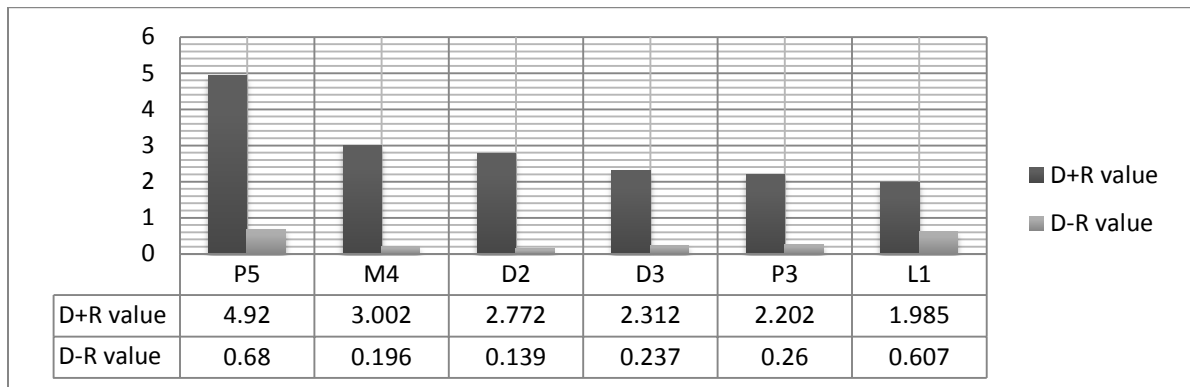
**Figure 13:- Over All Normalized Degree of Influence for Major Risk Categories**

When the normalized degree of influence result is explored management, procurement and construction related factors are the most influential with 22%, 21.83% and 21.26% respectively. The cause and effect groups are illustrated as follows.

- 1. Cause Groups:** - Based on the analysis undertaken 16 of the risk factors were found to be cause groups whereby  $(D - R) > 0$ . Since the risk factors with the highest positive  $D - R$  results have a direct impact on the other risk factors the major risks with the highest  $D - R$  results are therefore Importation, customs and visa issues (P5), Utility service delay (P4) and Permit requirements (L1) with  $D - R$  values of 0.68065, 0.66939 and 0.60744 respectively. If  $(D-R)$  is positive and axis  $(D+R)$  is large it indicates that the criteria are

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causes and they are also key for problem solving. Importation, customs and visa issues (P5) , M4- Poor communication between stakeholders, D2- Poor detailing and design change delay, D3- poor use of advanced software, P3 Unavailability of material, labor and Equipment and Permit requirements (L1) are the causes which are key for problem solving as per the assessment done. The top 7 risk factors whereby (D-R) is positive and (D+R) is large i.e. from the top 15 risk factors with large (D+R) values are outlined in the following graph



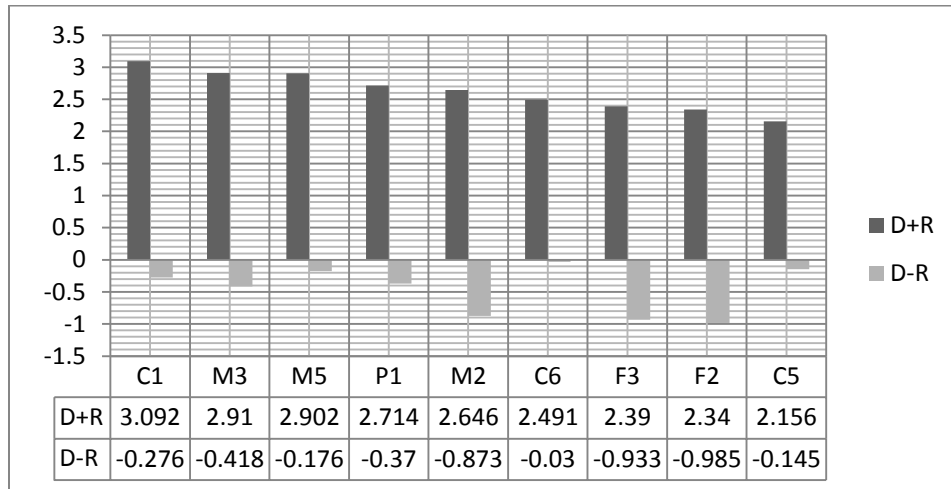
**Figure 14:- Top 7 Risk Factors Whereby (D-R) Is Positive and (D+R) Is Large**

**2. Effect Groups:** - The remaining 11 risk factors were effect groups which are influenced by the other factors. As a result, inappropriate advance payment use (F2), Inflation and Exchange rate fluctuation (F1) and interim payment delay (F3) have the most negative values of -0.9853, -0.9426 and -0.9334 respectively.

If (D-R) is negative and axis (D+R) is large it indicates that the criteria are the core problems that must be solved. I.e. they are effect type criteria with indirect impact. The following graph shows the top 15 risk factors with large (D+R) values with negative (D-R) results.

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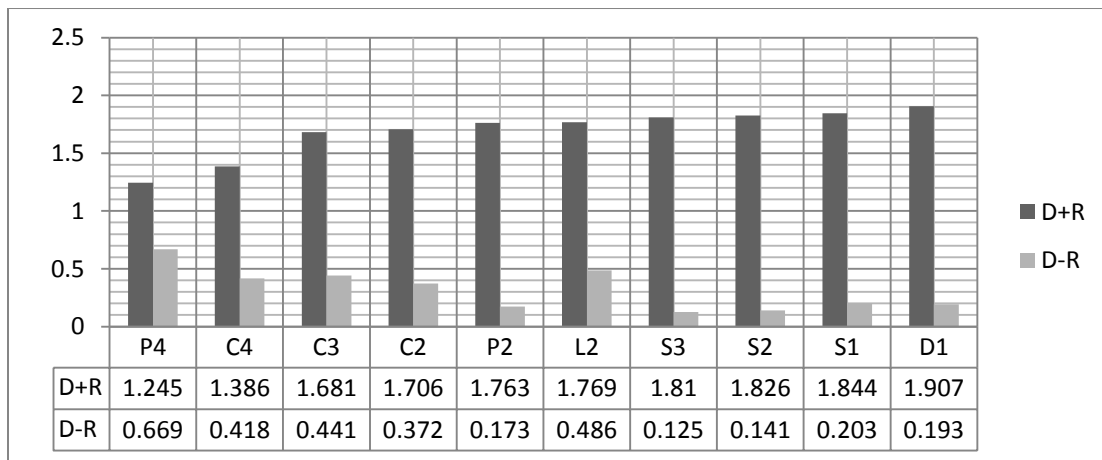
**Figure 15: Top 9 risk factors with large with large (D+R) values with negative (D-R) results**



If (D-R) is positive and (D+R) is small, it indicates that the criteria are independent and can only influence a few factors. Therefore, the three risk factors with the lowest (D+R) and with a positive (D-R) are Utility service delay (P4), Low labor productivity and labor shortage (C4) and Loss of time by traffic control and restriction (C3).

The top 10 risk factors with a small (D+R) and with a positive (D-R) are shown in the following graph

**Figure 16:- Top 10 risk factors with a small (D+R) and with a positive (D-R)**



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In order to analyze the result more clearly risk factors were categorically analyzed first by ranking their result within their risk factor group in order to show the data collected more clearly. The following table shows the cause and effect group with their respective values for the risk factors.

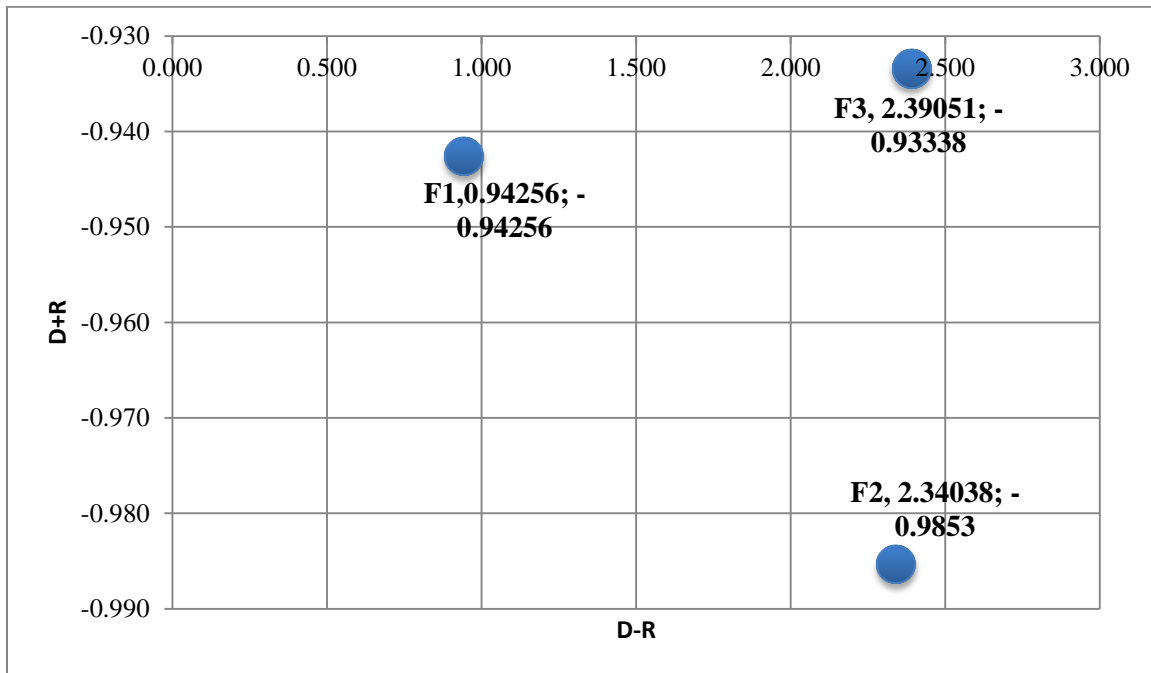
**Table 21:- Cause and effect group of risk factors analyzed under each risk factors**

Risk factors		Net effect (D-R)	Prominence (D+R)	Rank	Impact
Finan	F1	-0.94256	0.94256	3	Effect
	F2	-0.9853	2.34038	2	Effect
	F3	-0.93338	2.39051	1	Effect
Manageme	M1	-0.19453	1.73957	5	Effect
	M2	-0.87377	2.64615	4	Effect
	M3	-0.41837	2.91069	2	Effect
	M4	0.196071	3.00203	1	Cause
	M5	-0.17688	2.90243	3	Effect
Desig	D1	0.193833	1.90735	3	Cause
	D2	0.139484	2.77259	1	Cause
	D3	0.237681	2.31183	2	Cause
Construction	C1	-0.27679	3.09207	1	Effect
	C2	0.372524	1.70678	4	Cause
	C3	0.441074	1.68114	5	Cause
	C4	0.41888	1.38605	6	Cause
	C5	-0.14543	2.15643	3	Effect
	C6	-0.0302	2.49198	2	Effect
Lega	L1	0.607438	1.98549	1	Cause
	L2	0.486039	1.76936	2	Cause
Safety	S1	0.203674	1.84457	1	Cause
	S2	0.141491	1.82612	2	Cause
	S3	0.125879	1.8105	3	Cause
Procureme	P1	-0.37064	2.71414	2	Effect
	P2	0.173266	1.7633	4	Cause
	P3	0.260479	2.20277	3	Cause
	P4	0.669395	1.24542	5	Cause
	P5	0.680645	4.92747	1	Cause

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Using the data found from the DEMATEL analysis the cause and effect diagrams were plotted for all risk factors as follows.

- **For Finance Main Risk Category:** - All of the risk factors under the finance category were found to be in the effect group.

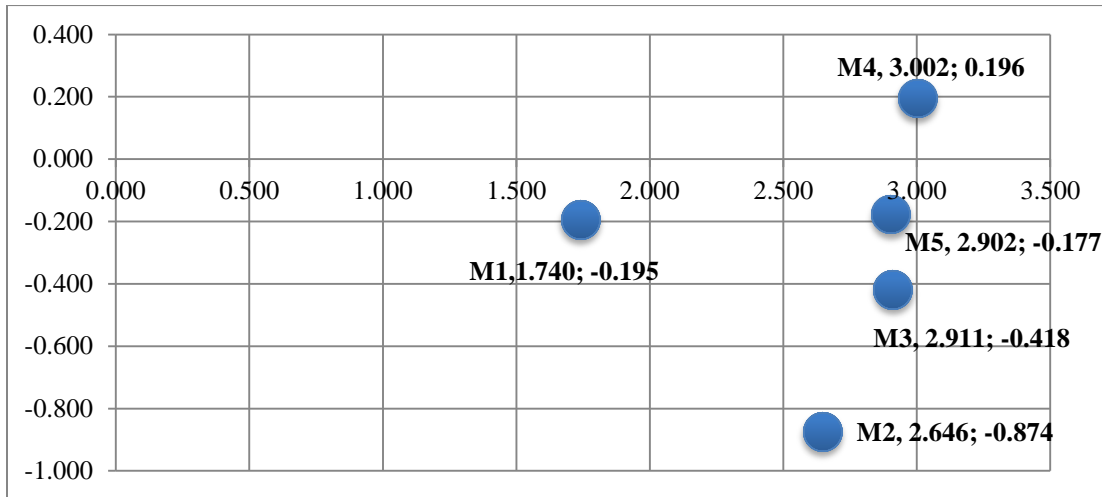


**Figure 17:- Cause and Effect Diagram For Risk Factors under Finance Main Risk Category**

- **For Management Main Risk Category:** - Poor communication between stakeholders (M4) is the only cause group from this risk category and all the others were categorized as the effect group as illustrated in the figure below.

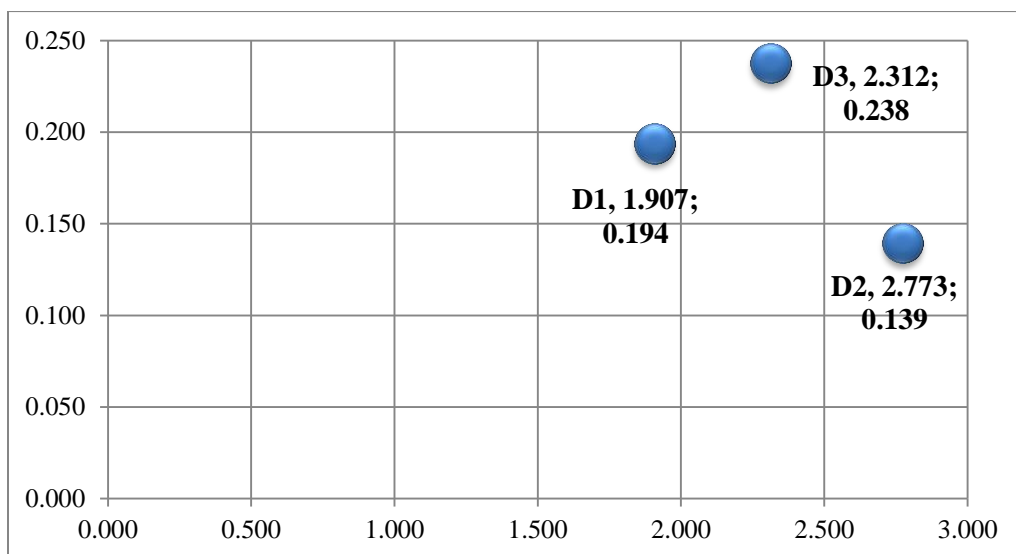
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**Figure 18 :- Cause and Effect Diagram For Risk Factors under Management Main Risk Category**

- **For Design Main Risk Category:** - All of the risk factors in the design risk category are found to be cause groups which need attention in order to respond to problems that may arise due to these factors.

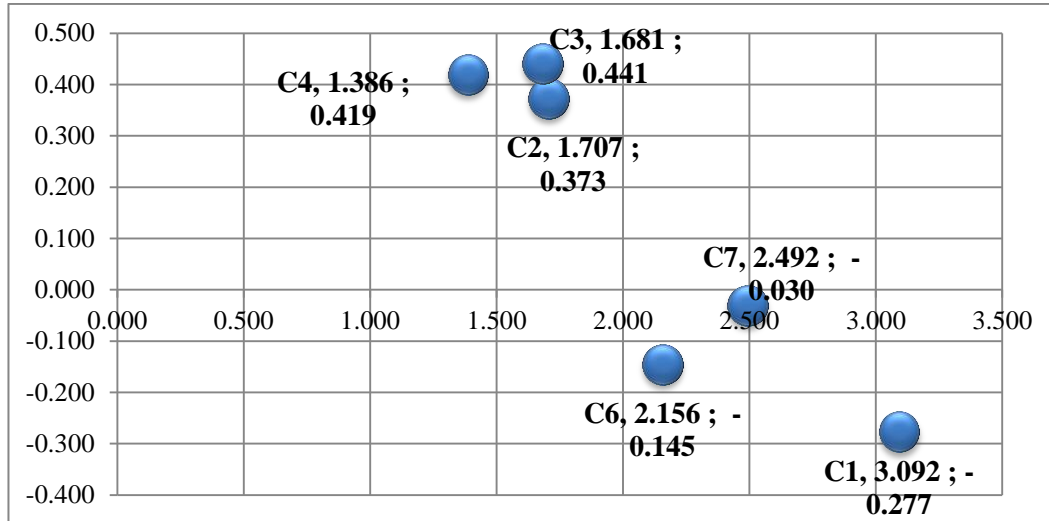


**Figure 19 :- Cause and Effect Diagram For Risk Factors under Design Main Risk Category**

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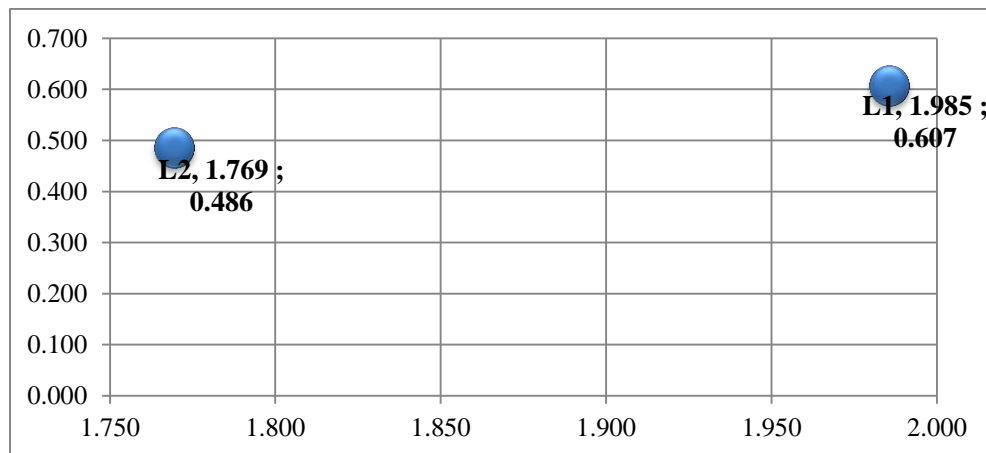
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- **For Construction Main Risk Category:** - Only two factors namely C6 and C1 are in the effect group and the remaining four risk factors are in the effect group.



**Figure 20:- Cause and Effect Diagram For Risk Factors under Construction Main Risk Category**

- **For Legal Main Risk Category:** -All of the risk factors in the legal risk category are in the cause group where by attention is needed in order to minimize risks that arise due to these risk factors.



**Figure 21 :- Cause and Effect Diagram For Risk Factors under Legal Main Risk Category**

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➤ **For Safety Main Risk Category:** - All three factors were found to be cause factors.

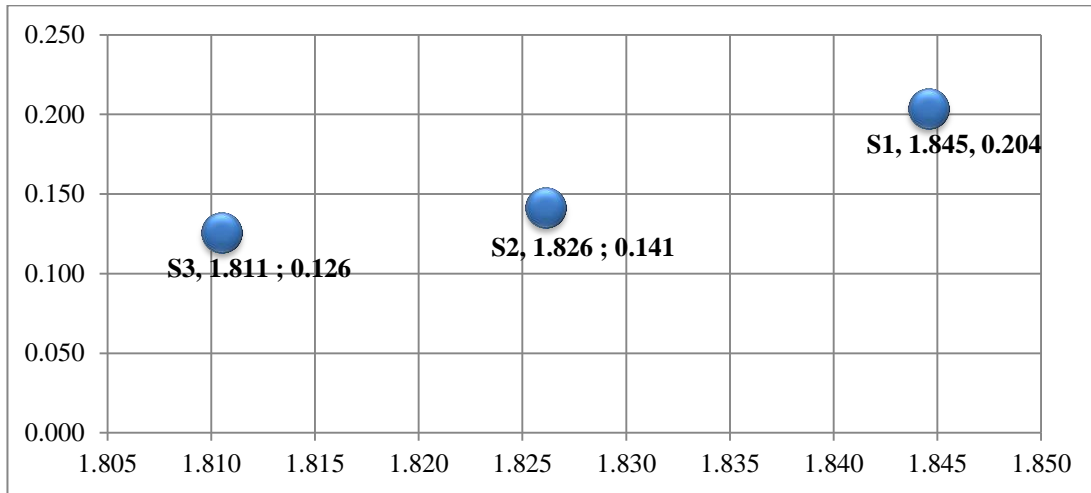


Figure 22:- Cause and Effect Diagram For Risk Factors under Safety Main Risk Category

➤ **For Procurement Main Risk Category:** - only late material procurement is in the effect group while the other remaining risk factors are cause groups.

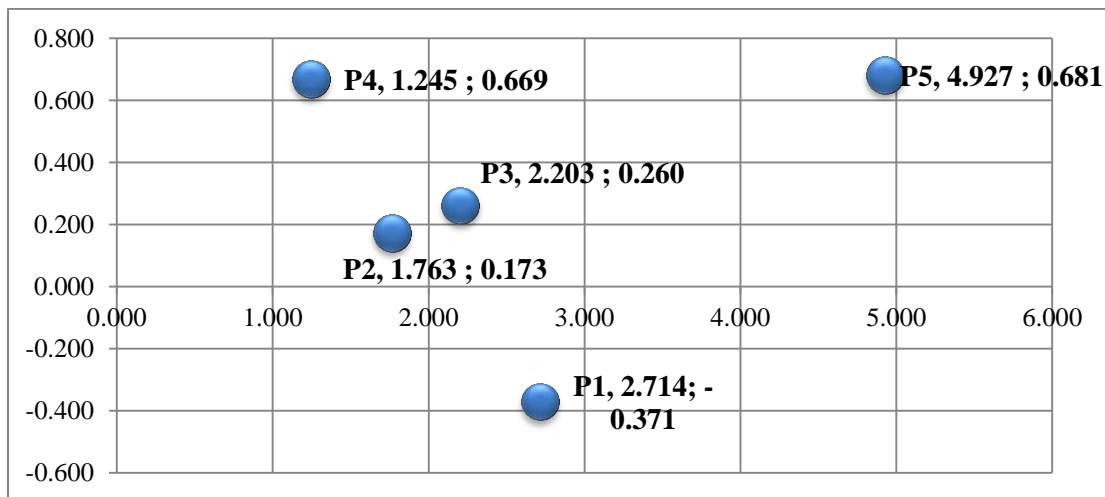


Figure 23:- Cause and Effect Diagram For Risk Factors under Procurement Main Risk Category

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## 3.5. Qualitative Data Presentation and Analysis of Case Study

### 3.5.1. Introduction

The case study method was used in line with the questionnaire prepared in order to fulfill the objective of the basic ideals of this research and so that they are understood more clearly to achieve the objective as a whole. This sub chapter tries to explore the three case studies with their own unique scenarios in terms of risk factors arising in the particular projects and after exploring them one by one a summary is prepared in order to compare, combine and make use of the data.

### 3.5.2. Overview of High Rise Building Construction Sites Studied

#### I. Back Ground of the Projects

The three high rise projects in which the case study was undertaken with their particular project information are shown in the following table as follows

**Table 22:- High rise Building construction sites studied through the case study**

Project Name	Contract Cost of Project in ETB.	Project Start Date	Contract Duration in years	Project progresses in %	No. of basement with story above ground level
1. Zemen Bank HQ construction	1.4 billion	October,20,2019	3	60	3B+32
2. Nile Insurance HQ construction	800 million	May 01,2019	2	42.5	3B+25
3. National Archive and library Building	498 million	May,14, 2015	5.4	75.6	3B+G+M+13
4. CMC Apartment	1 Billion	January, 29,2019	3	74	2B+21

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*II. Case Study Participants*

The interview participants were selected purposely based on their profiles as follows

**Table 23:- profile of case study participants**

<b>Case study</b>	<b>Respondent No</b>	<b>Interviewees qualification</b>	<b>Experience in Building construction</b>	<b>Stakeholder the respondent is currently working for</b>	<b>Education Qualification</b>
I	1	Project Coordinator	>10 years	Owner	Msc. Degree
	2	Construction Engineer	5-10 years	Contractor	Bsc. Degree
II	1	Project Manager	>10 years	Contractor	Msc. Degree
	2	Resident Engineer	>10 years	Consultant	Msc. Degree
	3	Site Supervisor	5-10 years	Consultant	Bsc. Degree
III	1	Senior Engineer	5-10 years	Contractor	Msc. Degree
IV	1	Resident Engineer	5-10 years	Consultant	Msc. Degree

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*III. Cross Case Evaluation of Case Studies*

The responses given by the case study participants were tabulated as follows.

**Table 24:- Case study results analysis**

<b>Risk factors</b>	<b>Is this risk factor evident in your project environment? Yes/No</b>	<b>Who is responsible for this risk factor?</b>	<b>What are the possible consequences which result because of this risk factor?</b>
<b>F1- Inflation and Exchange rate fluctuation</b>	Yes	The government	Affects project cost due to rise in the cost of resources needed from abroad, the project will not be accomplished on time, change in projects schedule will occur which in turn increases the cost of the project.
<b>F2- Inappropriate advance payment use</b>	Yes	Contractor/consultant	Cash flow shortage, Material will not be delivered on time; various critical works which need attention will lag behind.
<b>F3- interim payment delay</b>	Yes	Consultant/Client	It will affect the schedule; will cause conflict between the main contractor and the sub-contractors and even the suppliers linked to project.
<b>M1 - Change in top management</b>	Yes	Contractor	If the change is not fast enough work items that need expedition will be either halted or slow due to slow decision making and other related factors.

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<b>Risk factors</b>	<b>Is this risk factor evident in your project environment? Yes/No</b>	<b>Who is responsible for this risk factor?</b>	<b>What are the possible consequences which result because of this risk factor?</b>
<b>M2 - Type of delivery method selected</b>	Yes	Consultant/Client	Increase in project life time, dissatisfaction of the client and the end user due to delay and other issues.
<b>M3- Poor contract and site management</b>	Yes	Contractor / Consultant	Affects the project life time, safety risks arise, various disputes arising, dissatisfaction of the client or end user,.
<b>M4- Poor communication between stakeholders</b>	Yes	All	Claim and Disputes due to communication breakdown, no coordination among the stakeholders, lag of work due to slow decisions, differences in various issues related to project design and compromise in work achieving time, cost and quality.
<b>M5- Material handling and storage factors</b>	Yes	Contractor /consultant	Affects the quality of the building if materials deteriorate due to poor management, wastage of material will occur, additional cost may arise; some may be damaged due to stock life time,
<b>D1- Inadequate site investigation</b>	Yes	Consultant/client	Problems with existing structures, soil strata and other issues, right of way problem, .
<b>D2- Poor detailing and design change delay</b>	Yes	Consultant	Rework due to design change, demolition or reworks which incur additional cost and ambiguity which may lead to claims and disputes, financial issue due to extra overhead cost.

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<b>Risk factors</b>	<b>Is this risk factor evident in your project environment? Yes/No</b>	<b>Who is responsible for this risk factor?</b>	<b>What are the possible consequences which result because of this risk factor?</b>
<b>D3- poor use of advanced software</b>	Yes	Contractor /consultant	Integration issues, design rework taking a long time and problems with the design outputs and dissatisfaction of the client due to consequences arising because of such issues.
<b>C1- Incorrect plan of work, cost, schedule and quality</b>	Yes	Contractor /consultant	It will affect project life time and is difficult to measure the status of the project work, unproductive work organization, quality will be compromised, unnecessary manpower may be assigned and delay will occur due to this factor.
<b>C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials</b>	Yes	Contractor / Government	Slow work progress, concrete quality compromised if used slowly, productivity issues, safety issues, material may break and get damaged.
<b>C3- Loss of time by traffic control and restriction</b>	Yes	Government	Slow progress due to restriction and restrictions in relation to material movement in and out of site.
<b>C4- Low labor productivity and labor shortage</b>	Yes	Contractor	Increase in project duration, additional cost is added and delay in construction time will arise due to labor shortage.
<b>C5- Improper choice of curtain wall systems and deficient field installation</b>	Yes	Consultant/client	The quality of work is compromised, repetition of work, additional cost and added time.

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<b>Risk factors</b>	<b>Is this risk factor evident in your project environment? Yes/No</b>	<b>Who is responsible for this risk factor?</b>	<b>What are the possible consequences which result because of this risk factor?</b>
<b>C6- Changes and variation order</b>	Yes	All	Increase in project cost, delay in work activities and affect the project accomplishment/ finish date while some issues may lead to disputes.
<b>L1- Permit requirements.</b>	Yes	Government	Work stoppage until permit is provided and thus time delay.
<b>L2- Bribery/ Corruption</b>	No	-	-
<b>S1- No appointed safety personnel</b>	Yes	Contractor	Man power injury or death and other accidents may occur due to falling from height.
<b>S2- Labor Injuries</b>	Yes	Contractor /consultant	Compensation and the issue affect the image of the company.
<b>S3- Fire/ Theft of material and Equipment</b>	Yes	Contractor	Improper inventory management, Damage to the property in the compound and due to this additional cost.
<b>P1 – Late material Procurement</b>	Yes	Contractor / consultant	Increase in the material cost to the project and project lifetime may increase.
<b>P2- Defective material supply and price escalation</b>	Yes	Contractor / consultant	Quality issues, reworks related to this materials adding cost with the time of project also being affected.

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<b>Risk factors</b>	<b>Is this risk factor evident in your project environment? Yes/No</b>	<b>Who is responsible for this risk factor?</b>	<b>What are the possible consequences which result because of this risk factor?</b>
<b>P3 Unavailability of material, labor and Equipment</b>	Yes	Government/ Contractor	Utilization of the work to the fullest extent will not be possible, slow progress of project items, delays may arise.
<b>P4- Utility service delay</b>	No	-	-
<b>P5- Importation, customs and visa issues</b>	Yes	The Government	Project work delay and some works may stop until the material arrives.

**\*only respondents from Case – III said that there are no appointed safety personnel.**

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When it comes to the use of risk management principles the companies use it for evaluating, monitoring and controlling the work environment. In addition, there is a plan to evaluate workers and select the best individuals as an example to the others. In addition to these only Check lists are mainly used but as an addition the risks are evaluated in meetings before they arise or after they are seen on the project environment.

### **3.6. Integration of Case Study and Questionnaire Results**

#### *3.6.1. Key Risk Factors Associated with High Rise Building Projects*

The risk factors were identified through an extensive literature review and categorization was done based on their respective fields in the construction site. After the risks were identified and included in the questionnaire the ranking of these factors was done by using the probability impact matrix as shown in the previous analysis. In addition to the probability matrix the DEMATEL analysis was also done in using the questionnaire technique and the results are also included.

The ranking of risk factors was done using the probability impact table and DEMATEL technique. The PI matrix was used to analyze and categorize the risk factors based on their probability and impact scores. The following table tries to show the rank of the risks and their respective results of PI-matrix scores explained in order to understand the severity of these risks in terms of project dimensions.

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**Table 25:- Ranking of risks and their respective PI-Matrix result explained**

Risk Factors	Risk Ranking In PI- Matrix	PI- matrix Result	
		Probability	Impact
<b>F1- Inflation and Exchange rate fluctuation</b>	1	Frequent	Very high
<b>C1- Incorrect plan of work, cost, schedule and quality</b>	2	Frequent	Very high
<b>D3- poor use of advanced software</b>	3	Frequent	Moderate
<b>P5- Importation, customs and visa issues</b>	4	Frequent	Moderate
<b>L1- Permit requirements.</b>	5	High	High
<b>C6- Changes and variation order</b>	6	High	High
<b>D2- Poor detailing and design change delay</b>	7	Frequent	Moderate
<b>P1 – Late material Procurement</b>	8	Frequent	High
<b>C3- Loss of time by traffic control and restriction</b>	9	Frequent	High
<b>M5- Material handling and storage factors</b>	10	Somewhat frequent	Moderate
<b>C4- Low labor productivity and labor shortage</b>	11	Frequent	High
<b>D1- Inadequate site investigation</b>	12	Somewhat frequent	Moderate
<b>M2 - Type of delivery method selected</b>	13	Somewhat frequent	Moderate
<b>L2- Bribery/ Corruption</b>	14	Frequent	High
<b>M3- Poor contract and site management</b>	15	Somewhat frequent	Moderate
<b>S2- Labor Injuries</b>	16	Occasional	High
<b>S3- Fire/ Theft of material and Equipment</b>	17	Occasional	High
<b>P4- Utility service delay</b>	18	Somewhat frequent	Moderate
<b>S1- No appointed safety personnel</b>	19	Somewhat frequent	Moderate
<b>M4- Poor communication between stakeholders</b>	20	Somewhat frequent	Moderate
<b>F3- interim payment delay</b>	21	Somewhat frequent	Moderate
<b>P3 Unavailability of material, labor and Equipment</b>	22	Occasional	Moderate
<b>C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials</b>	23	Somewhat frequent	Low
<b>C5- Improper choice of curtain wall systems and deficient field installation</b>	24	Somewhat frequent	Low
<b>M1 - Change in top management</b>	25	Occasional	Moderate
<b>P2- Defective material supply and price escalation</b>	26	Rare	Low
<b>F2- Inappropriate advance payment use</b>	27	Rare	Low

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### *3.6.2. Severity and Impact Analysis of Risk Factors*

In terms of impact the DEMATEL technique was used to show the risk factors which impact project objectives in terms of schedule, quality and cost. The risk factors with the highest influence based on the risk Normalized degree of influence for the risk factors studied calculated using DEMATEL.

The top five risk factors with a higher normalized degree of influence were found to be P5- Importation, customs and visa issues, C1- Incorrect plan of work, cost, schedule and quality, M3- Poor contract and site management, M4- Poor communication between stakeholders and M5- Material handling and storage factors.

When we see whether or not these risk factors are in the cause or effect group P5- Importation, customs and M4- Poor communication between stakeholders are in the cause group while the remaining factors are in the effect group. When we see the responsible stakeholder for the risk factors the government is responsible for Importation, customs and visa issues, the contractor is responsible for Incorrect plan of work, cost, schedule, Poor contract and site management and Material handling and storage factors while all parties are responsible for the Poor communication between stakeholders because communication is not a one-way issue. The following table compiles the top 15 risk factors in terms of influence, cause/effect and their PI – matrix.

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**Table 26:- Analysis of risk factors in terms of influence, cause/effect and their PI – matrix**

<b>Risk Factors With Their Codes</b>	<b>Normalized Degree of Influence Using DEMATEL</b>
P5- Importation, customs and visa issues	8.15%
C1- Incorrect plan of work, cost, schedule and quality	5.11%
M4- Poor communication between stakeholders	4.96%
M3- Poor contract and site management	4.81%
M5- Material handling and storage factors	4.80%
D2- Poor detailing and design change delay	4.59%
P1 – Late material Procurement	4.49%
M2 - Type of delivery method selected	4.38%
C6- Changes and variation order	4.12%
F3- interim payment delay	3.95%
F2- Inappropriate advance payment use	3.87%
D3- poor use of advanced software	3.82%
P3 Unavailability of material, labor and Equipment	3.64%
C5- Improper choice of curtain wall systems and deficient field installation	3.57%
L1- Permit requirements.	3.28%
D1- Inadequate site investigation	3.15%
S1- No appointed safety personnel	3.05%
S2- Labor Injuries	3.02%
S3- Fire/ Theft of material and Equipment	2.99%
L2- Bribery/ Corruption	2.93%
P2- Defective material supply and price	2.92%
C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	2.82%
C3- Loss of time by traffic control and restriction	2.78%
C4- Low labor productivity and labor shortage	2.29%
F1- Inflation and Exchange rate fluctuation	1.56%

*3.6.3. Major Stakeholders Taking Responsibility for the Risk Factors*

Based on the case study result the major stake holders taking responsibility for the risk factors stated are contractor which takes about 40% of the risk factors, government 16%, shared between consultant and client 12%, shared between consultant and contractor 12%

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and finally consultant only which takes 8%. The responsible stakeholders are shown in the following table.

**Table 27:-Major stakeholders taking responsibility for stated risk factors**

<b>Risk Factors with the P-I matrix ranking</b>	<b>Responsible Stake Holder composed from Case Study</b>
P5- Importation, customs and visa issues	The Government
C1- Incorrect plan of work, cost, schedule and quality	Contractor /consultant
M4- Poor communication between stakeholders	ALL
M3- Poor contract and site management	Contractor /consultant
M5- Material handling and storage factors	Contractor /consultant
D2- Poor detailing and design change delay	Consultant
P1 – Late material Procurement	Contractor / consultant
M2 - Type of delivery method selected	Consultant / Client
C6- Changes and variation order	ALL
F3- interim payment delay	Consultant / Client
F2- Inappropriate advance payment use	Contractor / consultant
D3- poor use of advanced software	Contractor / consultant
P3 Unavailability of material, labor and Equipment	Government / Contractor
C5- Improper choice of curtain wall systems and deficient field installation	Consultant / Client
L1- Permit requirements.	The Government
D1- Inadequate site investigation	Consultant / Client
S1- No appointed safety personnel	Contractor
S2- Labor Injuries	
S3- Fire/ Theft of material and Equipment	Contractor
L2- Bribery/ Corruption	-
P2- Defective material supply and price	Contractor / consultant
C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	Government / Contractor
C3- Loss of time by traffic control and restriction	The Government
C4- Low labor productivity and labor shortage	
F1- Inflation and Exchange rate fluctuation	The Government

## **CHAPTER FIVE**

### **CONCLUSION AND RECOMMENDATION**

#### **5.1. Introduction**

This chapter tries to make a sense out of the data collection and analysis part based on the literature reviewed. In addition, recommendations were given for the problems stated.

#### **5.2. Conclusion**

As a contribution, the study revealed the major risk factors affecting the performance of the high rise building construction industry which is thriving in Addis Ababa. Knowing these risk factors and using them in a risk management strategy will be a meaningful help to the high rise construction industry through helping in the formulation of a risk management system and the results can be used as an input to decision making for future and existing projects. In addition, since risk management tools used are very traditional the research promotes the use of modern and practical tools for the high rise construction industry since knowing and making sure a risk response is prepared is a good step in producing the built environment on time, cost and within the standard quality. In addition, the research shows the stakeholders critical responsibilities to make sure they are responsive to risks that exist in their area of influence.

Based on the assessment and review of numerous literatures which were illustrated in the literature review 28 risk factors were identified and categorized in to seven main categories which relate to the main risk areas particular to the research at hand. The main risk categories were first formulated and their sub risks which relate to these risk categories were added to them. Finally, a code was given to each sub category in order to make sure those tables and figures that need too much space have a clear and simple tool to understand.

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The final outcome of the relative importance index (RII) ranking found the following risk factors to be the top 10 risk factors having negative impact on high rise building construction, these were Inflation and Exchange rate fluctuation (F1), Incorrect plan of work, cost, schedule and quality (C1), poor use of advanced software (D3), Importation, customs and visa issues (P5), Permit requirements (L1), Changes and variation order (C6), Poor detailing and design change delay (D2), Late material Procurement (P1), Loss of time by traffic control and restriction (C3) and Material handling and storage factors (M5).

### **5.3. Recommendation**

The main recommendation points as per the influential risk factors found by the research will be to

- ✓ Minimize incorrect plan of work, cost, schedule, quality issues.
- ✓ Changes and variation orders should be managed by making sure a detailed analysis is prepared and the quantity resembles the work on the ground.
- ✓ Late material Procurement should be reduced through planning ahead, storage locations are accessible, safe and without hazard.
- ✓ A risk management support system should be out lined for repetitive and known high rise building construction risks in order to respond to those risks when they occur

On the basis of the research work undertaken and based on the analysis carried out further recommendations are given as follows

- I. Importation procedures should be smooth and the economy is resilient interims of inflation and exchange rate fluctuation.
- II. Modern vertical transport mechanism should be availed in terms of upholding the work quality, schedule and reduction of cost.

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- III. Permit requirement should be clear enough with a speedy process in order to make sure the work is not idle due to bureaucratic issues and designs prepared should be clear and more detailed.
- IV. The contractor should have a contract management team with a set out procedures and site management should be effectively planned at an early stage.

### **5.4. Suggested Areas for Further Research**

The following further research topics are recommended

- Risk management strategy formulation in Ethiopian high rise building construction projects
- Assessment of risk estimation practices in Ethiopian high rise building construction
- Risk management knowledge integration practices in Ethiopian high rise building construction
- Risk management support systems in the Ethiopian high rise building construction industry

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**Appendix (A): - Questionnaire**



**Addis Ababa University**

**Addis Ababa Institute of Technology**

**School of Civil and Environmental Engineering**

**Msc. Program in Construction Technology and Management Stream**

**Questionnaire for Research Titled;**

**“Study of the Impact of High Rise Building Construction Risk Factors On  
Selected Sites Around Addis Ababa: A Case Study”**

**Prepared By: Yonatane Tadesse**

**Advisors Name: Dr.Abraham Assefa Tsehayae**

## **STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND ADDIS ABABA: A CASE STUDY**

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**Dear sir/madam**

I am currently conducting research for my MSc degree in the stream of construction technology and management under the School of Civil and Environmental Engineering at Addis Ababa Institute of Technology, Addis Ababa University.

The aim of this questionnaire is to study is to evaluate the major risk factors in the high rise building construction industry in Ethiopia, to assess their impact in projects success, project objectives and how these risk factors can be minimized.

The information gathered will used for academic purposes only and the information collected will be kept confidential. I wait for your heartwarming response in advance.

**Sincerely,**

**Yonatane Tadesse**

**Mobile:- +251904134318**

**Email: - yonatanatadesse1@outlook.com**

**Advisors Name: - Dr.Abraham Assefa**

**Email: - abraham.aau@gmail.com**

# STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND ADDIS ABABA: A CASE STUDY

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## Section 1:- Respondent Background

1. Your title and contact address

Job Title: \_\_\_\_\_

Contacts address (Optional): E-mail: \_\_\_\_\_ Tel:  
\_\_\_\_\_

2. Who are you currently working for

- Main Contractor
- Sub-contractor
- Consultant
- client

3. How many years of experience do you have in the building construction sector

- Less than one year
- 1-2 years
- 3-4 years
- 5-10 years
- More than 10 years

4. Your Education qualification

- Diploma
- B.Sc.
- M.Sc.
- PHD
- Other .....

5. What kind of building project are you currently engaged in

- Public
- Private

**STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND ADDIS ABABA: A CASE STUDY**

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6. What is your companies experience in high rise building construction projects

.....

**Section 2:- Project Information**

1. Building information

- ✓ Project name .....
- ✓ Number of basements .....
- ✓ Story above ground level.....

2. Contractual information

- Contract duration of project .....
- Contract cost of project .....
- Project start date .....
- Project contractual finish date .....
- Contract delivery method
  - Design Build (DB)
  - Design bid build (DBB)
  - Construction management consultancy (CM)
  - Others please specify .....

3. Current stage of project in % .....

**STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND ADDIS ABABA: A CASE STUDY**

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**SECTION 3:- PROJECT RISK FACTOR SEVERITY AND IMPACT ASSESSMENT**

Please fill out the following DEMATEL table and use the following points while filling out the likelihood and impact part of the table which is based on a 5-point Likert scale. Please use the following numerical values while filling both the probability and the degree of impact columns of the first table , 1 represents “very low”, 2 “low”, 3 “moderate”, 4 “high”, and 5 “very high”.

Risk Factors	Probability Of Occurrence					Degree Of Impact				
	1	2	3	4	5	1	2	3	4	5
F1- Inflation and Exchange rate fluctuation										
F2- Inappropriate advance payment use										
F3- interim payment delay										
M1 - Change in top management										
M2 - Type of delivery method selected										
M3- Poor contract and site management										
M4- Poor communication between stakeholders										
M5- Material handling and storage factors										
D1- Inadequate site investigation										
D2- Poor detailing and design change delay										
D3- poor use of advanced software										
C1- Incorrect plan of work, cost, schedule and quality										
C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials										
C3- Loss of time by traffic control and restriction										
C4- Low labor productivity and labor shortage										
C5- Improper choice of curtain wall systems and deficient field installation										
C6- Changes and variation order										
L1- Permit requirements.										
L2- Bribery/ Corruption										
S1- No appointed safety personnel										
S2- Labor Injuries										
S3- Fire/ Theft of material and Equipment										
P1 – Late material Procurement										
P2- Defective material supply and price escalation										
P3 Unavailability of material, labor and Equipment										
P4- Utility service delay										
P5- Importation, customs and visa issues										

**SECTION 4:- RISK FACTORS FOR DEMATEL ASSESSMENT**

Please fill the following DEMATEL matrix by assessing the impact relationship strength of one factor over the other. Use the following numerical values to express your response. *Fill 0 for*

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*no impact, 1 for little impact, 2 for medium impact, 3 for large impact and 4 for Very large impact. Please don't fill the blacked area.*

Risk factors		C6	L1	L2	S1	S2	S3	P1	P2	P3	P4	P5
Finance	F1- Inflation and Exchange rate fluctuation											
	F2- Inappropriate advance payment use											
	F3- interim payment delay											
Management	M1 - Change in top management											
	M2 - Type of delivery method selected											
	M3- Poor contract and site management											
	M4- Poor communication between stakeholders											
	M5- Material handling and storage factors											
Design	D1- Inadequate site investigation											
	D2- Poor detailing and design change delay											
	D3- poor use of advanced software											
Construction	C1- Incorrect plan of work, cost, schedule and quality											
	C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials											
	C3- Loss of time by traffic control and restriction											
	C4- Low labor productivity and labor shortage											
	C5- Improper choice of curtain wall systems and deficient field installation											
	C6- Changes and variation order	■										
Legal	L1- Permit requirements.		■									
	L2- Bribery/ Corruption			■								
Safety	S1- No appointed safety personnel				■							
	S2- Labor Injuries					■						
	S3- Fire/ Theft of material and Equipment						■					
Procurement	P1 – Late material Procurement							■				
	P2- Defective material supply and price escalation								■			
	P3 Unavailability of material, labor and Equipment									■		
	P4- Utility service delay										■	
	P5- Importation, customs and visa issues											■

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Risk factors		F1	F2	F3	M1	M2	M3	M4	M5	D1	D2	D3	C1	C2	C3	C4	C5
Finance	F1- Inflation and Exchange rate fluctuation	■															
	F2- Inappropriate advance payment use		■														
	F3- Interim payment delay			■													
Management	M1 - Change in top management				■												
	M2 - Type of delivery method selected					■											
	M3- Poor contract and site management						■										
	M4- Poor communication between stakeholders							■									
	M5- Material handling and storage factors								■								
Design	D1- Inadequate site investigation									■							
	D2- Poor detailing and design change delay										■						
	D3- poor use of advanced software											■					
Construction	C1- Incorrect plan of work, cost, schedule and quality												■				
	C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials													■			
	C3- Loss of time by traffic control and restriction														■		
	C4- Low labor productivity and labor shortage															■	
	C5- Improper choice of curtain wall systems and deficient field installation																■
	C6- Changes and variation order																
Legal	L1- Permit requirements.																
	L2- Bribery/ Corruption																
Safety	S1- No appointed safety personnel																
	S2- Labor Injuries																
	S3- Fire/ Theft of material and Equipment																

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<b>Procurement</b>	P1 – Late material Procurement																	
	P2- Defective material supply and price escalation																	
	P3 Unavailability of material, labor and Equipment																	
	P4- Utility service delay																	
	P5- Importation, customs and visa issues																	

**SECTION 5:-RISK MANAGEMENT STRATEGIES AND TOOLS USED**

5.1.What tools do you use to evaluate the risk management process you have outlined ( please check all that apply)

- Check list
- Interview
- Expert system
- Questionnaire
- The Delphi technique
- Influence diagram
- Cause and effect diagrams
- Others please specify .....

**Thank You!**

**For any questions and comments regarding the questionnaire please contact**

**Yonatane Tadesse**  
**Mobile: - +251904134318**  
**Email: - yonatantadesse1@hotmail.com**

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## **Appendix (B):- Structured Interview for Case Study**

### **CASE STUDY INTERVIEW QUESTIONS**

#### **PREFACE**

**Dear sir/madam**

I am very grateful for your participation in this research and would like to thank you first. The aim of this interview is to study is to evaluate the major risk factors in the high rise building construction industry in Ethiopia, to assess their impact in projects success, project objectives and how these risk factors can be minimized. The information gathered will be used for academic purposes only and information will be kept confidential. I wait for your heartwarming response in advance.

#### **INTRODUCTION AND ORIENTATION**

1. First of all I would like to thank you for your cooperation.
2. The responses you give to this interview will be kept confidential and anonymously used.
3. The interview comprises of 12 questions and will approximately take 35 minutes.
4. For any comments with regard to this interview you can contact **Mr. Yonatane Tadesse**, phone number: **+251904134318**, email: **yonatantadesse1@outlook.c**

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**INTERVIEW QUESTIONS**

7. Your title and contact address

Job Title: \_\_\_\_\_

Contacts address (Optional): E-mail: \_\_\_\_\_ Tel:  
\_\_\_\_\_

8. Who are you currently working for

- Main Contractor
- Sub-contractor
- Consultant
- Client

9. How many years of experience do you have in the building construction sector

- Less than one year
- 1-2 years
- 3-4 years
- 5-10 years
- More than 10 years

10. Your Education qualification

- Diploma
- B.Sc.
- M.Sc.
- PHD
- Other .....

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11. What kind of building project are you currently engaged in

- Public
- Private
- If other please specify.....

12. What is your companies experience in high rise building construction projects

.....

13. Building information

- ✓ Project name .....
- ✓ Number of basement .....
- ✓ Story above ground level.....

14. Contractual information

- Contract duration of project .....
- Contract cost of project .....
- Project start date .....
- Project contractual finish date .....
- Contract delivery method
  - Design Build (DB)
  - Design bid build (DBB)
  - Construction management consultancy (CM)
  - Others please specify .....

15. Current stage of project in % .....

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**10. Please respond to the following risk factors and evaluate whether or not the risk factors stated are evident in the high rise building construction project you are currently engaged in. In addition discuss the responsible parties and the possible consequences this risk factors have on the project?**

<b>Risk factors</b>	<b>Is this risk factor evident in your project environment? Yes/No</b>	<b>Who do you think is responsible for this risk factor?</b>	<b>What are the possible consequences which result because of this risk factor?</b>
F1- Inflation and Exchange rate fluctuation			
F2- Inappropriate advance payment use			
F3- interim payment delay			
M1 - Change in top management			
M2 - Type of delivery method selected			
M3- Poor contract and site management			
M4- Poor communication between stakeholders			
M5- Material handling and storage factors			
D1- Inadequate site investigation			
D2- Poor detailing and design change delay			

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D3- poor use of advanced software			
C1- Incorrect plan of work, cost, schedule and quality			
C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials			
C3- Loss of time by traffic control and restriction			
C4- Low labor productivity and labor shortage			
C5- Improper choice of curtain wall systems and deficient field installation			
C6- Changes and variation order			
L1- Permit requirements.			
L2- Bribery/ Corruption			
S1- No appointed safety personnel			
S2- Labor Injuries			
S3- Fire/ Theft of material and Equipment			
P1 – Late material Procurement			

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P2- Defective material supply and price escalation			
P3 Unavailability of material, labor and Equipment			
P4- Utility service delay			
P5- Importation, customs and visa issues			

11. Do you currently use risk management as one basic process in your project? If yes, please try to discuss how the project is using risk management to achieve its main goals?

.....  
.....  
.....  
.....

12. What tools do you use to help the risk management process your firm is undertaking currently?

.....  
.....  
.....  
.....

**Thank You Very Much for Your Precious**

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**Appendix (C):- List of high rise Buildings in Addis Ababa**

<b>Building name</b>	<b>Estimated Height in Meters</b>	<b>Floors</b>	<b>Building type</b>	<b>Status</b>
1. Commercial Bank of Ethiopia HQ	≈198 m	48	Skyscraper	Under construction
2. African Union Headquarters	118 m	21	Skyscraper	Existing
3. Nani Tower	103 m	22	Skyscraper	Existing
4. CCD Tower 2	≈146 m	39	high-rise building	Proposed
5. Noah Real Estate Tower	≈135 m	36	high-rise building	Under construction
6. Amhara Credit & Saving Institution HQ	≈135 m	36	high-rise building	Under construction
7. United Bank Headquarters	≈131 m	35	high-rise building	Under construction
8. NIB Bank Headquarters	≈131 m	35	high-rise building	Under construction
9. EEPCo Headquarters	≈127 m	34	high-rise building	Under construction
10. Four Points by Sheraton	≈120 m	32	high-rise building	Under construction
11. Zemen Bank Headquarters	≈112 m	30	high-rise building	Under construction
12. Red Cross Headquarters	≈112 m	30	high-rise building	Under construction
13. ORDA Headquarters	≈101 m	27	high-rise building	Under construction
14. Nile Insurance Company Headquarters	≈94 m	25	high-rise building	Under construction
15. Wegagen Bank Headquarters	≈86 m	23	high-rise building	Under construction
16. Kebede Ketema Tower	≈82 m	22	high-rise building	Under construction
17. Sileshi Sehine Business Center	≈82 m	22	high-rise building	Under construction
18. Legacy Real Estate Tower	≈82 m	22	high-rise building	Under construction
19. Huda Tower	≈82 m	22	high-rise building	Planned
20. Dashen Bank Headquarters	≈79 m	21	high-rise building	Existing
21. Mozambique Street Building	≈79 m	21	high-rise building	Under construction
22. Eleli Building	≈79 m	21	high-rise building	Under construction
23. Bole Central	≈75 m	20	high-rise building	Existing
24. Grace Plaza	≈75 m	20	high-rise building	Existing
25. ZED Building	≈75 m	20	high-rise building	Under construction
26. Chelelek Alsam Tower	≈75 m	20	high-rise building	Existing
27. Roosevelt Street Buidling	≈75 m	20	high-rise building	Under construction

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28. Nyala Insurance Building	≈71 m	19	high-rise building	Under construction
29. Bole Housing Project I	≈71 m	19	high-rise building	Existing
30. Bole Housing Project II	≈71 m	19	high-rise building	Existing
31. Bole Housing Project III	≈71 m	19	high-rise building	Existing
32. Bole Housing Project IV	≈71 m	19	high-rise building	Existing
33. Bole Housing Project V	≈71 m	19	high-rise building	Existing
34. Bole Housing Project VI	≈71 m	19	high-rise building	Existing
35. Bole Housing Project VII	≈71 m	19	high-rise building	Existing
36. Bole Housing Project VIII	≈71 m	19	high-rise building	Under construction
37. Bole Housing Project IX	≈71 m	19	high-rise building	Under construction
38. Bole Housing Project X	≈71 m	19	high-rise building	Under construction
39. Bole Housing Project XI	≈71 m	19	high-rise building	Under construction
40. Ring Road Residential Towers I	≈67 m	18	high-rise building	Under construction
41. Ring Road Residential Towers II	≈67 m	18	high-rise building	Under construction
42. Ring Road Residential Towers III	≈67 m	18	high-rise building	Under construction
43. Ring Road Residential Towers IV	≈67 m	18	high-rise building	Under construction
44. Equatorial Guinea Street Building	≈67 m	18	high-rise building	Under construction
45. Leghar Hotel	≈67 m	18	high-rise building	Under construction
46. Awash Bank Tower	≈67 m	18	high-rise building	Existing
47. Namibia Street Building	≈64 m	17	high-rise building	Existing
48. Coffee Plaza	≈64 m	17	high-rise building	Under construction
49. Giant Eagle Trading Building	≈64 m	17	high-rise building	Under construction
50. Bank of Abyssinia Building	≈64 m	17	high-rise building	Existing
51. Pullman Hotel	≈64 m	17	high-rise building	Under construction
52. Intercontinental Hotel	≈64 m	17	high-rise building	Existing
53. Bahar Building	≈64 m	17	high-rise building	Existing
54. NOC Building	≈60 m	16	high-rise building	Existing
55. Ring Road Building	≈60 m	16	high-rise building	Under construction
56. Noah City Point	≈60 m	16	high-rise building	Under construction
57. Radisson Blu Hotel	≈60 m	16	high-rise building	Under construction
58. Ene Regassa Apartment Building	≈60 m	16	high-rise building	Under construction
59. Ministry of Construction Building	≈60 m	16	high-rise building	Existing

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60. Athlete Derartu Tulu Building	≈60 m	16	high-rise building	Existing
61. Noah Residence	≈60 m	16	high-rise building	Existing
62. Namibia Street Building	≈56 m	15	high-rise building	Existing
63. Haile Gebre Silase Street Building	≈56 m	15	high-rise building	Under construction
64. Getfam Hotel	≈56 m	15	high-rise building	Existing
65. Ethio China Street Building	≈56 m	15	high-rise building	Under construction
66. Gerad Building	≈56 m	15	high-rise building	Under construction
67. KKG Building	≈56 m	15	high-rise building	Under construction
68. Enat Real Estate Tower	≈56 m	15	high-rise building	Existing
69. Dagi PLC Building	≈56 m	15	high-rise building	Existing
70. Osac Business Building	≈56 m	15	high-rise building	Existing
71. Renaissance Building	≈56 m	15	high-rise building	Existing
72. Debre Zeit Road Building	≈56 m	15	high-rise building	Existing
73. Addis Ababa City Government Building	≈56 m	15	high-rise building	Existing
74. Debrewerk Tower	≈56 m	15	high-rise building	Existing
75. Sur Tower	≈56 m	15	high-rise building	Existing
76. Lex Plaza	≈56 m	15	high-rise building	Existing
77. MTSE Building	≈56 m	15	high-rise building	Existing
78. Arada Building	≈56 m	15	high-rise building	Existing
79. African Union Grand Hotel	≈52 m	14	high-rise building	Existing
80. Yobek Commercial Center	≈52 m	14	high-rise building	Existing
81. METI Building	≈52 m	14	high-rise building	Existing
82. Mado Hotel	≈52 m	14	high-rise building	Existing
83. Kassa Grand Mall	≈52 m	14	high-rise building	Existing
84. Ras Lulseged Street Building	≈52 m	14	high-rise building	Existing
85. Noah Sky Gate	≈52 m	14	high-rise building	Under construction
86. Getu Commercial Center	≈52 m	14	high-rise building	Existing
87. KAS Tower	≈52 m	14	high-rise building	Existing
88. Kazanchis Finishing Mall	≈52 m	14	high-rise building	Existing
89. IOM Building	≈52 m	14	high-rise building	Existing
90. Yotek Building	≈52 m	14	high-rise building	Existing
91. Ethiopian Television	≈52 m	14	high-rise building	Existing

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92. Azzeman Hotel	≈49 m	13	high-rise building	Existing
93. Wabe Shebelle Hotel	≈49 m	13	high-rise building	Existing
94. Ethiopian Insurance Corporation Headquarters	≈49 m	13	high-rise building	Existing
95. Golagol Tower	≈45 m	12	high-rise building	Existing
96. Commercial Bank of Ethiopia building	≈45 m	12	high-rise building	Existing
97. Flamingo Building	≈45 m	12	high-rise building	Existing
98. Commercial Bank of Ethiopia Building	≈45 m	12	high-rise building	Existing
99. Equatorial Business Group Building	≈45 m	12	high-rise building	Existing
100. Mega House	≈45 m	12	high-rise building	Existing
101. Addis Ababa Hilton Hotel	≈45 m	12	high-rise building	Existing

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**Appendix (D): - Location and number of high rise buildings in various sub cities in Addis Ababa included in the research**

<b>Sub city</b>	<b>Number of high rises included in the study</b>
<b>Akaki Kality Sub city</b>	<b>3</b>
<b>Lideta sub city</b>	<b>10</b>
<b>Nifas silk lafto sub city</b>	<b>9</b>
<b>Arada Sub city</b>	<b>3</b>
<b>Addis Ketema sub city</b>	<b>2</b>
<b>Kirkos sub city</b>	<b>5</b>

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**Appendix (E): - Stakeholders responses for the probability of occurrence**

Risk factors		Main contractor																				RII
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Finance	F1- Inflation and Exchange rate fluctuation	4	4	4	5	3	5	5	4	4	3	5	5	4	4	3	5	3	4	3	3	0.8000
	F2- Inappropriate advance payment use	2	1	3	4	2	4	3	1	1	2	4	2	2	1	4	2	1	4	3	3	0.4900
	F3- interim payment delay	4	1	1	1	3	4	4	2	2	1	4	3	1	4	4	3	1	2	4	3	0.5200
Management	M1 - Change in top management	1	3	1	2	1	3	1	1	1	3	2	1	3	2	2	1	3	3	2	2	0.3800
	M2 - Type of delivery method selected	2	3	2	2	4	2	2	3	4	3	4	2	4	4	4	3	3	4	4	3	0.6200
	M3- Poor contract and site management	4	3	2	4	2	3	4	2	4	2	4	2	3	2	3	2	2	3	3	3	0.5700
	M4- Poor communication between stakeholders	3	3	4	2	3	1	1	4	4	3	3	1	2	1	2	1	2	1	1	4	0.4600
	M5- Material handling and storage factors	5	2	3	3	5	3	5	3	3	3	3	2	4	4	5	3	3	2	2	5	0.6800
Design	D1- Inadequate site investigation	5	2	2	5	2	4	5	4	2	3	5	4	2	3	2	3	2	3	3	3	0.6400
	D2- Poor detailing and design change delay	4	4	5	5	5	3	5	4	4	4	3	5	5	4	3	4	4	3	5	5	0.8400
	D3- poor use of advanced software	3	2	5	3	3	5	5	3	4	3	3	4	5	5	4	3	5	5	4	3	0.7700
Construction	C1- Incorrect plan of work, cost, schedule and quality	5	4	4	4	3	3	4	4	4	4	3	4	4	3	5	4	3	4	5	3	0.7700
	C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	3	3	1	5	4	5	4	2	5	4	2	3	3	4	4	1	3	1	1	1	0.5900
	C3- Loss of time by traffic control and restriction	5	3	1	1	5	2	3	1	2	5	3	3	1	5	5	1	4	3	3	1	0.5700
	C4- Low labor productivity and labor shortage	3	2	5	5	4	4	3	5	2	1	1	2	3	5	2	4	3	1	2	2	0.5900
	C5- Shortage of engineers and specialists	2	2	3	2	3	3	2	2	2	3	3	2	3	3	3	3	2	2	3	2	0.5000
	C6- Changes and variation order	3	3	5	5	4	5	3	3	4	4	5	3	5	3	4	3	3	4	4	5	0.7800
Legal	L1- Permit requirements.	3	4	1	4	4	3	3	3	4	3	3	4	4	5	4	4	4	4	3	3	0.7000
	L2- Bribery/ Corruption	4	3	1	3	4	3	3	4	2	1	1	4	2	4	2	4	4	4	4	4	0.6100
Safety	S1- No appointed safety personnel	4	1	2	4	2	3	4	4	4	3	1	4	3	2	2	2	3	4	3	3	0.5800
	S2- Labor Injuries	4	2	2	4	4	4	1	1	3	3	2	4	1	3	3	2	4	4	1	1	0.5300
	S3- Fire/ Theft of material and Equipment	4	2	1	3	3	1	4	3	3	4	2	4	2	1	4	1	2	4	1	1	0.5000
Procurement	P1 – Late material Procurement	3	3	3	3	3	3	3	4	3	3	4	4	4	4	3	3	3	3	4	3	0.6600
	P2- Defective material supply and price escalation	3	2	2	4	2	3	1	1	3	1	2	2	4	3	1	4	2	3	3	1	0.4700
	P3 Unavailability of material, labor and Equipment	4	1	3	4	1	4	3	4	3	4	3	1	1	3	2	3	2	1	1	2	0.5000
	P4- Utility service delay	4	2	2	4	4	2	3	3	4	4	3	3	4	2	3	2	2	4	2	4	0.6100
	P5- Importation, customs and visa issues	5	4	1	5	4	5	5	4	4	5	5	5	4	4	4	4	4	4	5	4	0.8500

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Risk factors		Sub-contractor								RII
		21	22	23	24	25	26	27	28	
Finance	F1- Inflation and Exchange rate fluctuation	4	5	5	4	3	3	4	3	0.7750
	F2- Inappropriate advance payment use	3	4	2	3	1	4	3	2	0.5500
	F3- interim payment delay	3	4	2	3	3	2	2	2	0.5250
Management	M1 - Change in top management	1	2	1	1	2	1	2	2	0.3000
	M2 - Type of delivery method selected	4	3	3	2	3	4	2	2	0.575
	M3- Poor contract and site management	2	2	4	4	4	4	2	4	0.6500
	M4- Poor communication between stakeholders	2	3	3	4	4	2	2	3	0.575
	M5- Material handling and storage factors	2	3	5	5	2	4	3	4	0.7000
Design	D1- Inadequate site investigation	2	5	3	4	3	5	5	3	0.7500
	D2- Poor detailing and design change delay	5	5	5	5	5	4	5	4	0.9500
	D3- poor use of advanced software	5	4	4	3	4	5	5	4	0.8500
Construction	C1- Incorrect plan of work, cost, schedule and quality	4	4	3	4	3	4	4	4	0.7500
	C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	2	3	1	2	4	2	1	5	0.5000
	C3- Loss of time by traffic control and restriction	5	3	2	5	5	4	4	1	0.7250
	C4- Low labor productivity and labor shortage	5	2	1	2	2	4	1	3	0.5000
	C5- Shortage of engineers and specialists	3	3	3	3	3	3	3	2	0.5750
	C6- Changes and variation order	4	3	4	5	4	4	3	3	0.7500
Legal	L1- Permit requirements.	3	4	3	3	3	4	5	3	0.7000
	L2- Bribery/ Corruption	1	3	2	4	1	4	4	2	0.5250
Safety	S1- No appointed safety personnel	1	3	3	1	4	2	4	2	0.5000
	S2- Labor Injuries	1	1	4	4	4	1	4	3	0.5500
	S3- Fire/ Theft of material and Equipment	4	2	3	4	4	2	3	2	0.6000
Procurement	P1 – Late material Procurement	3	4	4	3	4	3	4	3	0.7000
	P2- Defective material supply and price escalation	4	1	3	4	3	2	4	1	0.5500
	P3 Unavailability of material, labor and Equipment	4	4	2	4	4	2	3	1	0.6000
	P4- Utility service delay	2	4	4	4	3	2	2	4	0.6250
	P5- Importation, customs and visa issues	5	4	5	4	5	5	4	4	0.9000

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Risk factors		Consultant												RII
		29	30	31	32	33	34	35	36	37	38	39	40	
Finance	F1- Inflation and Exchange rate fluctuation	5	3	5	4	5	5	4	5	4	5	3	4	0.8667
	F2- Inappropriate advance payment use	2	1	3	4	4	4	2	2	3	3	1	4	0.5500
	F3- interim payment delay	4	3	1	2	4	4	3	4	1	3	2	1	0.5333
Management	M1 - Change in top management	2	2	1	1	2	2	1	2	2	3	1	1	0.3333
	M2 - Type of delivery method selected	4	4	2	3	4	2	2	4	2	4	3	2	0.6000
	M3- Poor contract and site management	3	3	4	3	3	2	3	2	3	2	4	4	0.6000
	M4- Poor communication between stakeholders	3	2	1	3	2	2	4	4	4	1	1	2	0.4833
	M5- Material handling and storage factors	3	5	3	2	4	3	4	4	2	5	5	3	0.7167
Design	D1- Inadequate site investigation	2	5	4	2	2	3	4	4	2	2	4	4	0.6333
	D2- Poor detailing and design change delay	5	3	5	4	3	5	4	5	3	3	4	3	0.7833
	D3- poor use of advanced software	5	3	4	4	5	4	4	4	3	5	4	3	0.8000
Construction	C1- Incorrect plan of work, cost, schedule and quality	5	3	4	3	5	5	3	4	3	5	5	3	0.8000
	C2- Vertical transport mechanism problems	2	5	3	2	2	1	5	5	4	2	4	2	0.6167
	C3- Loss of time by traffic control and restriction	1	1	5	3	2	2	2	4	3	5	2	4	0.5667
	C4- Low labor productivity and labor shortage	4	3	4	2	5	3	2	2	2	3	5	3	0.6333
	C5- Shortage of engineers and specialists	3	2	3	2	3	2	2	2	2	3	2	2	0.4667
	C6- Changes and variation order	4	3	5	3	5	4	3	3	5	3	4	4	0.7667
Legal	L1- Permit requirements.	5	4	3	3	3	5	4	5	4	5	5	5	0.8500
	L2- Bribery/ Corruption	3	4	4	2	1	4	4	3	4	1	4	3	0.6167
Safety	S1- No appointed safety personnel	4	4	4	3	1	1	2	1	3	2	3	4	0.5333
	S2- Labor Injuries	3	1	2	2	3	1	3	1	4	4	2	3	0.4833
	S3- Fire/ Theft of material and Equipment	1	1	1	2	1	3	2	1	1	3	1	2	0.3167
Procurement	P1 – Late material Procurement	4	4	3	3	3	3	3	3	4	4	3	3	0.6667
	P2- Defective material supply and price escalation	2	3	1	1	4	3	1	2	3	1	4	2	0.4500
	P3 Unavailability of material, labor and Equipment	3	4	2	1	4	1	1	3	4	1	2	4	0.5000
	P4- Utility service delay	2	2	3	4	2	4	3	2	2	3	2	2	0.5167
	P5- Importation, customs and visa issues	5	5	4	4	5	4	4	5	5	5	4	5	0.9167

**STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND  
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Risk factors		owner														
		41	42	43	44	45	46	47	48	49	50	51	52	53	54	RII
Finance	F1- Inflation and Exchange rate fluctuation	5	3	4	5	3	4	3	5	3	4	3	4	3	3	0.7429
	F2- Inappropriate advance payment use	1	1	2	2	4	2	2	1	3	2	1	3	2	3	0.4143
	F3- interim payment delay	2	4	3	3	2	1	2	3	1	1	1	2	4	2	0.4429
Management	M1 - Change in top management	2	1	1	1	3	1	3	3	2	1	2	2	1	2	0.3571
	M2 - Type of delivery method selected	4	3	2	4	4	3	4	2	2	2	2	3	2	4	0.5857
	M3- Poor contract and site management	4	2	2	3	2	4	2	3	4	2	3	3	2	3	0.5571
	M4- Poor communication between stakeholders	4	4	2	3	4	1	2	1	4	2	4	2	1	4	0.5429
	M5- Material handling and storage factors	2	4	2	3	2	5	3	2	5	2	3	5	5	5	0.6857
Design	D1- Inadequate site investigation	4	4	4	4	3	2	5	5	5	4	3	2	5	2	0.7429
	D2- Poor detailing and design change delay	4	3	5	3	3	4	5	3	4	4	4	4	4	3	0.7571
	D3- poor use of advanced software	5	4	3	5	3	3	5	4	5	3	3	4	3	5	0.7857
Construction	C1- Incorrect plan of work, cost, schedule and quality	4	5	3	3	4	5	3	4	5	5	5	4	3	4	0.8143
	C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	5	2	5	2	2	1	3	3	2	5	4	1	5	3	0.6143
	C3- Loss of time by traffic control and restriction	5	5	2	5	3	3	1	3	3	5	3	2	1	1	0.6000
	C4- Low labor productivity and labor shortage	5	3	1	4	1	1	4	3	2	1	5	1	3	3	0.5286
	C5- Shortage of engineers and specialists	3	3	2	3	3	2	3	3	3	2	2	3	3	2	0.5286
	C6- Changes and variation order	3	3	4	4	3	3	5	4	3	3	5	5	3	3	0.7286
Legal	L1- Permit requirements.	4	5	4	4	3	4	3	4	5	3	5	3	3	3	0.7571
	L2- Bribery/ Corruption	2	4	3	2	1	1	3	1	1	1	3	2	4	1	0.4143
Safety	S1- No appointed safety personnel	2	4	1	2	4	2	3	2	1	3	2	1	4	2	0.4714
	S2- Labor Injuries	1	2	1	4	1	3	4	4	3	2	1	1	1	2	0.4286
	S3- Fire/ Theft of material and Equipment	4	4	1	4	3	3	4	4	2	1	1	2	2	3	0.5429
Procurement	P1 – Late material Procurement	4	3	4	4	3	4	3	3	4	4	3	4	3	4	0.7143
	P2- Defective material supply and price escalation	1	4	3	3	3	1	3	1	2	1	1	4	4	2	0.4714
	P3 Unavailability of material, labor and Equipment	1	1	1	4	2	4	1	1	4	4	1	2	1	2	0.4143
	P4- Utility service delay	2	2	4	4	4	4	4	4	3	3	2	3	2	4	0.6429
	P5- Importation, customs and visa issues	5	5	4	4	4	5	4	5	5	4	5	4	5	5	0.9143

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**Appendix (E):- Stakeholders responses for the Impact of risk factors**

Risk factors		Main contractor																				RII
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Finance	F1- Inflation and Exchange rate fluctuation	4	4	4	5	5	4	5	5	5	5	5	5	4	5	4	4	4	4	4	5	0.9000
	F2- Inappropriate advance payment use	2	1	3	3	1	1	1	2	1	3	3	1	3	1	3	2	1	2	1	2	0.3700
	F3- interim payment delay	4	1	1	4	4	1	3	3	1	2	2	4	5	4	5	1	5	2	2	5	0.5900
Management	M1 - Change in top management	1	4	1	3	4	1	2	3	2	4	4	4	2	2	3	1	3	5	1	5	0.5500
	M2 - Type of delivery method selected	2	3	2	3	5	4	3	5	3	4	5	2	2	3	4	3	2	4	4	3	0.6600
	M3- Poor contract and site management	4	5	2	3	3	3	2	2	5	3	4	4	3	5	4	2	5	3	2	3	0.6700
	M4- Poor communication between stakeholders	3	2	4	3	5	5	5	1	4	2	3	1	1	2	1	4	3	5	5	4	0.6300
	M5- Material handling and storage factors	5	1	3	3	3	5	1	5	5	4	2	5	4	4	3	1	4	5	1	5	0.6900
Design	D1- Inadequate site investigation	5	2	2	3	5	3	1	5	1	2	1	2	1	4	1	4	3	5	2	3	0.5500
	D2- Poor detailing and design change delay	4	5	5	3	5	1	5	5	2	2	3	2	5	5	5	3	2	5	4	4	0.7500
	D3- poor use of advanced software	3	3	5	2	4	5	2	1	5	5	4	3	5	5	4	5	3	5	5	5	0.7900
Construction	C1- Incorrect plan of work, cost, schedule and quality	5	5	4	3	4	5	5	4	5	4	5	5	4	4	5	4	5	5	5	5	0.9100
	C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	3	3	1	4	1	2	2	2	2	3	2	1	1	3	2	1	3	2	2	3	0.4300
	C3- Loss of time by traffic control and restriction	5	3	1	3	3	2	2	4	3	4	4	5	2	5	3	3	4	5	4	3	0.6800
	C4- Low labor productivity and labor shortage	3	4	5	5	5	3	5	2	5	4	4	5	3	5	2	2	5	4	3	3	0.7700
	C5- Shortage of engineers and specialists	2	4	3	3	1	3	3	2	3	2	3	1	2	2	1	3	1	1	3	3	0.4600
	C6- Changes and variation order	3	4	5	4	5	2	3	3	4	4	3	5	3	3	3	3	3	2	3	5	0.7000
Legal	L1- Permit requirements.	3	5	1	3	5	2	4	4	2	4	5	5	5	4	3	4	2	3	2	5	0.7100
	L2- Bribery/ Corruption	4	3	1	5	3	5	5	5	5	5	5	5	5	2	4	2	4	2	4	5	0.7900
Safety	S1- No appointed safety personnel	4	1	2	3	4	2	5	4	2	2	4	3	3	3	4	2	2	5	2	3	0.6000
	S2- Labor Injuries	4	2	2	3	5	5	2	3	5	3	3	2	3	2	2	2	2	5	2	4	0.6100
	S3- Fire/ Theft of material and Equipment	4	2	1	5	2	5	5	5	5	3	5	3	4	5	3	4	3	2	5	3	0.7400
Procurement	P1 – Late material Procurement	3	5	3	5	3	3	4	5	4	2	4	5	4	3	4	2	5	2	5	5	0.7600
	P2- Defective material supply and price escalation	3	1	2	5	3	3	2	1	3	1	3	3	3	1	1	2	2	1	2	1	0.4300
	P3 Unavailability of material, labor and Equipment	4	1	3	5	2	3	5	3	2	4	2	4	5	2	5	3	1	5	2	1	0.6200
	P4- Utility service delay	4	2	2	5	2	2	3	2	4	1	5	3	3	1	2	5	2	5	2	5	0.6000
	P5- Importation, customs and visa issues	5	5	1	5	1	1	5	2	3	5	5	4	3	4	2	1	2	4	3	5	0.6600

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Risk factors		Sub-contractor								RII
		21	22	23	24	25	26	27	28	
Finance	F1- Inflation and Exchange rate fluctuation	5	5	4	5	5	5	4	4	0.9250
	F2- Inappropriate advance payment use	3	1	2	3	1	2	3	1	0.4000
	F3- interim payment delay	4	4	2	4	4	1	1	4	0.6000
Management	M1 - Change in top management	3	1	1	2	3	5	4	1	0.5000
	M2 - Type of delivery method selected	5	1	2	5	3	5	5	5	0.7750
	M3- Poor contract and site management	4	5	5	4	3	4	2	1	0.7000
	M4- Poor communication between stakeholders	3	3	1	1	4	2	5	2	0.5250
	M5- Material handling and storage factors	5	2	1	4	1	1	1	3	0.4500
Design	D1- Inadequate site investigation	3	3	3	5	2	3	5	4	0.7000
	D2- Poor detailing and design change delay	3	2	4	2	2	4	1	2	0.5000
	D3- poor use of advanced software	4	5	5	3	4	1	1	3	0.6500
Construction	C1- Incorrect plan of work, cost, schedule and quality	5	4	5	5	5	4	4	4	0.9000
	C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	2	1	1	2	3	3	2	3	0.4250
	C3- Loss of time by traffic control and restriction	4	5	2	5	4	2	2	5	0.7250
	C4- Low labor productivity and labor shortage	3	4	5	5	2	3	5	5	0.8000
	C5- Shortage of engineers and specialists	1	1	2	1	3	2	1	3	0.3500
	C6- Changes and variation order	2	4	2	3	5	4	2	3	0.6250
Legal	L1- Permit requirements.	3	5	5	2	2	5	3	3	0.7000
	L2- Bribery/ Corruption	2	2	4	4	5	3	2	2	0.6000
Safety	S1- No appointed safety personnel	3	4	3	3	2	4	2	3	0.6000
	S2- Labor Injuries	3	5	4	4	3	2	3	5	0.7250
	S3- Fire/ Theft of material and Equipment	3	3	2	3	4	2	4	2	0.5750
Procurement	P1 – Late material Procurement	2	4	2	5	5	5	3	3	0.7250
	P2- Defective material supply and price escalation	2	1	2	1	3	2	3	3	0.4250
	P3 Unavailability of material, labor and Equipment	2	5	2	2	1	3	5	3	0.5750
	P4- Utility service delay	1	1	5	5	1	3	2	2	0.5000
	P5- Importation, customs and visa issues	1	5	3	3	1	4	4	3	0.6000

**STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND  
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Risk factors		Consultant												RII
		29	30	31	32	33	34	35	36	37	38	39	40	
Finance	F1- Inflation and Exchange rate fluctuation	5	4	4	5	5	4	4	5	5	5	4	4	0.9000
	F2- Inappropriate advance payment use	1	1	2	2	1	2	2	1	2	2	2	3	0.3500
	F3- interim payment delay	5	3	1	5	2	3	5	5	4	1	3	4	0.6833
Management	M1 - Change in top management	4	5	3	3	1	5	4	5	5	4	3	4	0.7667
	M2 - Type of delivery method selected	3	2	4	3	2	1	1	4	4	1	2	3	0.5000
	M3- Poor contract and site management	3	5	2	1	4	2	4	1	5	1	3	5	0.6000
	M4- Poor communication between stakeholders	3	2	1	4	5	2	3	3	1	5	5	1	0.5833
	M5- Material handling and storage factors	1	4	3	2	2	3	2	4	3	3	5	5	0.6167
Design	D1- Inadequate site investigation	3	2	1	1	3	1	3	2	1	2	5	5	0.4833
	D2- Poor detailing and design change delay	1	5	1	3	2	4	3	2	2	1	5	2	0.5167
	D3- poor use of advanced software	3	4	2	1	5	5	5	1	1	3	3	1	0.5667
Construction	C1- Incorrect plan of work, cost, schedule and quality	4	4	5	4	5	5	5	4	5	4	5	5	0.9167
	C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	1	2	3	3	3	3	2	3	1	1	3	2	0.4500
	C3- Loss of time by traffic control and restriction	5	5	4	4	2	5	4	5	2	2	5	5	0.8000
	C4- Low labor productivity and labor shortage	3	4	3	2	2	4	5	4	4	3	4	5	0.7167
	C5- Shortage of engineers and specialists	3	2	2	2	2	1	1	3	1	3	2	3	0.4167
	C6- Changes and variation order	2	5	3	3	5	3	4	5	3	3	5	4	0.7500
Legal	L1- Permit requirements.	5	5	4	2	5	2	2	4	2	2	5	3	0.6833
	L2- Bribery/ Corruption	4	4	5	5	4	3	5	4	3	2	2	4	0.7500
Safety	S1- No appointed safety personnel	3	4	3	3	4	3	4	3	4	2	4	2	0.6500
	S2- Labor Injuries	2	2	3	3	5	4	3	5	4	2	4	4	0.6833
	S3- Fire/ Theft of material and Equipment	2	4	3	5	5	5	4	4	5	4	3	3	0.7833
Procurement	P1 – Late material Procurement	5	3	5	3	2	5	2	2	2	4	3	3	0.6500
	P2- Defective material supply and price escalation	1	3	2	2	3	3	1	3	2	3	1	1	0.4167
	P3 Unavailability of material, labor and Equipment	4	4	4	4	4	2	2	1	1	2	2	3	0.5500
	P4- Utility service delay	2	3	3	4	1	3	4	1	5	5	4	2	0.6167
	P5- Importation, customs and visa issues	2	2	2	4	4	3	4	3	3	1	2	5	0.5833

**STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND  
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Risk factors		owner														
		41	42	43	44	45	46	47	48	49	50	51	52	53	54	RII
Finance	F1- Inflation and Exchange rate fluctuation	4	4	4	4	5	4	4	5	5	5	5	4	5	5	0.9000
	F2- Inappropriate advance payment use	1	2	2	2	1	2	1	2	1	2	2	3	3	1	0.3571
	F3- interim payment delay	2	2	2	2	5	2	1	2	5	4	4	1	2	5	0.5571
	M1 - Change in top management	3	4	2	5	3	2	5	5	2	4	1	3	2	4	0.6429
	M2 - Type of delivery method selected	4	4	5	5	2	2	4	2	3	2	4	3	5	1	0.6571
	M3- Poor contract and site management	5	1	1	3	2	3	4	2	3	3	4	4	3	5	0.6143
	M4- Poor communication between stakeholders	2	2	3	1	5	5	5	5	2	4	1	5	5	4	0.7000
	M5- Material handling and storage factors	4	1	3	3	4	1	3	4	3	2	1	2	2	4	0.5286
Design	D1- Inadequate site investigation	2	3	2	2	3	5	3	5	1	3	5	3	3	4	0.6286
	D2- Poor detailing and design change delay	2	1	3	3	5	2	2	4	3	3	2	2	1	1	0.4857
	D3- poor use of advanced software	4	3	4	5	3	4	5	2	3	5	2	3	3	2	0.6857
Construction	C1- Incorrect plan of work, cost, schedule and quality	5	5	4	5	4	5	5	4	5	5	5	5	4	4	0.9286
	C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	1	2	1	2	2	2	3	1	3	3	1	2	1	3	0.3857
	C3- Loss of time by traffic control and restriction	5	3	5	4	3	4	4	5	3	3	3	4	3	3	0.7429
	C4- Low labor productivity and labor shortage	2	3	4	3	4	4	3	3	2	3	3	3	2	3	0.6000
	C5- Shortage of engineers and specialists	3	3	2	3	3	1	2	2	3	3	3	1	3	3	0.5000
	C6- Changes and variation order	3	3	5	4	5	3	3	5	2	4	4	3	5	3	0.7429
Legal	L1- Permit requirements.	4	2	5	5	2	5	3	5	4	5	3	2	5	5	0.7857
	L2- Bribery/ Corruption	2	4	3	3	2	2	4	2	4	3	5	2	2	3	0.5857
Safety	S1- No appointed safety personnel	5	5	2	3	4	3	2	3	2	2	2	4	3	3	0.6143
	S2- Labor Injuries	4	3	5	5	3	3	5	5	5	3	5	5	5	2	0.8286
	S3- Fire/ Theft of material and Equipment	2	3	5	3	4	3	5	2	5	2	4	4	5	2	0.7000
Procurement	P1 – Late material Procurement	2	5	4	3	5	2	5	4	3	2	3	2	4	2	0.6571
	P2- Defective material supply and price escalation	3	3	3	2	3	3	2	2	3	2	2	3	3	3	0.5286
	P3 Unavailability of material, labor and Equipment	5	1	2	2	2	5	5	3	1	2	4	1	4	3	0.5714
	P4- Utility service delay	4	2	1	1	2	4	4	1	5	2	1	2	3	4	0.5143
	P5- Importation, customs and visa issues	4	4	3	1	5	4	4	1	1	4	3	1	4	2	0.5857

**STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND  
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**Appendix (F):- Kendall's coefficient of concordance calculation Tabular forms for each risk factor probability**

<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup>= (R-A)<sup>2</sup></b>
F1- Inflation and Exchange rate fluctuation	1	1	1	1	4.00	4.00	16.00
F2- Inappropriate advance payment use	3	2	2	3	10.00	10.00	100.00
F3- interim payment delay	2	3	3	2	10.00	10.00	100.00
<b><u>A=ΣR/n =24/3=8</u></b>					<b><u>ΣR=24</u></b>		<b>S=216</b>

<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup>= (R-A)<sup>2</sup></b>
M1 - Change in top management	5	5	5	5	20.00	20.00	400.00
M2 - Type of delivery method selected	2	3	2	2	9.00	9.00	81.00
M3- Poor contract and site management	3	2	2	3	10.00	10.00	100.00
M4- Poor communication between stakeholders	4	3	4	4	15.00	15.00	225.00
M5- Material handling and storage factors	1	1	1	1	4.00	4.00	16.00
<b><u>A=ΣR/n =58/5=11.60</u></b>					<b><u>ΣR=58</u></b>		<b>S=822</b>

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<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup>= (R-A)<sup>2</sup></b>
D1- Inadequate site investigation	3	3	3	3	12.00	12.00	144.00
D2- Poor detailing and design change delay	1	1	2	2	6.00	6.00	36.00
D3- poor use of advanced software	2	2	1	1	6.00	6.00	36.00
<b><u>A=ΣR/n =24/3=8</u></b>					<b><u>ΣR=24</u></b>		S=216

<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup>= (R-A)<sup>2</sup></b>
C1- Incorrect plan of work, cost, schedule and quality	2	1	1	1	5.00	5.00	25.00
C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	3	5	4	3	15.00	15.00	225.00
C3- Loss of time by traffic control and restriction	5	3	5	4	17.00	17.00	289.00
C4- Low labor productivity and labor shortage	3	5	3	5	16.00	16.00	256.00
C5- Shortage of engineers and specialists	6	4	6	5	21.00	21.00	441
C6- Changes and variation order	1	1	2	2	6.00	6.00	36.00
<b><u>A=ΣR/n =80/6=13.33</u></b>					<b><u>ΣR=80</u></b>		S=1272

**STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND  
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<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup> = (R-A)<sup>2</sup></b>
L1- Permit requirements.	1	1	1	2	5.00	5.00	25.00
L2- Bribery/ Corruption	2	2	2	1	7.00	7.00	49.00
<b><u>A=ΣR/n =12/2=6</u></b>					<b><u>ΣR=12</u></b>		S=74

<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup> = (R-A)<sup>2</sup></b>
S1- No appointed safety personnel	1	3	1	2	7.00	7.00	49.00
S2- Labor Injuries	2	2	2	3	9.00	9.00	81.00
S3- Fire/ Theft of material and Equipment	3	1	3	1	8.00	8.00	64.00
<b><u>A=ΣR/n =24/3=8</u></b>					<b><u>ΣR=24</u></b>		S=194

<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup> = (R-A)<sup>2</sup></b>
P1 – Late material Procurement	2	2	2	2	8.00	8.00	64.00
P2- Defective material supply and price escalation	5	5	5	4	19.00	19.00	361.00
P3 Unavailability of material, labor and Equipment	4	4	4	5	17.00	17.00	289.00
P4- Utility service delay	3	3	3	3	12.00	12.00	144.00
P5- Importation, customs and visa issues	1	3	1	1	6.00	6.00	36.00
<b><u>A=ΣR/n =62/5=12.40</u></b>					<b><u>ΣR=62</u></b>		S=894

**STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND  
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**Appendix (G):- Kendall's coefficient of concordance calculation Tabular forms for each risk factor impact**

<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup> = (R-A)<sup>2</sup></b>
F1- Inflation and Exchange rate fluctuation	1	1	1	1	4.00	-4.00	16.00
F2- Inappropriate advance payment use	3	3	3	3	12.00	4.00	16.00
F3- interim payment delay	2	2	2	2	8.00	0.00	0.00
<b><u>A=ΣR/n =24/3=8</u></b>					<b><u>ΣR=24</u></b>		<b>S=32</b>

<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup> = (R-A)<sup>2</sup></b>
M1 - Change in top management	5	4	1	3	13.00	1.00	1.00
M2 - Type of delivery method selected	3	1	5	2	11.00	-1.00	1.00
M3- Poor contract and site management	2	2	3	4	11.00	-1.00	1.00
M4- Poor communication between stakeholders	4	3	4	1	12.00	0.00	0.00
M5- Material handling and storage factors	1	5	2	5	13.00	1.00	1.00
<b><u>A=ΣR/n =60/5=12</u></b>					<b><u>ΣR=60</u></b>		<b>S=4</b>

**STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND  
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<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup> = (R-A)<sup>2</sup></b>
D1- Inadequate site investigation	3	1	3	2	9.00	1.00	1.00
D2- Poor detailing and design change delay	2	3	2	3	10.00	2.00	4.00
D3- poor use of advanced software	1	2	1	1	5.00	-3.00	9.00
<b><u>A=ΣR/n =24/3=8</u></b>					<b><u>ΣR=24</u></b>		S=14

<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup> = (R-A)<sup>2</sup></b>
C1- Incorrect plan of work, cost, schedule and quality	1	1	1	1	4.00	-9.83	96.69
C2- Vertical transport problems including pumping and placing concrete, movement of operatives and materials	6	5	5	6	22.00	8.17	66.69
C3- Loss of time by traffic control and restriction	4	3	2	2	11.00	-2.83	8.03
C4- Low labor productivity and labor shortage	2	2	4	4	12.00	-1.83	3.36
C5- Shortage of engineers and specialists	5	6	6	5	22.00	8.17	66.69
C6- Changes and variation order	3	4	3	2	12.00	-1.83	3.36
<b><u>A=ΣR/n =83/6=13.83</u></b>					<b><u>ΣR=83</u></b>		S=244.83

**STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND  
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<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup>= (R-A)<sup>2</sup></b>
L1- Permit requirements.	2	1	2	1	6.00	0.00	0.00
L2- Bribery/ Corruption	1	2	1	2	6.00	0.00	0.00
<u><math>A = \sum R/n = 12/2 = 6</math></u>					<u><math>\sum R = 12</math></u>		S=0.00

<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup>= (R-A)<sup>2</sup></b>
S1- No appointed safety personnel	3	2	3	3	11.00	3.00	9.00
S2- Labor Injuries	2	1	2	1	6.00	-2.00	4.00
S3- Fire/ Theft of material and Equipment	1	3	1	2	7.00	-1.00	1.00
<u><math>A = \sum R/n = 24/3 = 8</math></u>					<u><math>\sum R = 24</math></u>		S=14

<b>Risk factors</b>	<b>Main contractor Rank</b>	<b>Sub contractor Rank</b>	<b>Consultant Rank</b>	<b>Owner Rank</b>	<b>R</b>	<b>(R-A)</b>	<b>D<sup>2</sup>= (R-A)<sup>2</sup></b>
P1 – Late material Procurement	1	1	1	1	4.00	-8.00	64.00
P2- Defective material supply and price escalation	5	5	5	4	19.00	7.00	49.00
P3 Unavailability of material, labor and Equipment	3	3	4	3	13.00	1.00	1.00
P4- Utility service delay	4	4	2	5	15.00	3.00	9.00
P5- Importation, customs and visa issues	2	2	3	2	9.00	-3.00	9.00
<u><math>A = \sum R/n = 60/5 = 12</math></u>					<u><math>\sum R = 60</math></u>		S=132

**STUDY OF THE IMPACT OF HIGH RISE BUILDING CONSTRUCTION RISK FACTORS ON SELECTED SITES AROUND ADDIS ABABA: A CASE STUDY**

**Appendix (H): - Critical value of chi square**

df	0.250	0.100	0.050	0.025	0.010	0.005	0.001
1	1.32330	2.70554	3.84146	5.02389	6.63490	7.87944	10.828
2	2.77239	4.60517	5.99147	7.37776	9.21034	10.5966	13.816
3	4.10835	6.25139	7.81473	9.34840	11.3449	12.8381	16.266
4	5.38527	7.77944	9.48773	11.1433	13.2767	14.8602	18.467
5	6.62568	9.23635	11.0705	12.8325	15.0863	16.7496	20.515
6	7.84080	10.6446	12.5916	14.4494	16.8119	18.5476	22.458
7	9.03715	12.0170	14.0671	16.0128	18.4753	20.2777	24.322
8	10.2188	13.3616	15.5073	17.5346	20.0902	21.9550	26.125
9	11.3887	14.6837	16.9190	19.0228	21.6660	23.5893	27.877
10	12.5489	15.9871	18.3070	20.4831	23.2093	25.1882	29.588
11	13.7007	17.2750	19.6751	21.9200	24.7250	26.7569	31.264
12	14.8454	18.5494	21.0261	23.3367	26.2170	28.2995	32.909
13	15.9839	19.8119	22.3621	24.7356	27.6883	29.8194	34.528
14	17.1770	21.0642	23.6848	26.1190	29.1413	31.3193	36.123
15	18.2451	22.3072	24.9958	27.4884	30.5779	32.8013	37.697
16	19.3688	23.5418	26.2962	28.8454	31.9999	34.2672	39.252
17	20.4887	24.7690	27.5871	30.1910	33.4087	35.7185	40.790
18	21.6049	25.9894	28.8693	31.5264	34.8053	37.1564	42.312
19	22.7178	27.2036	30.1435	32.8523	36.1908	38.5822	43.820
20	23.8277	28.4120	31.4104	34.1696	37.5662	39.9968	45.315
21	24.9348	29.6151	32.6705	35.4789	38.9321	41.4010	46.797
22	26.0393	30.8133	33.9244	36.7807	40.2894	42.7956	48.268
23	27.1413	32.0069	35.1725	38.0757	41.6384	44.1813	49.728
24	28.2412	33.1963	36.4151	39.3641	42.9798	45.5585	51.179
25	29.3389	34.3816	37.6525	40.6465	44.3141	46.9278	52.620
26	30.4345	35.5631	38.8852	41.9232	45.6417	48.2899	54.052
27	31.5284	36.7412	40.1133	43.1944	46.9630	49.6449	55.476
28	32.6205	37.9159	41.3372	44.4607	48.2782	50.9933	56.892
29	33.7109	39.0875	42.5569	45.7222	49.5879	52.3356	58.302
30	34.7998	40.2560	43.7729	46.9792	50.8922	53.6720	59.703
40	45.6160	51.8050	65.7585	59.3417	63.6907	66.7659	73.402
50	56.3336	63.1671	67.5048	71.4202	76.1539	79.4900	86.661
60	66.9814	74.3970	79.0819	83.2976	88.3794	91.9517	99.607
70	77.5766	85.5271	90.5312	95.0231	100.425	104.215	112.317
80	88.1303	96.5782	101.879	106.629	112.329	116.321	124.839
90	98.6499	107.565	113.145	118.136	124.116	128.299	137.208
100	109.141	118.498	124.342	129.561	135.807	140.169	149.449