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RISK ANALYSIS FOR SELECTED BUILDING PROJECTS IN ADDIS ABABA

A Thesis submitted to School of Graduate Studies of Addis Ababa University in partial fulfillment of the requirements of the Degree of Master of Science in Civil Engineering (Construction Technology and Management)

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LIST ABBREVIATIONS

AACE	Association for the Advancement of Cost Engineering
CII	Construction Industry Institute
EV	Expected Value
ERA	Estimating using Risk Analysis
MCS	Monte Carlo Simulation
PMBoK Guide	A Guide to the Project Management Book of Knowledge
RM	Risk Management
SVM	Support Vector Machine

ABSTRACT

Construction is a risk prone industry. Occurrence of risks in construction could affect project objectives negatively. Involvement of risk management plan and process is the best possible way to exist in this hasty environment. This is because analysis of risks gives better understanding of risks and the resulting impact of the risks, if they occur. This enables the project management team to have a better estimate of the impacts of risks. The estimated project cost is the sum of the baseline cost and an allowance to handle the cost impact of risks (i.e. contingency). Having a realistic estimate of this allowance would mean better estimate of project cost.

The research aims to review the risk management and contingency allocation practices at selected building constructions in Addis Ababa. A structured questionnaire served as a research instrument.

The study revealed that most contractors do not practice risk management because of lack of awareness of its importance for effective project management. This finding shades light on the need of development in the structure to be used as an input for the processes of risk management for when the need arises. The study deduced development of inputs to the processes of risk management requires understanding of the perception of the individuals involved in risk management team and in general of the respective organization.

The scope of this study also includes a demonstration of risk analysis for a case study that could be a guide to the use of the developed inputs and existing methods.

Key words: Contingency, Risk, Risk analysis, Risk management.

Chapter 1. INTRODUCTION

1.1. Background to the Research

Construction project comes into existence under the umbrella of the contract agreement made by the acting parties. Satisfaction of the parties involved, especially the owner, is vital with respect to achieving the objectives of the contract. The objectives of a construction project include ensuring that the work is carried out to the desired quality, within allowed time and budget. Management of construction project involves planning and estimating cost to ensure the realization of the objectives. In addition, the process of managing construction projects involves making decisions under variable conditions which encompasses uncertainty.

Uncertainty is the result of the gap between the information already possessed and information required to estimate an output by decision makers. Uncertainties and variations, ranging from change of mind by one of the parties involved to unforeseen occurrences, have been found to be inevitable in a construction project. It is therefore evident that for the proper execution of a project it is essential to quantify these measurable uncertainties or risks for their appropriate management.

Risk management, in short, involves identifying, analyzing and planning the appropriate response. Allocating a contingency is one way of responding to the measurable effect of the recognized risks. In a construction project, contingency is the budget that is set aside to cope with uncertainties during construction. The effectiveness of this contingency sum is dependent on the adequacy of consideration given to those factors that are responsible for the changes in plan. Any realistic contingency must serve as a basis for decision making concerning financial viability of the variations, and a baseline for their control [1].

Apart from its vast use and importance in many cases, risk management is not considered as a specific task, and generally goes undocumented. This gap along with lack of record from previous projects makes it difficult for managers to use historical data [2].

Most projects have experienced increase in cost resulting from persistent cost estimation and traditional conservative deterministic approach in estimating cost contingency [3]. This fact points out that cost overrun could be related to poor contingency planning and cost management. Hence, a sound cost base line and cost budgeting following a good risk assessment and analysis results in a coherent cost control mechanism [4].

The existence of such a relationship between risk management and project objective realization brought up the interest to pursue this research, study the practice of risk management in selected building construction projects in Addis Ababa.

1.2. Statement of the Problem

Risk management plays a vital role in understanding and managing the uncertainties faced in construction projects. Of the steps involved in risk management, the response provision step performs planning for responses to best manage risks whose materialization results significant effect on project objectives. Retaining the consequence of risk is one way of response which requires estimating the value of the impact on project objectives. The reserve put aside or considered to handle the cumulative impact of the critical risks is what we call contingency. A study carried out on Ethiopian federal road construction projects reported that contingency allowance was estimated as an arbitrary amount of the contract amount [5]. This research was then undertaken to answer the following questions:

- What method of contingency determination is practiced at building construction projects in Addis Ababa?
- How risk management is practiced in building construction projects in Addis Ababa?

1.3. Significance of the Research

At any stage of a construction project, the level of certainty of the information at hand is very important to the decision making. Being aware of the uncertainties, the risks that would result, and of the methods to best mange the risks is very vital for insuring realization of project objectives. Conducting risk analysis is helpful to determine their probability of occurrence, to allocate reasonable value for the possible impacts of important identified risk, and hence quantify the severity level each risk has on project objectives.

In this research the means by which verbal expressions of probability and impact are transformed to the numeric equivalent was developed. It can be used as guide to the process of risk identification and analysis which could be applied to building construction projects.

Using the output of risk analysis enables exhausting the best possible management solution to minimize negative effect of risk events and hence determine the project duration and project cost more confidently. Risk management is not a one-time procedure. It is a cyclic process which needs to be carried out at previously determined duration throughout the life cycle of the project. This is due to the ever changing characteristics of risk, its relation with level of information at different stages of construction project, and to insure the effectiveness of the risk management process. Practicing risk management process enables the project team to be well equipped and respond accordingly.

1.4. Objective of the Research

The general objective of this study is to review the risk management and contingency allocation practice of the construction firms that take part in building construction projects in Addis Ababa.

The specific objectives of this study are:

- To identify common risks of building construction projects and establishing a checklist to be used in the process of risk management,
- To review risk management processes,
- To assess methods of determining contingency,
- To establish scale for probability and impact of risks of building construction projects,
    - To provide a scale for probability of risk that occur.
    - To provide a scale for impact of a risk on cost of a project work package.
- To conduct a risk analysis for a case study, and
- To forward recommendations about the risk management process.

1.5. Research Methodology

The research was carried out following a four-step procedure. A structured questionnaire was designed based on the identified limitations of current literatures. The questionnaire was structured to collect information related to awareness of the concept of risk management, contingency estimation practice, checking the importance of risks identified from literature to this sector, and assessment of the understanding of impact and probability of occurrence.

Next to preparing the structured questionnaire, a pilot survey was carried out to make sure the questionnaire was going to meet its intended purpose and to understand how it was going to be interpreted by the respondents in the construction industry.

Risk analysis of a case study was then undertaken after the statistical analysis was carried out on the data collected through survey.

Finally, conclusions and recommendations are provided to improve the risk management that can be used to enhance best practices and become useful in the practical setting.

1.6. Scope and Limitations of the Study

The scope of this research is limited to building construction projects in Addis Ababa. Though risks are interactive this study is limited to assume that risk factors are independent and do not interact with each other. The scale developed is also assumed to be efficient for interpreting the probability of occurrence and impact on project cost of all risks equally.

1.7. Thesis Organization

The research report is organized into six chapters that are summarized as follows:

The first chapter introduces the research problem and the aim of the study followed by the objectives of the research. The approaches of conducting questionnaire survey and interview were selected as a means to collect data among the alternative approach.

Chapter two is a literature review from publications such as journals, books, conference proceedings. This chapter essentially provides a review of the current state of the art in construction risks management processes and construction contingency estimation methods.

Chapter three discusses the research methodology followed in order to achieve the objectives of this study.

Chapter four presents the results of the analysis of the data obtained from the questionnaire survey and the respective discussion accordingly.

In chapter five, case studies that illustrate the use of the developed checklist, probability and impact scales, prioritizing the identified risks, and conducting risk analysis.

Finally, in chapter six, conclusions and recommendations are forwarded from the major findings of the study.

Chapter 2. LITERATURE REVIEW

2.1. Introduction

Construction project is involved with a very wide environment even wider than the scope and concept of the project itself. Construction projects undergo various stages including conceptual design, preliminary design, detailed design, construction, and commissioning. At these stages in construction project life cycle decisions are made based on uncertain information, potential risk events and other various variables.

The mere fact that construction projects are unavoidably unique, works with nature and in a changing environment makes them uncertain. Hence risk cannot be avoided but it is recommended to recognize, assess and manage it. This reason brings about the essence of risk management to ensure successful project delivery. Risk management is an important project management planning and control tool which plays a vital role in improving decision-making that is active throughout the life of a project. It enables proper management of the inevitably unique and consistently changing projects. Its objective is to increase and decrease the probability and impact of positive and negative events respectively [5, 6].

The Project Management Institute presumes that all projects irrespective of their size and complexity can have a general life cycle structure involving characteristics such as risk, and uncertainty. The institute determines these characteristics to be greater at the start of the project and decreases over the life of the project as shown in Figure 2-1 [5].

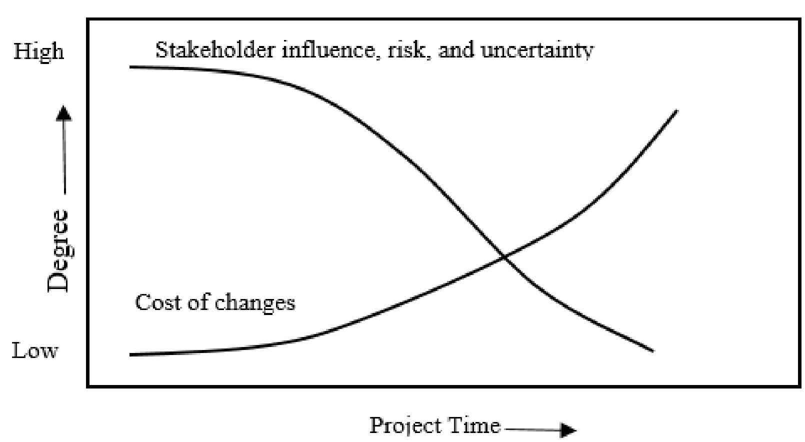


Figure 2-1: Impact of variable Vs Project time [5].

Figure 2-1 also shows the result of change along the line of the project life. It can even be linked and be used to understand the importance of the risk identification step of risk management. Assume a risk was identified incorrectly or left out at the beginning of the process, i.e. by ignoring particularly important risk, and that it was to occur at later stages of construction. If the response to this previously left out risk requires a change, this change will incur a more increased cost. The losses incurred during the implementation may be so huge that the entire construction work may not be profitable. This is because change costs more at a time far from the start of a project according to Figure 2-1.

The characteristics of the construction process, specifically uncertainties and risks, that affects countless areas of a project delivery including productivity, performance, and objectives of construction project increases with the size and the complexity of a project [7]. In addition to its' relation with size and complexity risk is defined as being magnitude dependent, time dependent and value based. The expression "greater the payoff the more the risk acceptable" is what is meant by magnitude dependent. The other behaviors of being value based and time dependent refer to the facts that everyone has different tolerance level for risk and that risk is a future event whose perception is affected by time what is a risk today may not be tomorrow [2].

The uniqueness of construction projects and the characteristics of construction makes risk management, in the construction industry, a very challenging but indispensable assignment. There is no one-for-all set of risk management structure or templet. Though each project can use the steps developed and presented by standards or recognized associations the risk management process needs to be tailor made for each. There is no guarantee that initial assumptions for the scope and use of the building will not change with the demand for the product. Because of this, focus of risk management comprises of building in flexibility and contingency, so that change is possible.

Risk analysis is a process that can be used to understand uncertainty and involves identifying risk events, quantifying those risks, and developing mitigation strategies to enhance project success. In the remaining section of the literature review, methods of risk management along with detail discussion of the steps involved, contingency, and the practice in Ethiopia are presented.

2.2. Definition

2.2.1. Risk

The following definitions are the commonly encountered sets of the numerous definitions of risk available:

- The “effect of uncertainty on objectives”. The effect can be negative or positive deviation from expected objectives. The definition emphasizes that in order to complete risk analysis the objectives, the events that could cause a deviation from achieving the defined objectives, the likelihood of occurrence of such events and their consequences must be established [8].
- “Risk is the possibility of suffering harm or loss; that something unpleasant or unwelcome will happen; a factor, thing, element, or course involving uncertain danger”. It distinguishes hazard as “a situation involving exposure to danger” [9].
- Risk is “an uncertain event or condition that if it occurs has a positive or negative impact on at least one project objective that could include scope, schedule, cost, and quality” [5].

As the sample of definitions highlight some group relates the explanation of risk with only negative effect and the other group emphasizes both the negative and positive effects of risk. The occurrence of an uncertain event could in fact result in an opportunity of positive effect. For this reason looking at risk as “an uncertain event that if it occurs would result negative or positive impact on the project objective” seems reasonable. The later definition is aimed at widening the perspective of risk management and to maximize the benefits of the project by considering the opportunity presented by uncertainty. Though the definition tries to encompass the positive effect the main focus of most risk management is still on the negative effects of uncertainty [10].

2.2.2. Threat and Opportunity

Risk can be seen as a subset or special case of uncertainty. It is actually a measure of the amount of uncertainty that exists. Risk relates primarily to the extent of one’s ability to predict a particular outcome with certainty [11, 12].

The definition which states “risk is uncertainty that matters” is not exclusively about negative or adverse impacts on achievement of objectives (i.e. threats). As discussed under 2.2.1(Risk), the effects of risk can be positive or negative. Positive effects of risk are often referred to as opportunities. Opportunities are uncertain events or sets of circumstance which, if they were to occur, would be helpful towards achieving goals of a project. Threats are specific events that drives a project in the direction of outcomes viewed as unfavorable [11]. Both threats and opportunities are types of future uncertainty differing only in the nature of their impact on project objectives.

2.2.3. Uncertainty

In distinguishing risk from uncertainty, risk can be viewed as measurable uncertainty; and uncertainty as immeasurable risk. Uncertainty is a mere intellectual curiosity and only becomes a risk when it matters. This clarifies the fact that not all uncertainty is a risk, though risk is always uncertain. Risk becomes a subset of uncertain, filtered on whether or not it matters. The definition of risk as the “subset of uncertainty that matter” tightly couples risk management to achievement of objectives, since the goal is to identify and manage any uncertainty that could affect our desired outcome [12]. Uncertainty can be broadly classified into four categories with different states of knowledge requiring different responses as discussed below in Table 2-1.

Table 2-1: Category of Uncertainity [10]

	Known	**Unknown**
Known	**1. Certainties** (project aspects known for certain, i.e, there is no doubt about them.) Examples • Location and boundary of the site. • Liaison with the local community will be essential	**3. Uncertainties the project team know about** (project aspects that are unclear, i.e. there is awareness of doubt about it) Examples • The ground conditions where boreholes have not been made. • Availability of skilled labour at the time of construction
Unknown	**2. Uncertainties that others are aware of but the project team are unaware of** (the things known by others but the project team currently have no knowledge of) Examples • Propensity of the site to flood during extreme weather events (not formally recorded, but known to local community). • Upcoming environmental legislation	**4. Uncertainties beyond current human knowledge** (the things that nobody is aware of, that no-one has ever thought of and cannot possibly know about) Examples • A previously unknown species or historical settlement is found on site. • Future adverse changes to the financial stability of a project supplier

2.2.4. Probability and Impact

Risk can be better expressed by its two characteristics i.e. probability of occurrence and an impact upon its occurrence. Probability is simply the likelihood that a risk event will occur. Whereas, impact is the result or consequence the occurring risk event has on project objectives. Impact, in simpler terms, tells you how bad or how good the realized risk is going to hurt the project [5].

The propensity for project risk depends on the project's life-cycle phase. Risks can occur at any time during the course of the project. Since the beginning of a project has lots of uncertainty, risk is most likely to occur during the initiating phase as compared to the closing phase, as it has been emphasized by Figure 2-1 (Section 2.1). This indicates that probability for risk is greatest in the early phases. As a project approaches the closing phase, since the majority of the project work is completed the probability of risk events occurring decreases.

The opposite can be said for risk impact. The impact of a risk event that materializes in the early phase of the project is lesser in comparison to the impact of a risk that would occur later in the project life cycle. The consequence or impact of a risk at starting phase is minimal because the only resource usually expended at this point is human resource assigned to plan, gather information, and talk with stakeholders. Therefore, if a risk event occurs the consequences it produces will not be as overwhelming as it would be if the risk is to eventuate at later stages [13].

The point is, the further the progress made in the project life cycle, the less likely it is for the risk event to occur, but the greater the impact to the project if the risk event does occur. These whole idea is well represented in Figure 2-2 and shows the inverse relationship of probability and impact as the project progresses through the life-cycle processes.

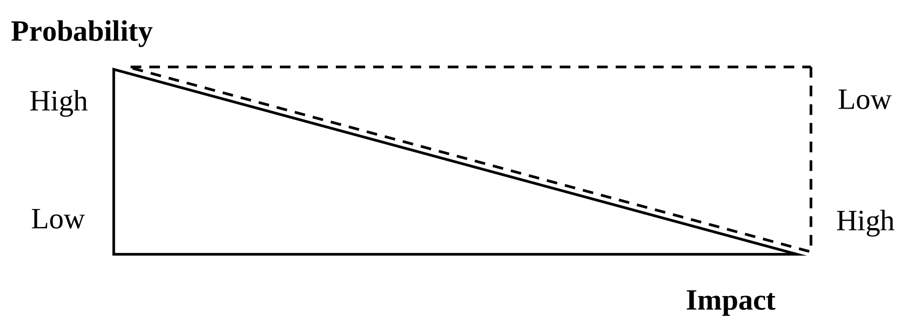


Figure 2-2: Relationship of probability and impavt Vs Project life-cycle [13]

2.3. Sources and Types of Risks

Most literatures recognize identification of the source of risk as a key element for successful risk management and hence realization of project objective. Classifying risks and taking a closer look at the categories clarifies the process of risk identification. The consideration of the relevant primary sources of risks and the subsequent detailed examination of the risks linked to each primary sources is crucial in any project. Different grounds of classification of root causes of risk have been developed by different literatures as presented by Table 2-2. There are also different way to look at risks in construction projects. Classifications considering the project phase during which it would eventuate and to which party in the project would it be a risk to can also be made. Nonetheless, many have considered the source as the most important criterion. All tried to recognize the influence of the environment on a project. The category includes causes that are from the macro or far external environment, which includes social, economic, political, environmental, and market (i.e. external). The near or operating environment has also been identified as root cause of risk by the group of categories. These include the technological, design, legal, financial, construction, operation which could be summarized under technical, organizational and project management. The cause of construction project risk can clearly be classified as technical, external, organizational, and those resulting from project management.

These risks can be grouped at a higher level in the breakdown structure, using the concept of environment layers, in search of the advantage of reducing the numbers of classes and facilitating the analysis. The structures of the environment surrounding a project can be subdivided into three distinct layers as outer layer or general environment; operational environment; and inner layer or internal environment [14].

Table 2-2: Types of primary risk categories [5, 14, 15, 16]

Ayyub (2003)	Akintoye (1997)	Daniel B. (2012)	Jaafari (2001)	Thompson & Perry (1992)	PMBOK (2008)
-Technological -Economic climate -Political -Contractual/ legal	-Environmental -Design -Financial -Contractual/ legal -Political -Construction -Operation	-Organizational -Global -Acts of God	-Market -Political -Technical -Financing -Environmental	-Technical -Construction -Legal -Natural -Social -Economic -Financial -Commercial -Political	-Technical -External -Organizational -Project management

The general environment contains domains that are broad in scope and have little immediate and direct impact on the project's activities. The operating environment is the external environment including factors whose impact is immediate and more specific to the project. And finally the internal environment has direct, close, and immediate impact on the project. The domains under each environmental layer are presented under Table 2-3. According to their primary source and the environmental layer project risks can also be classified as Act of God, global risk factors, and organization [14].

Table 2-3: Higher level risk classification [14]

General Environment	Operating Environment	Internal Environment
- Economic environment	- Suppliers	- Financial resource
- Political environment	- Clients	- Physical resource
- Social environment	- Sub-Contractors	- Human resource
- Technological environment	- Consultants	- Technological resource
- Physical/Natural environment	- Competitors	- Managerial value and Ethics

Determining the source and dealing with categories of risks helps in identifying risks which will then be effectively managed. But we have to be careful to meet the target of risk identification which is identifying risk and not complaints, problems, causes of risk, or effects of risk. Risk metalanguage can be used for clarifying ambiguities of differentiating risks from their causes and effects. This can be done by arranging risk statements in a three-part as follows: ‘As a result of <definite cause>, <uncertain event> may occur, which would lead to <effect on objective(s)>’ [12].

2.4. Approaches to Risk Management

It is well accepted, though it is inevitable in all project undertakings, that risk can be effectively managed to minimize its’ adverse impacts on project objectives. It is important for the construction companies to face these uncertain risks by assessing their effects on the project objectives because a quantitative risk analysis method allows deciding which project is more risky, planning for the potential sources of risk in each project, and managing each source during construction.

According to the Construction Industry Institute CII in Austin, risk management means the practice of analyzing exposures to risk of loss (loss by fortuitous or accidental means) and taking steps to minimize those potential or real losses to levels acceptable to the organization.

Risk management in the construction industry is perceived in a number of ways. The essential thing here is to create the best possible risk management system for a given entity, and to implement the system practically. This may serve as a basis for formulating tailor made risk management that would be appropriate for the specific project. Taking into account the processes involved, construction risk management in the simplest terms, is a process of identifying, analyzing, reducing and administering risk.

The increased interest to improve the ability to deal with uncertainty at the organization level has led to the development and application of different tools and techniques which are classified as risk management. The first ever published risk-related standard was Norsk Standard NS5814:1991: Krav til , but it only addresses risk analysis and does not cover other portions of the risk assessment or risk management processes. In fact, the origins of operational risk management can be traced to the discipline of safety engineering, which is mainly concerned with the physical harm that may occur as a result of improper equipment or operator performance. The field of operational risk management has grown and reached a point where the qualifier “operational” is no longer needed. A clearly distinct meaning of risk management different from financial or business risk management has been attained. This level of activity has also led to the development of a number of standards that prescribe for and advise organizations on the best way to manage their risks [17].

Several approaches to project risks management were defined in standards and guidelines issued by different literatures, which provide frameworks for managing project risks. Table 2-4 summarizes a comparison of steps involved on risk management identified by different standards and guidelines as was presented by Hillson. He pointed out two interesting facts after comparing these risk standards and guidelines. The first observation he made is that most standards lack a distinct step for implementation of agreed risk responses. And this is likely to have contributed to a common shortcoming in risk management where risk exposure is analyzed and documented but not turned into action. Subsequently the processes of risk management fails to actually manage risk. The analysis-to action link is often not made but the presence of a formal risk response implementation step is very vital.

His second observation is the lack of closure of the risk-related lessons for the benefit of future projects and the wider organization. Among the international risk standards listed, only the international standard ISO 31000:2009 mentions of the need to capture lessons though it was given a small cover. The previously mentioned approaches, identified through literature review, are all variations of the same general approach even if they have their distinctive finesses in terms of detail in the procedures. The following sections discuss about a general process of risk management [12].

Table 2-4: Mapping generic risk process to risk standards [12]

Informal Process Step	**Formal Process Step**	**APM Body of Knowledge: APM Project** Risk Analysis and Management (PRAM) Guide	**PMI PMBOK Project Risk Management: PMI Practice Standard for Project Risk Management**	**ISO31000:2009 Risk Management-Principles and Guidelines**	**OGC Management of Risk (M_o_R)**	**IRM Risk Management Standard**
Getting started	Risk process Initiation	Initiate	Plan Risk Management	Establishing the Context	Identify Context	[Organization strategic objectives]
Finding risks	Risk Identification	Identify	Identify Risks	Risk Identification	Identify Risks	Risk Identification Risk Description
Setting priorities	Qualitative Risk Assessment Quantitative Risk Analysis	Assess	Perform Qualitative Risk Analysis Perform Quantitative Risk Analysis	Risk Analysis Risk Evaluation	Assess	Risk Estimation Risk Evaluation
Deciding what to do	Risk Response Planning	Plan Responses	Plan Risk Responses	Risk Treatment	Plan	Risk Treatment
Taking action	Risk Response Implementation	Implement Responses	-		Implement	
Telling others	Risk Communication	-	Monitor & Control Risks	Communication and Consultation	Communicate	Risk Reporting
Keeping up to date	Risk Review	Manage Process		Monitoring and Review	Embed and Review	Monitoring and Review
Capturing lessons	Post-Project Review	-	-		-	-

A similar attempt of showing the generic steps involved in risk management among different standards was also made by other literatures. The comparison of processes of the six standards is presented in two separate tables (Table 2-6,Table 2-7). In each table, the rows correspond to the standards while the columns correspond to the steps. The entries in the table include numbered sections of the respective standard and related to the particular step in the process.

Table 2-5 presents list of six national or international standards that were developed or adopted by standardization bodies, and standards developed by professional organizations having an interest in risk management. In this table the standards were distinguished between two levels of standard scope, i.e. project and organization, which is related to whether the standard was meant to be implemented at the project level, or by the entire organization. But in all the cases the standards are meant for application to, projects or organizations, in any area of activity.

Table 2-5: Review of risk management standards [17]

No.	Title	Author	Scope
1	AS/NZS 4360:2004 Risk Management	Standards Australia/New Zealand	Organization
2	JIS Q2001:2001(E): Guidelines for Development and Implementation of Risk Management System	Japanese Association Standards	Organization
3	BS 6079-3:2000: Project Management Part 3: Guide to the Management of Business-related Project Risk	British Standards Institution (BSI)	Project
4	CAN/CSA-Q850-97: Risk Management: Guideline for Decision-Makers	Canadian Standards Association (CSA)	Organization
5	Project Risk Analysis & Management (PRAM) Guide, 2nd edition	Association for Project Management (APM), UK	Project
6	Guide to the Project Management Body of Knowledge (PMBoK®): Chapter11, Project Risk Management,3rd edition	Project Management Institute, USA	Project

The columns of Table 2-6 compare the way this standards address the planning step, which is the step where widest variability in terms of scope and level of detail is exhibited.

The difference extends from standards that include organization-wide issues such as establishing the risk management policy, defining roles and responsibilities at various levels, and establishing the process to be followed, at one extreme. At the other end, a more focused approach of simply planning the application of an existing risk management process to a specific project is followed.

Table 2-6: Elements of the planning step [17]

No.	Title of the Standard	Section of planning for risk management
1	**AS/NZS 4360: 2004**	4.2 Establish the context 4.2.2 Establish the internal context 4.2.3 Establish the external context 4.2.4 Establish the risk management context 4.2.5 Develop risk evaluation criteria 4.2.6 Define the structure for risk analysis
2	**JIS Q2001: 2001 (E)**	3.2 Organizational structure 3.2.1. Role of top management 3.2.2. Role of chief risk management officer 3.3 Risk management policy: 3.3.1 Announcement of the risk management policy 3.3.2 Risk management conduct guide 3.3.3 Establishment of risk management objectives
3	**BS 6079-3 2000**	4 Managing the process - Risk management policy - Organizational infrastructure - Risk management program at organizational, cross-organizational, project and sub-project levels
4	**CAN/CS- Q850-97**	4. Initiation 4.2 Defining the problem or opportunity and the associated risk issues 4.3 Identifying the risk management team 4.4 Assigning responsibility, authority and resources 4.5 Identifying potential stakeholders 4.6 Risk communication considerations
5	**PRAM**	**Initiate**: Set the scope, objectives and context for the risk management process **Organizational structure** - Planning for risk management - Responsibilities - Functional roles - Risk management and the project life cycle - Resourcing the risk management process - Resourcing risk response actions
6	**PMBoK®**	11.1 Risk management planning The process of deciding how to approach and conduct the risk management activities for a project. - **Inputs**: enterprise environmental factors; organizational process assets; project scope statement; project management plan. - **Tools and techniques:** planning meetings and analysis. - **Outputs**: Risk Management Plan (methodology; roles and responsibilities; budgeting; timing; risk categories; definitions of probability and impact; stakeholder tolerances; reporting formats; tracking

Table 2-7 is dedicated to the three central steps in the process (identification, analysis, treatment), which were addressed in basically similar manner by the standards. Most of these risk management processes have a similar framework with differences in the way of structuring the process, scopes, and kind of planning [18].

In the analysis step, there seems to be a distinction between the following two main activities:

- risk characteristics estimation: meaning an assessment of the likelihood of occurrence and possible impact/consequences of the risk events identified in the previous step in order to determine the priority for treatment; and
- risk quantification/assessment: referring to evaluation of risk by comparison with the criteria and thresholds of the decision maker.

In the risk treatment step, most of the standards mentioned set of possible actions of including avoidance, probability reduction (preventive counter-measures), and consequence limitation including recovery and contingency planning, and risk transfer, including subcontracting.

The key exceptions are PRAM and PMBoK, where equal emphasis is given to both threats and opportunities throughout the process. Consequently, the risk treatment step in these two standards includes equivalent strategies for dealing with opportunities, namely exploitation, probability enhancement, consequence improvement, including contingency planning; and risk-sharing, including joint ventures.

Table 2-7: Elements of risk identification, analysis and treatment steps [17]

No.	Title of the Standard	Identification	Analysis	Treatment
1	AS/NZS 4360:2004	4.2. Risk Identification 4.2.2. What can happen 4.2.3. How and why it can happen	4.4. Risk analysis 4.4.2. Determine existing strategies and controls 4.4.3. Consequences and probability 4.4.4. Types of analysis: a. qualitative analysis: b. semi-quantitative analysis c. quantitative analysis 4.4.5. Sensitivity analysis 4.5. Evaluate risks	4.6. Risk treatment 4.6.2 Identifying options for risk treatment 4.6.3 Assessing risk treatment options 4.6.4 Preparing and implementing treatment plans
2	JIS Q 2001: 2001	3.4.1 Risk analysis a. Risk finding b. Risk identification	3.4.1 Risk analysis c. Risk estimation (quantitative/ qualitative) 3.4.2 Risk evaluation: comparison to necessary risk criteria 3.4.3 Risk management targets	3. 4.4 Selection of risk treatments 3.4.5 Establishment of risk management program 3.5.1 Implementation of risk management program 3.5.2 Additional considerations for emergencies 3.5.3 Additional considerations for resumption 3.5.4 Operative control documentation and management of preventive measure implementation procedures
3	BS 6079-3: 2000	4.3 Risk identification and strategy 4.3.1 Risk model clarification	4. 3.2 Risk analysis 4.3.3 Risk evaluation: unacceptable threat; negligible threat; acceptable threat; critical opportunity; desirable opportunity;	4. 3.4 Risk treatment 4.3.5 Implementation

No.	Title of the Standard	Identification	Analysis	Treatment
4	CAN/CSAQ850-97	5. Preliminary analysis 5.2. Defining scope of decision(s) 5.3 Identifying hazards 5.4 Beginning stakeholder analysis 5.5 Starting risk information library	6. Risk estimation 6.2. Defining methods for estimating frequency and consequences 6.3. Estimating frequency 6.4 Estimating consequences 6.5 Refining stakeholder analysis through dialogue 7 Risk evaluation 7.2 Estimating and integrating benefits and costs 7.3 Assessing acceptability of risk to stakeholders	8. Risk control 8.2 Identifying feasible risk control options 8.3 Evaluating risk control options 8.4 Assessing stakeholder acceptance 8.5 Risk financing 8.6 Assessing stakeholder acceptance of residual risk
5	PRAM	Identify phase: • search for sources of risk and responses; • classify: suitable structure for risks and responses, aggregating/ disaggregating as appropriate; • characterize: simple label or description	Assess phase: • Structure: - Search/brainstorm/interview; - order risks and responses for discussion purposes; - distinguish specific and general responses. • Ownership: - allocate responsibility; - approve contractor allocations. • Estimate: - identify areas requiring careful decisions; - identify areas requiring more data and analysis; - estimates of likelihood and impact. • Evaluate	Planning responses phase: • plan risk event responses; • plan project risk responses
6	PMBoK®	11.2. Risk Identification	11.3. Qualitative risk analysis 11.4. Quantitative risk analysis	11.5. Risk response planning

The control step may refer to two levels of control. Control of the residual risks that remain after implementation of the treatment actions selected, or of the effectiveness of the risk management process. All the standards address the issue of monitoring and controlling the effectiveness of the risk treatment actions selected for implementation in the previous step of the process. However, not all are concerned with managing and improving the risk management process itself.

Different individual standards emphasize particular points, and present differences in meaning of key terms, are summarized in Table 2-8.

Table 2-8: Special emphasis and semantic differences in the standards [17].

No.	Title of the Standard	Special Emphasis	Semantical Differences
1	AS/NZS 4360:2004	- Entire chapter (2) devoted to embedding RM in the organization. - Lists communication and consultation (4.1) as a main element in the process. - Mention in the preface that it applies to both the management of potential gains and losses; however, no further discussion of this in the standard.	
2	JIS Q 2001: 2001	- Designed in terms of a Risk Management System, defined as the subset of the organization management system concerned with risk	- Risk planning includes analysis, prioritization, and treatment planning. - Risk analysis includes identification and estimation. - RM means monitoring and controlling the risks that were identified, analyzed and for which treatment plans were devised.
3	BS 6079-3: 2000	- Focus on link to business objectives and strategy. - Role of stakeholder analysis.	- Addresses opportunities as well as threats.
4	CAN/CSAQ850-97	- Emphasizes risk communication at all steps in the process.	- 'Risk control option' means 'an action intended to reduce the

No.	Title of the Standard	Special Emphasis	Semantical Differences
		- Emphasizes collaboration with stakeholders.	frequency and/or severity of loss.'
5	PRAM	- Includes chapters on benefits of managing risk (2), establishing an RM organization (5), behavioral aspects (6), and implementation/application issues (7).	- Addresses opportunities as well as threats. - Defines risk at two levels: risk event, as an individual uncertainty that could affect one or more project objectives; and project risk, as overall impact of uncertainty on project itself.
6	PMBoK®	- Strong process orientation (inputs/tools and techniques/outputs)	- Addresses opportunities as well as threats

The summarized information about the risk management processes presented in Table 2-6 and Table 2-7 shows that all six selected standards have so much in common. This hence suggests that there is a universal consensus about what the risk management process should cover. Most of the differences in the processes are largely attributed to variations in terminology. There are, however, some genuine and material differences among the standards, and these arise from the following sources:

- The scope of coverage of the standards is one source of variability, which was indicated in Table 2-6 between the standards. Certain standards cover mainly the risk management process and ignore establishing the organizational infrastructure needed to apply the process. They also devote little or no attention to the aspect of managing the process as an organizational asset.
- The other difference relates to the differing definitions of 'risk' (Table 2-9) among the selected standards, which can be seen in two areas. First, some standards explicitly state that risk includes both threat and opportunity, while others focus totally on threats, or are ambiguous about the type of risk. Secondly, the PRAM Guide has introduced a new concept by distinguishing between risk event and project risk, both in the terminology and in how these should be managed. Creating a common language for all risk standards was the intention behind the development of the definition guide ISO/IEC Guide 73:2002, which is a vocabulary guideline for use in risk management standards. However, currently available standards have not yet reflected its use as can be seen from the six standards reviewed.

Table 2-9: Comparison of definition of risk [17].

Negative Definition	Neutral Definition	Broad Definition
CAN/CSA-Q850-97:1997: ‘the chance of injury or loss’	**AS/NZS 4360:2004:** ‘the chance of something happening that will have an impact upon objectives’	**PMBoK® 2004:** ‘an uncertain event or condition that, if it occurs, has a positive or negative effect on a project objective includes both threats to the projects objectives and opportunities to improve on those objectives.’
	BS6079-3:2000: ‘uncertainty…that can affect the prospects of achieving… goals’	**PRAM Guide 2004:** ‘an uncertain event or set of circumstances which, should it occur, will have an effect on achievement of…objectives... either positively or negatively’
	JIS Q2001 (E): ‘a combination of the probability of an event and its consequence.’	

All in all, the risk management processes agree on the basic step of identification, analysis, response, monitoring and control. Detail description of risk analysis pointing out the actual procedure as qualitative and quantitative can be seen in the steps provided by PMBOK.

I. Approach Presented by PMI.

According to the PMBOK project risk management has an objective of either increasing or decreasing the probability and impact of positive and negative events respectively. This guide expresses the processes, included in Annex B, involved in project risk management. The processes involved are planning, identification, analysis, response planning, monitoring, and control as presented by Figure 2-3. Project objectives are better addressed by this approach as compared to the approach of Construction Industry Institute (CII).

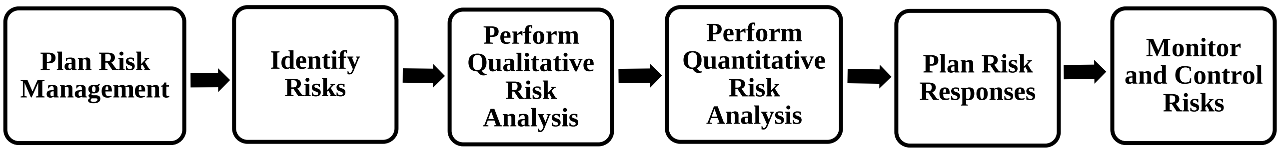


Figure 2-3: Process of project risk management

II. Approach presented by CII

Construction Industry Institute presented three levels of risk analysis which are Level 1-Risk identification; Level 2- deterministic risk analysis; and Level 3- probabilistic risk analysis as illustrated by Figure 2-4 [19].

Carrying out Level 1 and Level 2 might be sufficient at times of managing risk in small projects. But when dealing with large and more complex projects, careful review of output of Level 2 will point out the need for a probabilistic risk analysis.

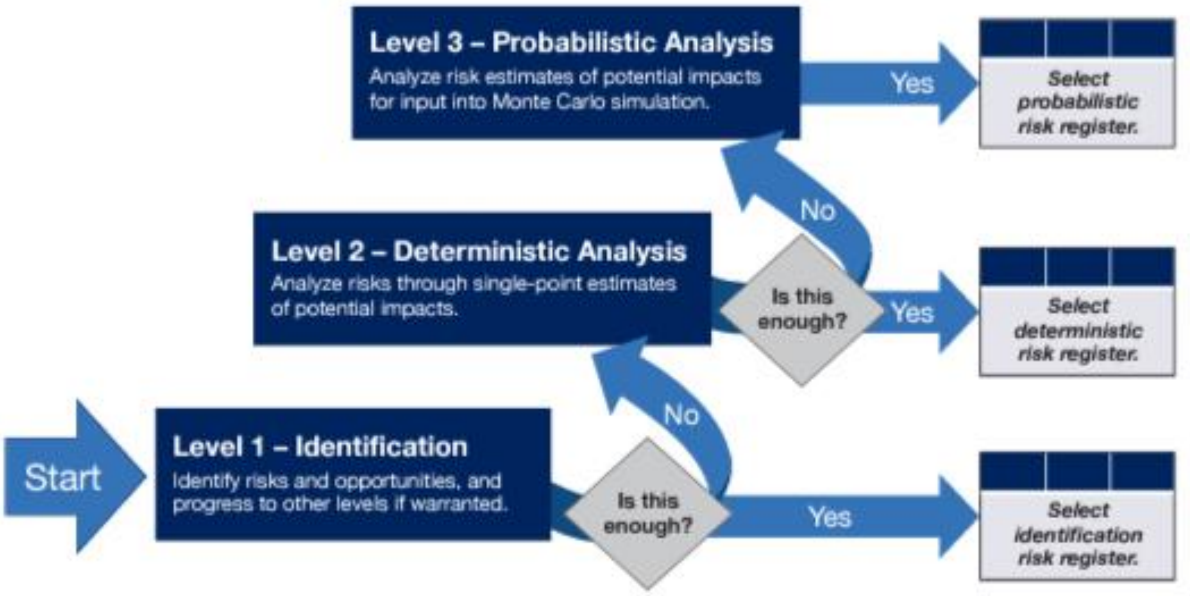


Figure 2-4: Risk Management Flow Chart [19]

It is understood among the literature that while these steps can be outlined in general as linear, it is a cyclical process that can continue to re- course throughout a project's lifespan.

The risk analysis quantification process can generally take a variety of forms. The Construction Industry Institute (CII) Implementation Resource 280-2 outlines three levels of risk analysis based on the level of quantification required. In Level 1, risk factors are identified and quantification is limited to a simplistic ranking of the importance of risks. Level 2 requires estimating probabilities and impacts of each risk factor using approximate indicators from tables. A more detailed analytical technique such as Monte Carlo simulation modeling is required in Level 3.

2.4.1. Risk Management Planning

Risk management planning is expressed as a "process defining how to conduct risk management activities for a project". During this phase, owner's objectives, scope, and risk criteria are outlined. Both the external and internal environment are considered to understand the overall project expectations.

The process of planning for risk management is concerned about deciding on the type of method to be used, assigning roles and responsibilities, budgeting, timing, risk categories, defining probability and impact scales, establish or revise stakeholder's risk tolerances, defining how the output will be documented [5, 19].

2.4.2. Risk Identification

Risk identification is about determining which risks may affect the project and documenting their characteristics. As new risks may evolve or become known as the project progresses through its life cycle the identification undertaking is iterative.

Some of the common information gathering techniques include brainstorming, interviewing, using standard checklists, and Delphi technique. One could start with reviewing documentations of previous similar projects to identify project risks. Analysis of document of historical information and knowledge accumulated from previous similar projects in form of a checklist and analysis of assumptions could also be implemented to identify project risks.

2.4.3. Qualitative Risk Analysis

It is a process of prioritizing risks for further analysis or direct mitigation action by assessing and combining their probability of occurrence and impact. This process assesses the priority of identified risks by considering their relative probability or likelihood of occurrence and the corresponding impact on project objectives if the risks occur. This process provides a rapid and cost-effective means of establishing and prioritizing risks for further implementation of risk response and lay the foundation for quantitative risk analysis. Inadequate attention is given to the ability to assess probability distributions for tasks.

Probability and impact assessment of the identified risks could be conducted by interviewing or meeting with participants that are familiar with the type of project and risk categories. In this stage, the likelihood and impact of risks are examined in terms of linguistic expressions and the risks are categorized based on the assed impact [2, 5, 20].

Probability and impact risk scales are assigned not only using expressions of High, Medium and Low values. Numeric values are assigned for respective linguistic expressions so that the overall risk score can be calculated. Risk probability and impacts are rated according to the definitions given by probability and impact scales, similar to the one presented in Table 2-10.It has been noted that inadequate attention is given to the ability to assess probability distributions for tasks [21]. It calls for a little more subjectivity to determine the ranking scale. For very small projects, the three point scale would work fine. But when one get into more complex projects using the five-point scale could be considered.

Table 2-10: Likelihood/ Probability scale [2]

No.	Expression	Probability
1	Highly likely	Over 70%
2	Likely	50-70%
3	Somewhat likely	15-50%
4	Unlikely	1-15
5	Very unlikely	0.01-1
6	Extremely unlikely	Less than 0.01

With the help of probability and impact matrix, such as the one presented in Figure 2-5, evaluation of each risk's importance and hence its priority for attention can be evaluated. The higher the number in the matrix the higher the risk that event presents to the project. The scale for probability and impact could be developed for a particular project or at organization level depending the risk attitude of the organization or project. The rating rules of the matrix would be set in advance by the organization so that further quantitative analysis is undertaken depending on their position in the matrix. The rating category is best shown by filling cells containing numbers with in one rating range with similar color. For example, Figure 2-5 was filled by three different colors where green represent low risks, yellow representing medium risks, and red representing high risks.

Qualitative risk analysis should be revisited during the project's life cycle to stay current with changes of the risks in the project. This is the most common and probably the easiest method for analyzing risks for small-to-medium-sized projects.

Probability					
0.90	0.05	0.09	0.18	0.36	0.72
0.70	0.04	0.07	0.14	0.28	0.56
0.50	0.03	0.05	0.10	0.20	0.40
0.30	0.02	0.03	0.06	0.12	0.24
0.10	0.01	0.01	0.02	0.04	0.08
	0.05	**0.10**	**0.20**	**0.40**	**0.80**

Impact (number of scale) on an objective

Figure 2-5: Probability and impact matrix [5]

2.4.3.1. Methods of Qualitative Analysis

There are several methods for performing qualitative risk analysis such as brainstorming, interviewing, Delphi technique, review of historical data, SWOT analysis [5].

a. Document Review

A review performed on project documentation, including plans, assumptions, previous project files, contracts, and other information. Historical data gained from previous projects record can be used as one method of risk identification. The quality of plans and consistency of the plans and the project requirements and assumptions can be indicators of risk in the project.

b. Information Gathering Techniques

- Brainstorming: The project team along with multidisciplinary set of experts usually performs brainstorming to gain a comprehensive list of project risks. A traditional free-form brainstorm session with ideas contributed by participants, or structured using mass interviewing techniques (nominal group technique) can be applied to generate ideas about project risk under the leadership of a facilitator. This method of risk identification is usually used since face to face interactions are needed to encourage open communication [5, 22].
- Interview: interviewing experienced project participants, stakeholders, and subject matter experts can identify risks.
- Delphi technique: Here a facilitator distributes a questionnaire to experts, responses are summarized (anonymously) and re-circulated among the experts for comments. This technique is used to achieve a consensus of experts and helps to receive unbiased data, ensuring that no one person will have undue influence on the outcome.

c. Checklist Analysis: this method considers examination of checklist of risk items developed based on historical information accumulated from previous similar projects, for performing a risk analysis.

d. Diagrammatic Technique: may include cause and effect diagrams, system or process flow charts, and influence diagrams.

2.4.4. Quantitative Risk Analysis

The result of qualitative risk analysis could indicate the need for carrying out quantitative risk analysis or going directly into risk response. Quantitative risk analysis is the "process of numerically analyzing the effect of identified and prioritized risks on overall project objectives" [5]. It may be used to assign a numerical rating to those prioritized risks individually or to evaluate the aggregate effect of all risks affecting the project.

After gathering the necessary data, interviewing technique focusing on experience and historical data or facilitated workshop can be used to quantify the probability and impact of risks on project objectives. Then depending on the type of information gathered, one of the different probability distribution techniques could be implemented to represent the data.

Quantitative risk analysis models simply represent risk factors in a model with each risk modeled with (1) a probability of occurrence and (2) an impact upon its occurrence. The proper conduct of this requires proper understanding and determination of the 'likelihood' and 'impact' of the occurring risk. Risk can be characterized in terms of its severity which can be defined as product of probability and impact scores of a given risk [2, 23]. In this step of risk management, probability and impact values will be assigned to the verbal expressions determined in the qualitative analysis in order to determine the magnitude of severity of risk.

Once a simulation is complete, the project cost (and/or schedule) is represented with a distribution. The decision maker can then uses this distribution to determine the project budget by accepting a certain amount of risk. Using the out puts of quantitative risk analysis decision makers are able to see the direct application of risk management to their work including gaining results in terms of monetary values and schedule which could affect the project.

As it has been mentioned in the previous sections, probability and impact are often defined in qualitative terms and then converted to numerical values for simulation. The group of individuals involved in this process will choose the term they feel expresses the probability of the risk factor considered very well. Not all individuals will not have the same understanding about the terms presented [24]. This makes it clear that the process of risk analysis is subjective in nature.

2.4.4.1.Methods for Quantitative Risk Analysis

The purpose of any risk analysis technique is to determine the impact of the risk on the project. It gives a means to control the risk and determine if a response plan is needed instead of allowing risks to spark forest fires on their own during the project. It is most definitely worth once time and effort to perform this important step [13].

There are a great deal of risk analysis techniques. Some of which include sensitivity analysis, decision tree analysis, and Monte Carlo simulation. The purpose of any risk analysis technique is to determine the impact the risk has on the project. It gives a means to control the risk and determine if a response plan is needed instead of allowing risks to spark forest fires on their own during the project. It is most definitely worth once time and effort to perform this important step [13].

Several factors need to be considered prior to selecting a specific analysis technique for a particular condition. Of the factors considered effectiveness of a specific analysis techniques to capture the inherent uncertainty is of paramount importance. On the contrary, the selection of a specific modeling and analysis technique is governed by factors such as familiarity, simplicity and availability [14].

a. Modeling and Simulation

Risk analysis could be carried out using appropriate methods and tools, including risk simulation. Monte Carlo simulation is the most common simulation technique that makes use of probability distributions in place of deterministic values in order to model the uncertainty associated with a particular input and the possible outcomes that can occur. It uses a model that translates the specified detailed uncertainties of the project into their potential impact on project objectives.

Monte Carlo analysis typically examines schedule and cost risks both individually and from the perspective of the whole project. This analysis is performed by plugging in schedule and cost variables for each of the work packages from the work breakdown structure (WBS). Several variables may be used, including the pessimistic, most likely, and optimistic values or the mean and standard deviations. Monte Carlo then simulates potential outcomes of the project over and over using the range of variables. This analysis takes randomly sampled values using probability distributions of cost and duration as an input. The outcome of this technique produces a reasonable range of schedule dates and costs for the project. It also shows at a glance what the impact of each of the variables is on the project as a whole.

A simulation uses cost estimates for a cost risk analysis and a schedule network diagram and duration estimates for schedule risk analysis. Since a component is randomly selected from its defined probability distribution (e.g. cost or schedule distribution) the more the iterations run the more realistic the resulting distribution will be. The outcome from each iteration is recorded and the combined results are used to estimate the overall project total cost or completion date in the form of a probability distribution. The output from a cost and schedule risk simulation gives respective likelihood of achieving specific cost and schedule targets. [5, 25]

b. Decision Tree Analysis

Decision tree analysis is an analysis method that shows the sequence of interrelated possible decisions and the expected results of choosing one alternative over another using graphical model. It is usually used for risk events that impact time or cost.

There may usually be more than one choice when faced with a risk event or a decision. Each possible decision is mapped in a tree form starting at the left, with the risk event and branches out to the right with possible outcomes. [5]

A sample decision tree with the probability of two outcomes of Choice A and Choice B for the same risk event is shown in Figure 2-6. The cost impact of Choice A and Choice B is 7,000 ETB and 6,000

ETB respectively. Looking at these figures only one would be tempted to go for Choice B. This analysis could be interpreted a couple of ways depending on the target objective. If the aim is maximizing return while minimizing potential loss selecting Choice A will be the best decision. This is because it enable more investment to be recovered and less lose will be felted if the outcome is not so good. However, if the objective was simply to minimize loss, one would choose Choice A since the probability of a bad outcome is less than that of Choice B.

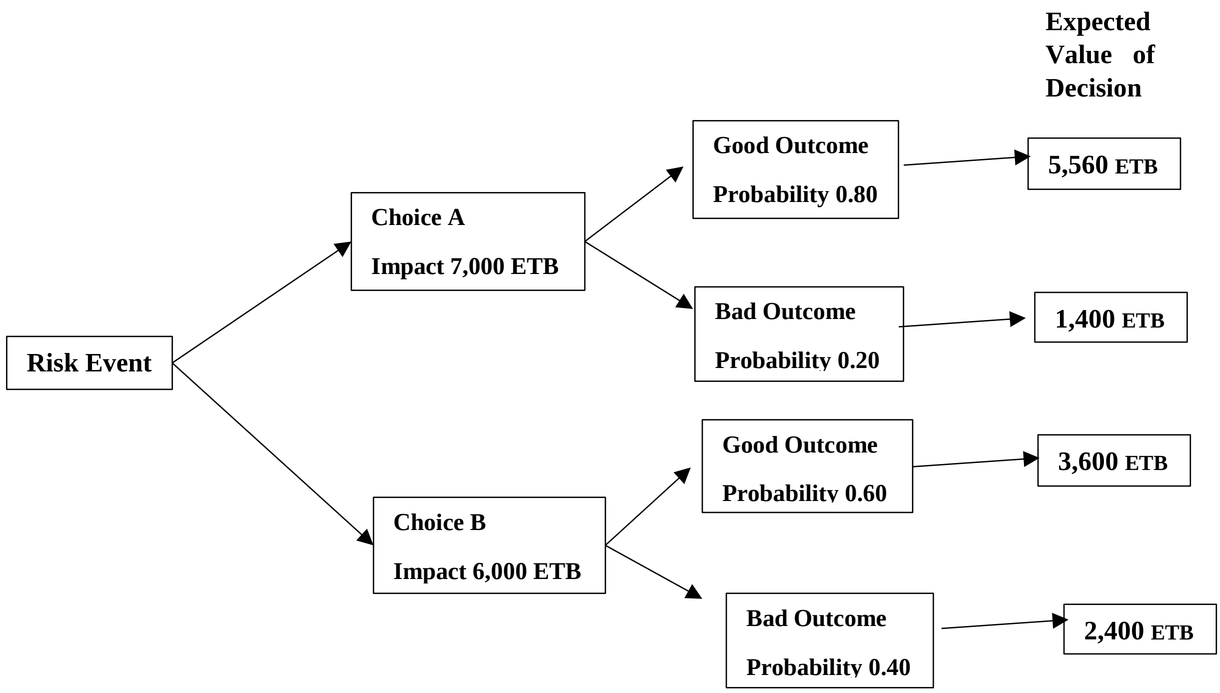


Figure 2-6: Sample decision tree [5]

c. Sensitivity Analysis

Sensitivity analysis is a means of testing what small change to one of variables result an unbalanced effect [26]. A modeling technique that determines which risk event (or events) has the greatest potential for impact. It is primarily concerned with risk events that impact time, cost, or anticipated project revenues but can be used for any risk event.

A range of variation for each of the impacts including levels of acceptance must be established. The effect of the risk event is assessed across this range. The higher the level of uncertainty about the risk, the more sensitive it is. And the most sensitive variables (usually those most critical to the project) are the ones that require risk response plans.

2.4.5. Risk Response Planning

This process involves the development of actions that will reduce threats and enhance opportunities of project objectives. It includes the identification and assignment of a responsibility of each agreed-to and funded risk response.

High and moderate risks are addressed using agreed upon and detail appropriate responses. A watch-list is developed for low priority risks to assist periodic monitoring and insure that their status has not changed. Appropriate risk treatment strategies are formulated after evaluating the risks based on their financial impact or as a response to the effects of risk on project objectives. Some of the risk treatment strategies within the framework of risk management are discussed.

a. **Risk avoidance:** involves changing the project management plan to eliminate the treat entirely if the risk is intolerable and no other means can be undertaken to mitigate its damages. The project management may also isolate the project objectives from the risk's impact, change the objective that is in jeopardy, changing the project scope, doing the project in a different way or even shut down the project entirely. Risk which results due to lack of knowledge can be eliminated by obtaining information, improving communication, and acquiring expertise [27].

b. **Risk Transfer:** requires shifting some or all of the negative impact of a threat, along with ownership of the response, to a third party. Transferring the risk does not eliminate it at all but simply gives the responsibility of its management to another party.

   Transferring liability of risk is most effective in dealing with financial risk exposure. Transference tools are quite diverse and includes the use of insurance, performance bonds, warranties, guarantees, etc. Risk transferring through insurance always involves payment of a risk premium to the insurance provider. Insurance may be seen as a means of response against adverse impacts by spreading the financial loss of the insured over the whole of the insuring community [28]. However, insurance only shifts the potential financial consequence of the risk event to a third party. But transferring risk can turn out to be expensive if the risks are managed by those who are inexperienced, or who do not have the influence to reduce its impact or probability [26].

   Contract may also be used to share or transfer liability for specified risks to another party. Risk transfer through the use of contract can be looked at in different ways. That is in relation to the use of the contract clauses and provision, using different project delivery mechanism, and contact types. Risks cannot be eliminated through procurement but contractual arrangement can greatly influence how risks are managed. Figure 2-7 provides a simplified view of the balance of risk according to the procurement strategy chosen [26, 29].

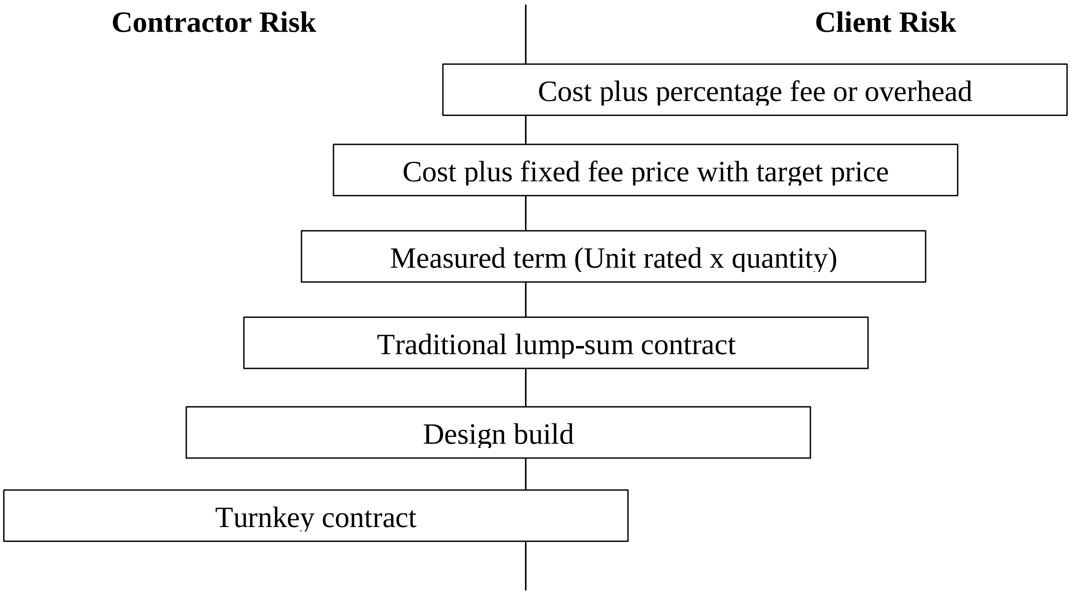


Figure 2-7: Procurement and the allocation of risk [26]

c. Risk Reduction: is expressed as "a reduction in the probability and/or impact of an adverse risk event to be within acceptable threshold limits" by taking actions such as obtaining more information [5]. Taking preventive mitigation strategies to reduce the probability and/or impact of a risk are often more effective than reactive mitigation strategies. The reactive mitigation strategies try to repair the damage after the risk has occurred [5, 27]. Risk mitigation is the most commonly employed response strategy to deal with project risks. However, this type of strategy handles particular causes of the risk and it is almost impossible to come up with exhaustive list of mitigation alternatives. Moreover, new set of secondary risks might be encountered by implementing different mitigation strategies [27].

d. Risk Acceptance: This strategy is adopted because it is seldom possible to eliminate all threats from a project. This strategy adapted:

(i) when the project team has decided not to change the project management plan to deal with a risk,

(ii) when is not possible to identify any other suitable response strategy,

(iii) to handle risks that remain after avoidance, transfer, or mitigation responses have been taken,

(iv) to handle risks whose probability of occurrence and/or impact are lower than the acceptable level.

This strategy can be either passive or active. Passive acceptance requires no action and the risks will be dealt with when they occur. Estimating a contingency reserve, which is like establishing fallback plans, is the most common active acceptance strategy. The strategy that will be used as a reaction to a risk that has occurred includes reserves as amounts of time, money, or resources to handle the risks [27].

Implementation of a risk response is definitely going to change the risk profile of the project. The response is designed to improve the situation, but this might not always be the case. Risk response implementation may at times introduce more risk into the project than it removes. Primary response may proves to be inadequate in completely removing the risk. Risks that arise as a direct result of implementing a response are termed secondary or residual risks. Figure 2-8 further clarifies the fact that the process of risk analysis and response will not completely remove all risks. This perspective to risk management elaborates that planning, analyzing, and forwarding response needs to be carried out to the residual risks the same way as primary risks. The project team should determine whether the risk position after implementation of a response is better or worse than it was beforehand [27].

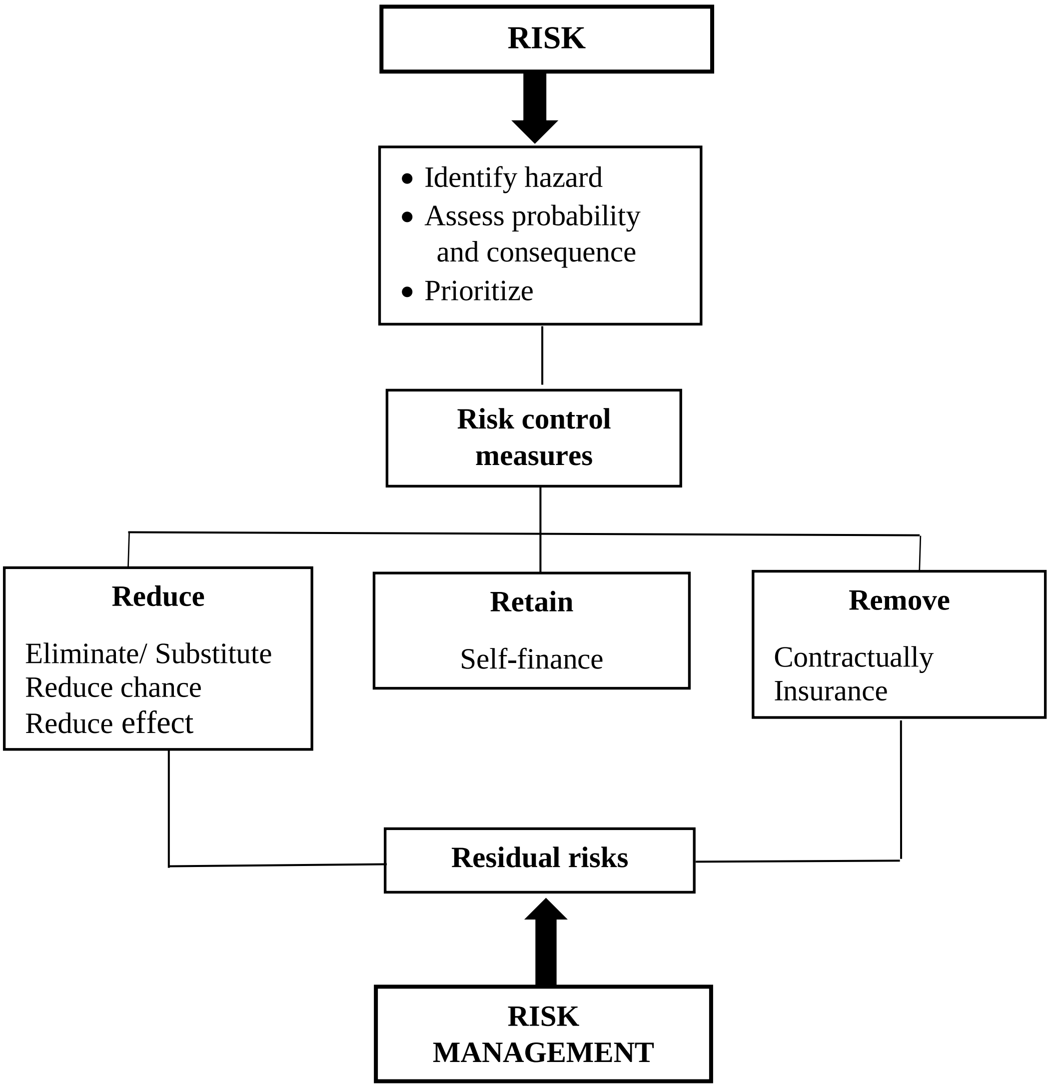


Figure 2-8: Risk management-Residul risks [29]

2.4.6. Risk Monitoring and Control

Monitoring and controlling risks, is the process of keeping track of identified risks, monitoring implementation of risk response as planned, monitoring residual risks, and identifying new risks. It also involves keeping a close look of the risks on the watch-list and evaluating the effectiveness of response actions in reducing threats and enhancing opportunities throughout the project.

This process is conducted to check the validity of project assumptions, whether the status of assessed risk has changed or has the risk retired, whether risk management policies and procedures are being followed, and if contingency reserves of cost or schedule should be modified in alignment with the current risk assessment. It often results in identification of new risks, reassessment of current risks, and the closing of risks that are outdated. It can also involve choosing alternative strategies, executing a contingency or fallback plan, taking corrective action, and modifying the project management plan [5].

2.5. Estimation of Project Duration

Construction projects are hardly ever constructed as designed. The current practice for modeling the resulted change is organizing as built drawings and project schedules updated consistently. The change to design would impact both cost and time of a project [30].

Use of an integrated approach to project management, whose proposed model diagram is presented in Figure 2-9 , considers cost estimation and control plus planning and time control [31].

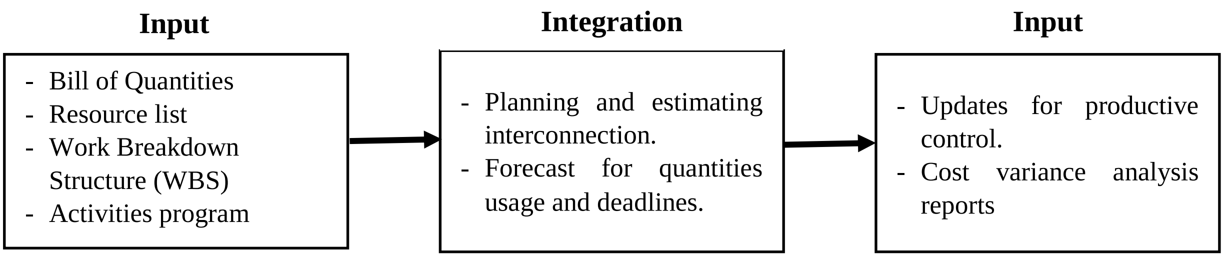


Figure 2-9: Proposed Model Diagram [31]

This approach of integration create a dynamic interconnection between time and cost. Thus, any change in the activity program will affect the time element resulting change in the previous forecast. Construction planning seem to rely on deterministic scheduling method despite the high level of uncertainty and risk involved. However, to cope with the uncertainties involved in construction projects, a probabilistic duration estimation model needs to be developed [32].

In the consideration of regression model for the modified project duration factors such as project type, project area, estimating project price, and estimated project duration are identified as dependent variables [30].

Bromilow's "time-cost" model, expressed by Equation 1, is based on the relation between construction price and time [33]. Converting this equation into its linear form allows the use of simple statistical procedure, i.e., a single linear regression. This model has been confirmed in many countries afterwards its development.

$$\mathrm{T} = K * C^{\mathrm{B}} \quad \textbf{Eq. 1}$$

Where; T= Contracted time,

C= Contracted price,

K= Model parameter that is a specific way to measure productivity because it shows the average time needed for the construction of a monetary value,

B= Model parameter that shows time dependence of cost change.

Neural networks are intelligent systems that are based on simplified computing models of the biological structure of the human brain. Neural network can work on real world data and model nonlinear functions. In a research work, project time prediction using a linear regression using "time-cost" model and neural network mode were applied to the data of contracted and real time of construction projects. The data was of 75 objects built in the Federation of Bosnia and Herzegovina. The research revealed using neural network prediction model improves the accuracy of the prediction significantly [33].

In recent years, machine learning has become a center of focus in artificial intelligence. Support vector machine is a relatively new modeling method. The support vector machine performs well on regression problems and has been proven superior to the conventional neural network method [34].

2.6. Contingency

2.6.1. Definition

The inevitable presence of risks in projects requires introduction of contingency in order possibly to mitigate their impact. Cost contingency has been defined in the following literatures as:

- An amount added to an estimate to allow for additional costs that will likely be required. This definition specifically focuses on a single project objective, i.e. cost that needs to be added on the base estimate [35].

- An essential provision required as an additional resource for management to respond to uncertainties or unexpected events [36].
- "Planning a backup, when things go differently from the original plan". It is defined as an allowance for adverse changes and generally as a monetary allowance for things beyond control [26].
- "The amount of funds, budget or time needed above the estimate to reduce the risk of overruns of project objectives to a level acceptable to the organization" [5].

The above sets of definitions show that there are two different perceptions about contingency. The first one only considers it as a monetary allowance. Whereas the second group looks at it as additional resource to be used for managing uncertainties.

Contingency reserves are estimation and planning to account both for known risks and for those that are unknown currently [5, 27]. It could in the form of an amount of time, money or resource. A distinction between two types of contingencies has been made. For defined risks (known unknowns) contingency takes the form of a risk budget with the size determined by the impact of the risk. Whereas unforeseen risks (unknown unknowns) are covered by "true contingency" which reflects the amount of residual uncertainty in the project [27].

Contingency in practice can also be understood in different ways based on the perceptions held by parties involved in construction project. For instance, the owner may view contingency as a fund available to address risks and uncertainties that may arise in realization of the project; the consultant may consider it as an extra fund for covering underestimation, lack of definitions, design errors, or change orders; whereas the contractor may consider contingency as a potential fund for additional profit .

Furthermore, literatures also make a clear distinction between contingency reserve and management reserve [5, 37]. Contingency reserve is an element of a projects' cost that is included to allow for the unknowns and to ensure project completion within the budget. To take care of "unplanned but potentially required changes that can result from realized risks identified in the risk register".

An amount of the total allocated budget withheld for management control purposes to enhance performance is a management reserve. It is explained as reserved budgets for "unplanned changes to project scope and cost". Such a reserve is not part of the project cost baseline, but may be included in the total budget for the project.

A study conducted to identify the challenges cost contingency estimation revealed "five out of eight most significant factors affecting cost contingency are result of poor design and scope definition. These factors include differing site condition, design completeness and status, changes in scope, incomplete scope definition, and change in specification" [4].

As a part of a project's cost estimate, contingency under estimation or over estimation can lead approval of a project that should be rejected, rejection of a project that should be accepted, or misallocate resources during the project implementation.

2.6.2. Types of Contingency

Contingency is categorized into different types based on various criteria. The ground for classification of contingency could be nature of the resource, project stage, or type of risk. According to the classification based on the type of resource, contingency can be regarded as time contingency, cost contingency, capacity contingency (manpower, tools, equipment), and material contingency [38]. Contingency is also classified into two major types as design and construction contingency based on the stage in project life [39]. In a somewhat similar manner, i.e. based on the stage of design contingency, contingency is classified as designer and contractor contingency [40]. Designer contingency is an allowance for potential cost increases that occur through the detail design phase of a construction project. Whereas, contractor contingency is included to cover unexpected events that may occur during actual construction work. It is evident that designer contingency is similar to design contingency and construction contingency to that of contractor contingency. Based on the type of risk, project contingency can be distinguished into two components as allocated and unallocated contingency [41]. Allocated contingency, which is also known as risk budget, is set for identified risks by determining their impact of on project objectives. Unallocated contingency is assigned for unforeseen risks of a project.

2.6.3. Contingency Estimation

The budget of a project to represent the total project financial commitment cost contingency has to be included (i.e. total project cost is the sum of cost baseline estimate plus cost contingency). The fact that project cost overruns are common happening in construction projects made estimation of cost contingency of ultimate adequacy and be of critical importance to projects.

Table 2-11 presents few of the range estimating methods available for calculating project cost contingency. Once contingency has been estimated it is added to the contract sum to represent the predicted final cost of the project for the sponsor. The accuracy of the contingency can be measured by comparing the predicted final cost against the actual final cost.

Table 2-11 : Contingency estimating methods [37]

No.	Contingency Estimating Methods
1	Traditional percentage
2	Monte Carlo simulation
3	Range Estimating
4	Fuzzy Sets
5	Individual risks-expected value
6	Influence Diagrams
7	Theory of constraints

The methods used for contingency estimation are generally divided into deterministic and probabilistic classes. But lately fuzzy systems and the hybrid methods, which a product of combined use of any two or more approaches, have also immerged into picture.

a. Traditional percentage

The deterministic methods, most traditionally employed, involves a simple assignment of a percentage contingency based upon the estimate of project cost or based upon components of project cost. This method has been referred to as “Crystal Ball” and “across-the-board” percentage addition [42, 43]. Traditionally and more widely, this method of setting a “blanket” percentage, usually between 5% and 10% of total project cost. These percentages are typically derived from intuition, past experience and historical data, which is generally based on a subjective approach and may consider project characteristics (i.e. type of work, phase of the project, and level of scope definition). This estimating method is arbitrary and difficult to justify or defend. A percentage addition results in a single-figure prediction of estimated cost which implies a degree of certainty that is not justified [41, 44].

Allocating a contingency percentage is insufficient unless linked to a confidence level. i.e. the level of probability that the final project cost will be within the estimate including contingencies. The weaknesses of the traditional percentage addition approach for calculating contingencies has led for a search for a more robust approach as evidenced by the range of estimating methods set out in Table 2-11. A review of the practice of contingency allocation in Nigeria revealed that this method of percentage addition is the popular one in the industry. The more recent methods such as the Monte Carlo simulation and those dependent on artificial intelligence are less famous [45].

A more rational and reliable approach than the traditional overall percentage addition to the total cost, encourages close examination of each cost area. A different contingency percentage can be calculated for each major cost element, which reflects that some parts of the project may have greater uncertainty than others. Each major segment, if the estimate is classified in terms of uncertainty or accuracy then attracts its own appropriate contingency.

A review of literatures about the concept of project cost contingency found no model to represent the elements that play a part in its estimation or the measurement of the accuracy of these estimates [37].

b. Monte Carlo Simulation

Traditionally, construction cost estimates have been “point-in-time” estimates that represent a single value for the cost of a project and its elements, which can lead to miscommunication among designers, project managers, funders and decision-makers. Traditional point estimates, especially those delivered early on in the project impart a false sense of accuracy because they are not capable of describing the wide variability that can occur as risks and opportunities unfold. For many years, this limitation has been understood.

The first major “input” into a probabilistic model for construction costs (lies in the probability distributions chosen to represent the individual cost components. It is often the simple triangular distribution that is most commonly employed to the detriment of the end estimate which is believed to have gained its popularity from its simplicity. However, some literatures contended that this very simplicity is necessary precisely because the quantification of risk is often being attempted at the time in a project (the beginning) when there isn’t enough information available to more thoroughly characterize the risk.
In addition to the choice of the probability distributions chosen to represent the various cost components, another frequently-cited concern with Monte Carlo simulation is the assumption that all of the cost components or system variables are independent.

Monte Carlo simulation allows the examination of what would happen if many trials of a project were undertaken. It is a quantitative technique for analyzing risk and provides a structured way of setting the contingency value in a project cost estimate. Its’ output is a probability distribution for total cost of the project. This approach often yields a recommended contingency value of less than 5%, or zero for a well-defined project. However, for very large or strategic projects, an 80% or 90% probability level is chosen for contingency; and at a preliminary stage of a project, 95% is usually required. Many authors advocate assigning contingency so that the Base Estimate + Contingency = median point because this establishes a target for the project team where they have an equal chance of underrunning or overrunning the estimate. The US Federal Aviation Administration (FAA) uses the median (50/50) point as its budget baseline, and contingency is the different between the 50% and 80% confidence level [44].

In addition to the choice of the probability distributions chosen to represent the various cost components, another frequently-cited concern with Monte Carlo simulation is the assumption that all of the cost components or system variables are independent.

c. Individual Risks-Expected Value

Expected value is the mean of a probability distribution of a risk. The amount of contingency reserve can be based on the "expected value" for individual risk events.

In the Expected Value method, individual risks to the project are identified, along with their impact value and the probability of their occurrence. Generally, risks are classified into two broad types as fixed and variable. Fixed risks represent risks that either occur or don't (e.g. Consider a project with a system upgrade amounting to 500,000 ETB was going to be required or not, in which case the cost would be zero ETB). Variable risks are those that will occur in some degree (e.g. site remediation of some amount between 100,000 ETB and 1,000,000 ETB). For each risk, the maximum and "average" risk value is calculated with the contingency representing the sum of the average values of individual risks. This specific approach to contingency setting by Expected Value was also referred as Estimating using Risk Analysis (ERA) [46]. The accuracy of contingencies for ERA projects were found to be significantly superior to non-ERA projects with contingencies set using the traditional "Crystal Ball" method [47].

d. Method of Moments

Each cost item in an estimate is expressed by a probability distribution, reflecting the risk within the cost item. Each cost item distribution has its expected value and variance. The expected values and variances for all cost items are added to arrive at the expected value and standard deviation for the total project cost. Total project cost can be assumed to follow a normal distribution based on the central limit theorem, but only if the cost items are independent. Then, using probability tables (z scores) for a normal distribution, a contingency can be derived from the probability distribution based on a desired confidence level i.e. level of probability of total project cost not being exceeded [47].

The approach known as "Method of Moments" further extends the Expected Value approach by expanding the role of probability in the calculation of individual risks, although it falls short of the pure stochastic process like Monte Carlo simulation because it lacks the element of randomness. In this method, rather than simply calculating an 'average' and a 'maximum' value for each individual risk, each cost element is given minimum, most likely and maximum values (a triangular distribution). For each cost item, the expected value (EV) is calculated simply as an average of the maximum, most likely and minimum values. The standard deviation of the cost elements is calculated and assuming the total project cost (the sum of EV for individual cost elements) follows a normal distribution, Z scores can be used to find contingency at a given level of confidence. For example, if the "most likely" or "expected value" of a project is 20M ETB, and the calculated standard deviation (based upon the individual cost elements) is 1M ETB, then in order to have a 90% confidence interval, the contingency would have to be set so that the overall project budget is 1.3 standard deviations higher than the mean or at approximately 1.3M ETB [44, 43].

The advantage the method of moments offers is mainly the same as advantages of ERA or Expected Value approach over the traditional “Crystal Ball” method. It disaggregates contingency into a more granular format and thereby attempts to construct a more cause-and effect relationship between risk and contingency. One advantage this method has over the Expected value approach is that the final project cost is at least approximately described as a continuous probability distribution rather than as a static figure. This helps senior decision makers recognize the inherent variability of construction costs, even in the most highly specified and tightly managed project. It also helps decision-makers set contingency reserves based upon their preferred risk tolerance; rather than setting a contingency as an arbitrary percentage of construction costs [47].

e. Regression Analysis

Regression models have been used since for over three decades for estimating cost. The purpose of linear regression is to use the linear relationship between a dependent variable (e.g. estimated final cost) and independent variables (e.g. location, size) to predict or explain the behavior of the dependent variable. Multiple regression analysis is generally represented in the form: $y = a + b_1x_1 + b_2x_2 +\ldots b_nx_n.$ Where y is the total estimated cost; x_1, x_2, etc. are the measures of variables that may help estimate y; and b_1, b_2 etc. are the coefficients estimated by regression analysis. The regression equation can then be used to predict the value of a dependent variable once the values of the independent variables are inserted. This technique is also applicable to schedule-risk applications provided that the ranges determined for the critical schedule tasks do not result in a change in the critical path. Range estimating combines Monte Carlo sampling, a focus on the few critical items, and heuristics to rank critical items and opportunities [47].

f. The Hybrid method

The following method is one that combines parametric and expected value analysis. This can be done because both methods directly estimate the probable cost distribution of the impacts of each risk. To combine the methods, one simply includes the outcomes of the parametric model as the first in the expected value model. The project-specific risks are then quantified and added to the expected value model. Monte-Carlo simulation is then applied to the combined cost risk model to obtain a combined outcome probability distribution. It is important to ensure that risks are not double counted when combining methods. The objective of contingency allocation is to prevent a project from experiencing cost overrun. Cost contingency must be used for their intended purpose and not incorrectly used for poor performance [44].

2.7. Ethiopian Context

The Ethiopian construction industry has undergone different stages of development. Prior to 1968, the industry was dominated by foreign construction companies. With an aim of facilitating integration and capacity building the industry has welcomed participants from abroad to work with domestic companies. A good example to this attempt is the Ethiopian road construction industry where contractors form different foreign countries are participating.

Though it has developed in many aspects the construction industry is still leaving out the practice of formal and systematic risk management. Lack of risk management could be the reason for projects suffering not only from cost overrun and delay in completion but also project performance, development of the industry and in general the country's overall economic growth [48].

Furthermore, a desk study made on Ethiopian Federal road projects indicated that 80% of the considered sample of road projects suffered an average of 26.95% cost overrun. This study made recommendations for parties involved in Ethiopian road construction industry to improve understanding of risk and contingency allowances for covering risks. The recommendation extends to providing appropriate contingency allowances for each project based on the assessed and expected level of risk instead of arbitrary allocation, to be included in the cost estimates [49].

Ways of transferring risk to another party includes the use of contractual clauses or buying insurance coverage. A thesis done as an attempt to understand the level of use of construction contract risk management technique identifies the use clauses to manage risks. The study asserts the use of clearly placed contractual clauses to deal with risk of none or under performance of the parties and the lack of thorough identification and management of specific risks. The study further expounds list of concerned articles of the country's civil code and the general conditions of contract prepared by the Public Procurement Agency of Ethiopia (PPA 2006) as having different clauses that deal with the general risks common to most projects. The general condition of contract by the Ministry of Works and Urban Development (MoWUD) was also recognized as specifying some special risks which the contractor is not liable for [50]. This study addresses construction risks after grouping them under different areas and studying their probability of occurrence and consequence on project objectives. Financial, contractual and performance risk were identified as risk areas having highest influence on project objective.

In addition, this study revealed that most of the respondents that participated in the research work were aware of the concept of risk management where the knowledge was gained through study and training. However, the respondents evaluated their knowledge of principles of risk management as fair to medium. The author interpreted this response as parties involved, in the building construction projects, do not have enough confidence to implement their knowledge of risk management.

Now a days, the design and build type of procurement has been introduced to the road sector whose traditional method of procurement is the design-bid-build type. The contract documents of the projects are usually prepared either by the employer or by a representative based on the FIDIC general condition of contract. Consequently, the contracts will follow procedures and the risk allocation principles of FIDIC.

The same trend of arbitrary assignment of contingency as a certain traditional percentage of the total project cost is noticed in the building construction sector of Ethiopia. This gap in practice raises a call for a study in the area of systematic risk assessment and management by which a more systematic method of estimating contingency is assessed and selected.

2.8. Gap Identified in the Literature Survey

A review of the process steps described by the selected standards identified the following main steps: planning, identification, analysis, treatment and control. The review of risk management standards revealed the consensus among them about the central risk management processes. One source of gap identified in the risk management standards is the requirement of inclusion of additional elements beyond the central process. Additional required processes include elements such as communication, consultation and collaboration with stakeholders; links to the organizational objectives and strategy; guidance related to the management effectiveness. Since the inclusion of these valuable elements would enhance the value of the standard there seems to be a room for additional work to address these important issues explicitly.

Risk management is always forgotten when managing projects but the irony is that all projects have risk. Risk can never be abolished, but can only be reduced to an acceptable level by managing it. Since the occurrence of risks affects project objectives, risk management is a must for any project. It has to be adapted and active starting from the initiation phase throughout the lifecycle of a project. Risk management is neither free nor cheap. These facts makes it clear that commitment and continual management support is required to ensure project success. The project can also be monitored and reviewed to look out for further risks involvement. Organizational culture need to change and accept risk management as part of their daily work, rather than a one-time thing.

The step risk treatment of risk response planning comes next to identifying and carrying out analysis. The most common active acceptance treatment strategy is providing a contingency reserve. Cost contingency has been defined as “The amount of funds, budget or time needed above the estimate to reduce the risk of overruns of project objectives to a level acceptable to the organization" recognizing that it involves not only reserves of monetary nature but also of time, resources [5].

Traditionally, contingencies are often calculated as an across-the-board percentage addition on the base estimate, typically derived from intuition, past experience and historical data. This subjective method of contingency estimation, which is very popular, is difficult to justify or defend. The single-figure prediction of contingency implies a degree of certainty that is not justified and requires little or no investigation in decision making.

Subjective analytical methods have been developed and used to assess the impact of construction risk and uncertainty, which rely on historical information and the experiences of individuals and companies. At times of not having well organized historical data, which is the case most of the time, it all rests on the hand of the person conduction the risk management process. In addition to this, inadequate attention is given to the ability to assess probability distributions for tasks.

The process of risk management is highly dependent on the understanding and perception of the terms involved by group performing the process of risk analysis. This research address this problem and attempts to present and share the experience of a method that helps to understand the perception of professionals practicing in the building construction sector by undertaking a survey, following the practice presented in literature [25].

In the following section, Chapter 3, of this paper presents the methods and process gone through in the attempt of developing a means to transform verbal expressions of likelihood and impact to numeric equivalents (both deterministically and in terms of distributions).

Chapter 3. RESEARCH DESIGN AND METHODOLOGY

3.1. Introduction

This chapter describes all the procedures that were undertaken to achieve the objectives set for this study. The procedures that were adopted such as where and how those data were obtained are discussed. In addition, sources of data, research instruments, sample size and method of analysis are also presented. In general this chapter provides a general description of the research strategy adopted for this thesis, as well as justification of the methodology.

3.2. Research Design

The goal of this study is to create a more systematic approach to deriving data used in risk management. This survey aimed to do this by understanding certain verbal expressions in terms of their quantitative meaning.

The study was carried out using analysis of primary and secondary data. First, review of previously published relevant literature on risk management processes, the methods and application of risk analysis, measures for understanding and quantifying verbal expression, methods of estimating contingency, and Monte Carlo simulation in the construction industry is carried out.

Second, a structured questionnaire was designed based on limitations in current literatures. The structured questionnaire consists of the following sections:

- General Information: prepared to collect general information of the organizations and respondents experience and professional background.
- Basic risk management awareness: this section gathers the respondent's awareness of the concept of risk management, level of knowledge about the necessary steps for risk management, and current practice of risk management.
- Checklist verification: this section was structured to inquire the respondents to rank the probability of occurrence and impact on project cost of the list of risk factors, which was developed from reviewed literatures.
- Assessment of estimation practice: gathers information about the practice of estimating project duration, cost, and cost contingency.
- Probability of occurrence: gather data about the understanding of the respondents and create a link between verbal expressions with a quantitative value such as the term "very likely" and "90% probability of occurrence" [25].
- Impact on project cost: gather data on the respondents' understanding about impact of risk on project cost and create a link between verbal expressions with a quantitative value [25].

Next to preparation of the structured questionnaire, a pilot survey was carried out to make sure the questionnaire was going to meet its intended purpose and how it was going to be interpreted by the respondents in the construction industry.

After the statistical analysis of the results was carried out qualitative and quantitative analysis of a case study was conducted.

Finally, conclusions and recommendations that can be used to improve the risk management, enhance best practices, and become useful in the practical setting were provided.

3.3. Data Collection

3.3.1. Primary Data

The source of the primary data was in the form of interview and questionnaire, designed to gather data from contractors, consultants, and clients. The questionnaire is composed mostly of closed type of questions and includes few open type questions The survey had a primary function of assessing major risk factors in the building construction industry, the practice and understanding of risk management and contingency determination.

3.3.2. Secondary Data

A desk study on a secondary data from published text such as academics periodicals, conference proceedings, research journals, past research reports, and books was carried out as a compliment to the primary data.

3.3.3. Sampling

The focus group of this research was grade one contactors and category one and two consultants. The reason behind choosing this focus group is that the cost of the project such construction firms take under is in the range of 210 Million and above birr. It is then assumed that such firms are more involved with more complex projects than others. The importance of risk management is more pronounced when dealing with complex projects. Hence, a representative sample was taken from the group of grade one contactors in Addis Ababa using Equation 2.

$$\boldsymbol{n} = \frac{\frac{\boldsymbol{P}(\mathbf{1}-\boldsymbol{P})}{\frac{\boldsymbol{A}^{\mathbf{2}}}{\boldsymbol{Z}^{\mathbf{2}}}+\frac{\boldsymbol{P}(\mathbf{1}-\boldsymbol{P})}{\mathbf{N}}}}{\boldsymbol{R}} \quad \textbf{……………………………………………………………………………Eq. 2}$$

Where, **N**= number of people in the population

P= estimated variance in the population, as decimal:(0.5 for 50-50)

A= Precision desired, expressed as decimal: (i.e.,0.03,0.1,0.15 for 3%,10%,15%)

Z= Based on confidence level:(1.6449 for 90% confidence.)

R= Estimated response rate, as decimal (assumed to be 95%)

There is a tendency to divide research into qualitative and quantitative when the approach to research has been considered as the criterion of classification. This research has a qualitative research feature as it seeks to describe various aspects about behavior and other factors studied. It uses questionnaire survey to understand among other things the perception of professionals towards the linguistic expressions for probability and impact of risk factors. The process of measurement is central to quantitative research because it provides the fundamental connection between empirical observation and mathematical expression of an attribute. Use of a case study to test the finding of the questionnaire survey served as a quantitative approach. By this sense, this research could be identified as having both qualitative and quantitative character as it tries to work with perception and attempts to enhance the processes of contingency determination.

Chapter 4. ANALYSIS AND DISCUSSION OF RESULTS

4.1. Introduction

A total of 20 construction firms, 10 consultants, and 2 clients of grade one contractors; category one and two consultants; and government authorities as clients in Addis Ababa were respondents. The data collection through interview and questionnaire were conducted and filled by both top-level management and professionals working in the respective construction firm. The survey concentrated on such groups of respondents to meet the objectives of this research. The second column of Table 4-1 shows that the number of questionnaire distributed to the client and consultant stakeholders is comparatively small. This was because the respective stakeholders were not to willing to participate as they considered the topic to be revailing company confidential information.

Out of the total 32 questionnaires 20 was collected form contractors, six from consultants, and none form client. Table 4-1 shows the stakeholders contribution and that the response rate was 100% for contractor, 60% for consultant, and 0% for client respectively.

Table 4-1: Survey-response comparison

Stakeholders	Questionnaire Distributed	Questionnaire Returned	Percentage Return (%)
Clients	2	0	0
Consultants	10	6	60
Contractors	20	20	100
Total	32	26	81.25

4.2. Analysis and Discussion of Results

In this section, analysis of respondent's response that expresses their understanding of risk management, practice of estimating base line cost and duration, and cost contingency estimation of projects has been considered and discussed. The response of the various group of respondents to the questionnaire and sub-interview questions, included under Annex D, were analyzed and discussed in the following subsequent sub sections.

4.2.1. Company's Year of Experience

The query to the total year since the year of establishment of the respective organization, summarized by Table 4-2, revealed that greater portion of the organizations have existed for over five years. More specifically, 95% the construction companies and 100% the consultancy firms had been more than five years since they were established. Moreover, 45% of the construction firm and 83.34% of the consultancy offices have been around for over ten years. This question was put forward to see if there is a relation with the year of experience and development in risk management awareness as well as formal risk management practice.

Table 4-2: Organization's Experience

Organization's Experience (Year)	Contractor				Consultant			
	Since Establish't		In Current Grade		Since Establish't		In Current Grade	
	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
Below 5	3	15	11	55	0	0	4	66.67
5-10	8	40	4	20	1	16.67	1	16.67
10-15	2	10	3	15	1	16.67	0	0
Above 15	7	35	2	10	4	66.67	1	16.67
Total	20	100	20	100	6	100	6	100

4.2.2. Formal Risk Analysis Practice at Organization and Project Level

Majority of the respondents indicated that there is no formal risk management practice in the respective organization. As shown in Table 4-3 only 15% of respondents from construction firms recognized the presence of a formal risk management practice and 10% explained that the risk management practice at their organization is at initial stage of development. As for the consultancy offices, only one undertakes a formal risk management. This made it evident that there is lack of formal risk management practice at most building construction projects in Addis Ababa.

Table 4-3: Response to existence of formal risk management practice

No	Question	Consultants		Contractors		Overall % Resp.
		No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	
1	Does your company have a formal risk management practice? [Yes response]	2	33.33	3	15	15.38
2	Does your company have a formal risk management practice? [No response]	4	66.67	15	75	76.92
3	In the process of developing risk management process inputs	0	0	2	10	7.69
Total		6	100	20	100	100

The information presented in Table 4-2 asserted that significant portion of the organizations (45% of the contractors and 83.34% of consultants) have been in existence for ten years or more. Development in both the overall structure of the organization and in facilitating the practice of management, which is vital to ensure effective project success, is be expected from an organization involved in the construction industry for ten years. The very competitive and demanding nature of the industry is the fact underlying this expectation.

Table 4-4 is about the respondents that gave a “yes” response, i.e. 33.33% of the consultant and 15% of the contractor, to the question about the company having formal risk management practice. The information provided in this table also emphasizes that those organizations that have a formal risk management practice can be grouped as having an experience between five to ten years and more than ten years. Hence, the development of risk management practice is not directly dependent on year of experience of the organization.

Table 4-4: Year of experience – Organization

Respondent	Year of experience	
	Since Estabilish’t	In Current Grade
Contractor	6	3
	10	3
	21	15
Consultant	12	4
	25	4

Assessment of the reason proposed by respondents that gave a “No” response, i.e. 66.67% of the consultant and 75% of the contractor, to the question about the company having formal risk management practice is presented by Table 4-5. “Fear of the need to hire additional staff” was ranked as a main reason behind by the consultants with 50% of response. Whereas the overall percentage of response (57.14%) of both group identified “lack of awareness” as the highly rated reason that lies behind not having formal risk management.

Table 4-5: Reason for not having formal risk management

No	Question	Consultants		Contractors		Overall % Resp.
		No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	
1	Lack of awareness	1	25	11	73.33	63.16
2	Fear of the need to hire additional staff	2	50	2	13.33	21.05
3	It is not necessary	-	-	-	-	
4	It is expensive	1	25	-	-	5.26
5	Time consuming	-	-	-	-	
6	Other	-	-	2	13.33	10.53
Total		4	100	15	100	100

Respondents mentioned that many construction companies do not consider risk management both at project and organization levels. 13.33 % respondents presumed that the practice of risk management would subsequently increase the cost estimates of projects. As a result, respondents fear undertaking the practice of risk management in this current environment of the construction industry would eventually push the company out of the market.

4.2.3. Understanding and Awareness of the Concept of Risk Management

The responses to questions concerning respondents' awareness and understanding of the concept of risk management, which was included to assess the level of awareness of the professionals in the industry, is discussed in this section.

The participants reported that they all have knowledge about risk management though the level of awareness is variable. The larger portion the contractors reported of having deep understanding of the steps involved. Where 75% of the responding contractors are aware of the principles and necessary steps and 10% are well acquainted with the necessary steps that can be implemented. The overall percentage of response shows that 65.38% of the respondents are aware of the principles and necessary steps.

Table 4-6: Understanding of risk management

No	Risk Management Understanding	Consultants		Contractors		Overall Res. %
		No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	
1	Only know what it means	2	33.33	3	15	19.23
2	Aware of the principles and necessary steps	2	33.33	15	75	65.38
3	Well acquainted with the necessary steps that can be implemented	2	33.33	2	10	15.38
4	Not aware of the concept	0	0	0	0	0
Total		6	100	20	100	100

Form what is presented on Table 4-6 it is clear that all of the respondentes are aware of the concept on risk management. A similar understanding was presented by a study done on construction contract risk management where 97% of the respondents were aware of the concept of risk management. In this study the author pointed out that tough most of the respondents ansewed of being aware of the concept of risk management they aer not confidence enough to implement what they know [50].

The understanding comprehended in Table 4-5 seems to vary from the one presented in Table 4-6. The first table deduces that lack of awareness is the main reason for not having forml risk managmeent practice at the organizations and hence the industry. The later, on the other hand, points out that 80.76% of the respondents are aware of the princilples and even more. This information can help explain that the existance and development of risk management practice in an organization is not affected by the level of awareness of the employees. But rather on the understanding and consiousness of the organization's managenet teams towards risk and its management.

4.2.4. Respondent's Position in the Organization and Experience

The question corresponding to the respondent's position in the organization was included to know the capacity of the respondent and ensure a respondent well aware of the organizations strategies provided the response. The information presented in Table 4-7 shows that 80% and 67% of the respondents who provided the responses for the contractor and consultant respectively were for the middle and top management.

Table 4-7: Respondents level in the organization structure

Level on management	Contractor		Consultant	
	No. of Resp.	**% of Resp.**	**No. of Resp.**	**% of Resp.**
Top management	6	30	4	67
Middle management	10	50	0	0
Lower Level	4	20	2	33
Total	20	100	6	100

In addition to the awareness about the company's strategy, the respondent's level of experience in relation to their engagement in both the construction industry and respective company has also been addressed as shown in Table 4-8. Only 5% of the respondents from the construction firm have less than five years of experience in the construction industry. This means that experienced respondents provided the gathered data.

Table 4-8: Respondents experience

Respondent's Experience (Year)	Contractor				Consultant			
	In the Industry		**In Current Organization**		**In the Industry**		**In Current Organization**	
	No. of Resp.	**% of Resp.**	**No. of Resp.**	**% of Resp.**	**No. of Resp.**	**% of Resp.**	**No. of Resp.**	**% of Resp.**
Below 5	1	5	11	55	0	0	3	50
5-10	8	40	6	30	2	33.33	2	33.33
10-15	7	35	3	15	1	16.67	0	0
Above 15	4	20	0	0	3	50	1	16.67
Total	20	100	20	100	6	100.00	6	100.00

4.2.5. Method of Risk Identification

The common risk identification methods found from literature were presented and were ranked in accordance with the frequency of usage. The response of the consultants and contractors is presented in Table 4-9 and Table 4-10 respectively. The ranking were assigned based on the relative importance index of each method calculated using Equation 3.

$$\mathrm{RII} = \frac{\Sigma W}{SxN},\ 0 < \mathrm{Index} < 1 \ldots\ldots \textbf{Eq. 3}$$

Where; ΣW= The summation of the weighting given to each factor

=Σ(weight of each score x no of respondents that selected each score)

S= Maximum score=5

N= Total number of firm that responded in the sample. ($N_{Contractor}$=20, $N_{Consultant}$=6)

The analysis result shows that the contractor and consultants ranked “Brain-storming” as the number one method for risk identification. This clearly shows that majority of the respondents agree on its wide use. “Experts opinion” and use of “Checklist” were ranked second and third.

Table 4-9: Rank of risk identification method by Consultant

No	Method	Score					Relative Importance Index	Rank
		1	2	3	4	5		
1	Brain-storming	1	1	0	3	1	0.67	1
2	Checklist	1	1	3	1	0	0.53	3
3	Expert opinion	2	1	1	0	2	0.57	2
4	Risk Record	4	1	1	0	0	0.3	5
5	Record	3	0	0	3	0	0.5	4

Table 4-10: Rank of risk identification method by Contractor

No	Method	Score					Relative Importance Index	Rank
		1	2	3	4	5		
1	Brain-storming	9	1	2	2	6	0.55	1
2	Checklist	13	1	1	4	1	0.39	3
3	Expert opinion	9	1	4	3	3	0.50	2
4	Risk Record	16	1	0	2	1	0.31	4
5	Record	15	2	1	2	0	0.30	5

4.3. Rank of Risk Factors and Methods of Estimation

List of risk factors, categorized based on the source of risk, gathered through literature review was included in the questionnaire as presented in Annex F [2, 48, 20]. Since the list was a result of reviewed literature, respondents were asked to rank the risk factors considering the probability of occurrence and impact on project cost to ensure the importance of these risks to building construction projects in Addis Ababa. Respondents also reported of other common risks in the building construction industry that are presented in Table 4-11.

Table 4-11: Additional risks identified by respondents

Risk Category	Risk Factors in Building Construction
External Risks	Availability of foreign currency
	Change requirement of permit
	Good governance
	Uncertain market rate
	Change in infrastructure
	Uncertain under laying utilities
	Corruption
Organizational Risk	Financial capacity of the contractor
Technical Risks	Inspectors timing to supervise
	Coordinate locating

Annex D shows the relative importance indices and the relative ranking of the 47 list of factors that are considered to be risk factors in the construction industry for the purpose of this study.

The assigned ranking were given based on the relative importance index of individual risk factor calculated using equation 3 but for this consideration the maximum score is 3.

After calculating the RII, the weighted average of each factor was determined by considering the contribution made by each group using equation 4.

$$\text{Weighted Average} = \frac{n_1 RII_1}{N} + \frac{n_2 RII_2}{N} + \frac{n_3 RII_3}{N} \qquad \textbf{Eq. 4}$$

Where; RII_1= Relative importance index for consultants

RII_2= Relative importance index for contractors

n_1= Number of consultants that responded

n_2= Number of contractors that responded

N= Total number of respondents

4.3.1. Verified Risk Factors

Table 0-2 and Table 0-3 of Annex D respectively show the ranking of risk factors from the point of their respective probability of occurrence by the consultants and contractors. Summary of the ten most probable risk factors as ranked by each group is presented in Table 4-12 .

Here the consultants ranked "Inadequate program scheduling" as the most probable risk factor whereas the contractors ranked "Delay in payment to contractor for work done".

Table 4-12: Ranking of the risk factor considering probability

No	Consultants	Contractors
1	Inadequate program scheduling	Delay in payment to contractor for work done
2	Financial Problem resulting from incorrect estimation	Unrealistic project duration
3	Unrealistic project duration	Price inflation of construction materials
4	Price inflation of construction materials	Client/ owner incompetency
5	Shortage of materials in market	Change order
6	Exchange rate fluctuation	Material damage during transportation
7	Permits delayed or take longer than expected	Inadequate program scheduling
8	Shortage of fund	Variation
9	Mistakes and discrepancies in design documents	Delay in subcontractors work
10	Delay in payment to contractor for work done	Poor construction method

Table 4-13: Ranking of the risk factor considering impact

No	Consultants	Contractors
1	Inaccurate material estimation	Price inflation of construction materials
2	Delay in subcontractors work	Delay in payment to contractor for work done
3	Shortage of material in the market	Unrealistic project duration
4	Price inflation of construction materials	Shortage of fund
5	Shortage of fund	Shortage of material in the market
6	Financial problem resulting from incorrect estimation	Mistakes and discrepancies in design documents
7	Permits delayed or take longer than expected	Inadequate contractors experience
8	Delay in payment to contractor for work done	Inadequate design team experience
9	Inadequate design team experience	Delay in subcontractors work
10	Inadequate or insufficient site information	Inaccurate material estimation

Ranking was also made considering the severity of the consequence of the risk factors, which is calculated using equation 5, as presented Table 0-8, Table 0-9, and Table 0-10.

$$\text{Severity} = \text{Probability} * \text{Impact} \quad \text{.........} \textbf{Eq. 5}$$

The risk factors ranked as ten most sever once by the consultants, contractors, and the considering the weighted average of the two groups is presented in Table 4-14. Considering the combination of the ranking given by the respondents the "Price inflation of construction materials" risk factor is considered to result the highest severity.

Table 4-14: Ranking of the risk factor considering severity of consequence

No	Consultants	Contractors	Weighted Average
1	Inaccurate material estimation	Delay in payment to contractor for work done	Price inflation of construction materials
2	Shortage of material in the market	Price inflation of construction materials	Delay in payment to contractor for work done
3	Price inflation of construction materials	Unrealistic project duration	Unrealistic project duration
4	Financial problem resulting from incorrect estimation	Mistakes and discrepancies in design documents	Inadequate program scheduling
5	Unrealistic project duration	Inadequate program scheduling	Shortage of fund
6	Shortage of fund	Shortage of fund	Mistakes and discrepancies in design documents
7	Delay in subcontractors work	Change order	Delay in subcontractors work
8	Permits delayed or take longer than expected	Delay in subcontractors work	Shortage of material in the market
9	Inadequate or insufficient site information	Delay in response to design information	Inadequate design team experience
10	Inadequate design team experience	Exchange rate fluctuation	Exchange rate fluctuation

4.3.2. Method for Estimating Contingency

The respondents were asked to rank the level of use of the list of contingency estimating methods gathered from literature. The response of the consultants and contractors is presented in Table 4-15 and Table 4-16 respectively. As it can be observed from both tables, the use of the "Traditional percentage" method was ranked as the most used method.

Traditional percentage estimation was recognized as being the method applied to estimate contingency. The research revealed that the reasons why professionals in the construction industry predominantly use the deterministic method (traditional percentage method) was the ease of its application and unavailability of any other tested and approved framework.

Table 4-15: Rank of contingency estimating method by Consultants

No	Method	Score					Relative Importance Index	Rank
		1	2	3	4	5		
1	Traditional percentage	1	1	0	0	4	0.77	1
2	Individual risks-expected value	2	2	0	1	1	0.50	2
3	Range estimation	3	1	0	2	0	0.43	3
4	Factor rating	4	1	1	0	0	0.30	4
5	Monte Carlo Simulation	6	0	0	0	0	0.20	5
6	Advanced Estimating Models	6	0	0	0	0	0.20	5

Table 4-16: Rank of contingency estimating method by Contractor

No	Method	Score					Relative Importance Index	Rank
		1	2	3	4	5		
1	Traditional percentage	6	1	1	0	12	0.71	1
2	Individual risks-expected value	12	1	1	4	2	0.43	2
3	Range estimation	12	2	1	4	1	0.40	3
4	Factor rating	9	1	0	3	1	0.28	4
5	Monte Carlo Simulation	19	0	1	0	0	0.22	5
6	Advanced Estimating Models	19	0	1	0	0	0.22	5

4.3.3. Estimating Practice

a. Consultants Response

Consultants identified the use of cost for similar projects, expert’s opinion and even considering the critical path analysis for concrete work along the method used to produce concrete to estimate cost of projects.

A rule of thumb for duration presented by Equation 6 was identified as the common method of estimating the project duration by consultants.

$$\text{Duration} = (\text{Project cost in Million Birr})^{\frac{1}{3}} * (7 \text{ to } 9 \text{ month}) \quad \text{.. } \textbf{Eq. 6}$$

b. Contractors Response

The contractors responded that factors such as climatic condition and soil characteristics of the site; total transportation distance to deliver materials to site; prices and availability of local material, labor, and equipment are considered in estimating the cost of a construction project.

Actual determination of project cost requires collecting price quotation for important items, fixing productivity and output of labor from experience or record, preparing cost breakdown of each item and also taking off quantities of work.

As for estimation of the project duration, the contractor uses the project duration estimated by the consultant as a base. The contractors consider the work items to be completed within scope of the project and estimate the duration of each. The contractors then make arrangements by defining the sequential relationship between the activities, whether the time estimated by the consultant is adequate or not. The contractor has to submit a work schedule that falls within the time frame estimated by the consultant. The construction firm can only manage its available resource to meet the consultant’s duration. Even when the consultant’s estimate of duration is not attainable the contractor would only squeeze the tasks within the estimated time frame of the project.

4.4. Impact and Probability Scale

4.4.1. Probability Scale

Section five of the questionnaire includes questions that tried to measure the respondents understanding and perception of the impact and probability expressions presented. Responses to these questions are analyzed and comparisons of the responses from the contractors are presented in this section of the data analysis.

The goal of this section is to understand how people relate to likelihood expressions in terms of qualitative data. The questions are structured to gain correlations between word and number. In these set of questions two approaches were requested. These approaches were of providing range of values and a single value for each of the subjective expressions. Table 4-17 presents the summarized result of the survey for the approach where the respondents were asked to provide a range of values for the subjective terms. Whereas, information in Table 4-18 corresponds to the single value approach for each of the subjective expressions.

Study of the contractors' response summarized by Table 4-17 shows that the group has increased consensus about the corresponding range for the two most probable expressions. This convergence in understanding seems to decrease for the expressions of 'Somewhat likely' and 'Unlikely' and tends to go back up for 'Very unlikely'. Somewhat similar pattern is notices form the response of the consultant. The consultants seem to agree about the corresponding value for the two less probable expressions (i.e., Unlikely and Very unlikely).

Each responding group seems to have consensus about the two extreme ends of likelihood as it is presented in Figure 4-1. Similar understanding can be concluded from the charts shown in Table 4-19. Columns of Table 4-19 contain responses from each group of respondents whereas the rows represent the five expressions of probability. The chart for each expression presents the different ranges proposed for that specific expression in relation with the respective percentage of the group that choose that range. Looking at the first column, one can notice that better consensus for terms 'VL, SL,UL, and VU. Here greater than half of the responding group choose the range selected for each respective expression. As for the response of the contractor, greater than half of the responding group choose the range selected for the expression of VL, L, SL, and VU.

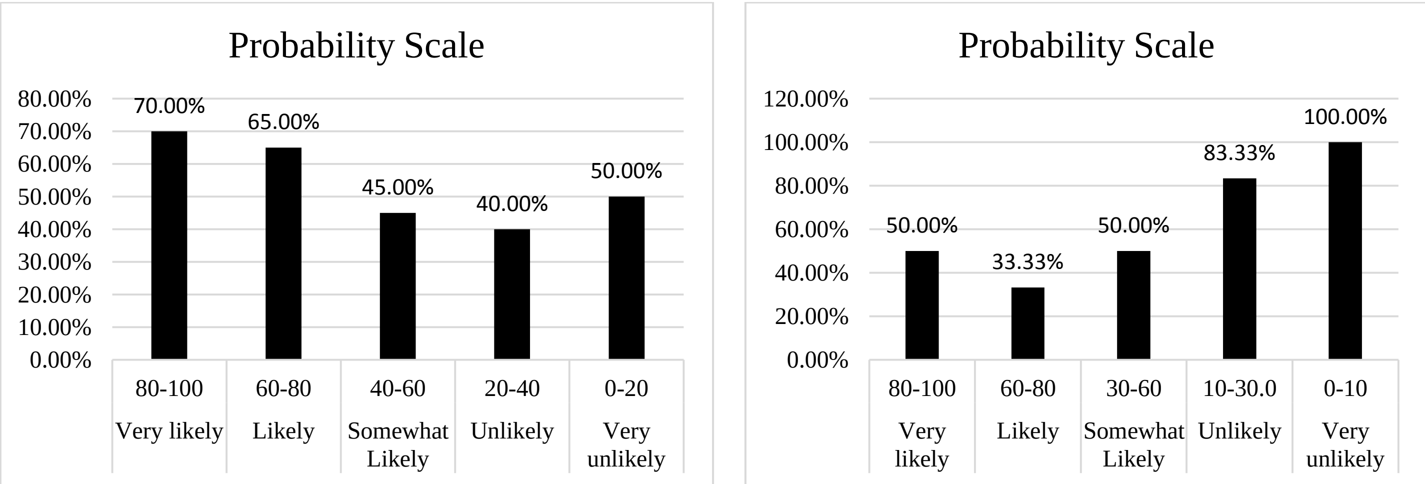
Comparing the range presented on Table 2-10 with that of Table 4-17 one can notice a very significant difference especially between the ranges of the expressions SL, UL and VU. The fact that the practice was new to the professionals could be reason for such big percentage variation. Specific reference to the terms UL and VU could clearly show less understanding of the concept of unlikelihood.

Table 4-17: Scale for probability expression-in form of range

Probability Expression	Contractor			Consultant		
	Scale	No. of Resp.	% of Resp.	Scale	No. of Resp.	% of Resp.
Very likely	80-100	14	70	80-100	3	50
Likely	60-80	13	65	60-80	2	33.33
Somewhat Likely	40-60	9	45	30-60	3	50
Unlikely	20-40	8	40	10-30	5	83.33
Very unlikely	0-20	10	50	0-10	6	100

Table 4-18: Single value for probability expression

Probability Expression	Contractor			Consultant		
	Single value	No. of Resp.	% of Resp.	Single value	No. of Resp.	% of Resp.
Very likely	90	7	35	90	2	33.33
Likely	70	6	30	70	2	33.33
Somewhat Likely	60	6	30	55	2	33.33
Unlikely	20	5	25	20	4	66.67
Very unlikely	5	8	40	5	3	50

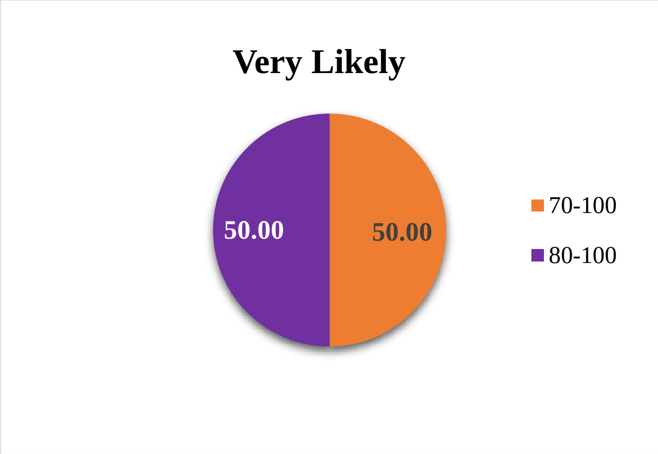


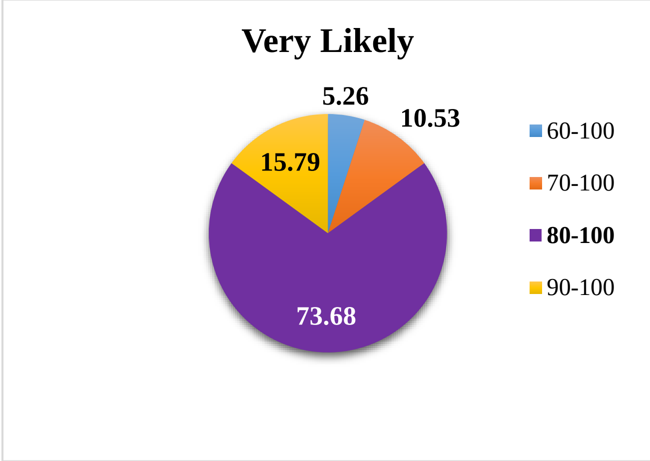
Contractor **Consultant**

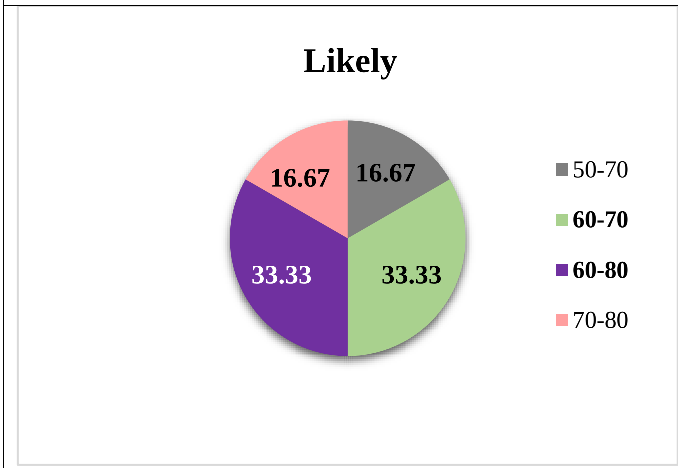
Figure 4-1: Response rate for range of value probability scale

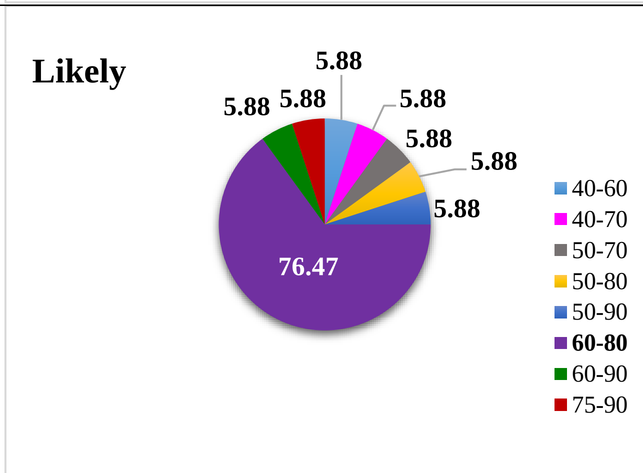
Table 4-19: Distribution of probability scales

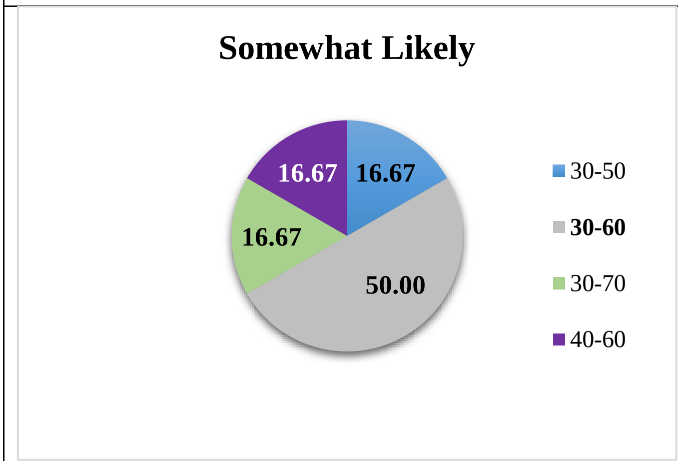
Consultant	Contractor

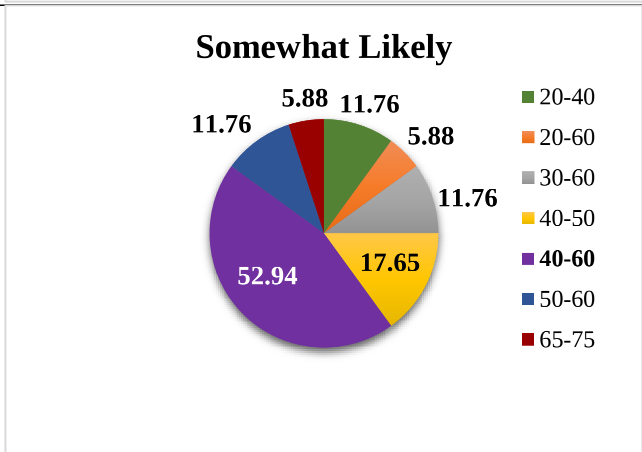


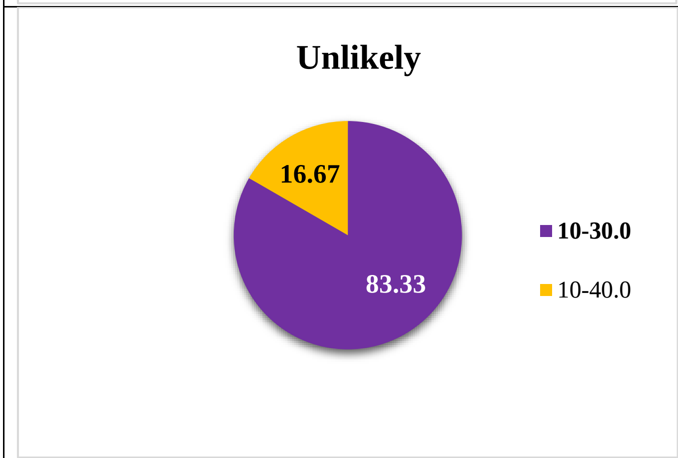


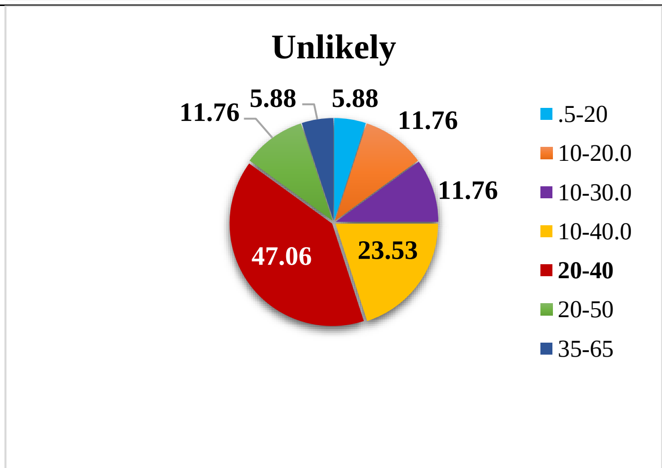


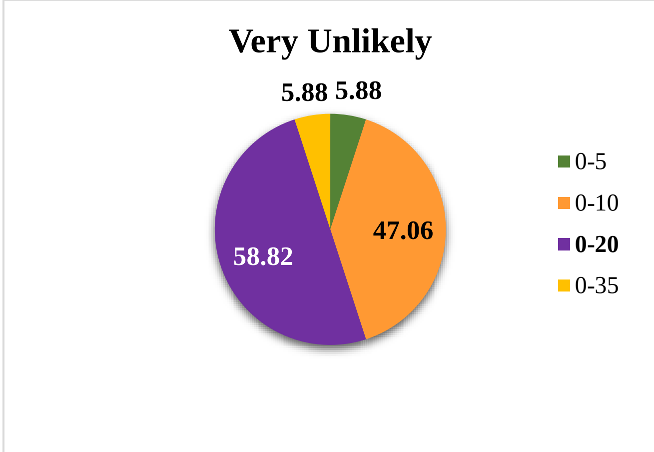










Consultant	Contractor
	

4.4.2. Impact Scale

In a similar manner, Table 4-20 presents the summarized results of the survey for the approach where the respondents were asked to provide a range of values for the subjective terms. Table 4-21 presents single values corresponding to each of the subjective expressions. Unlike the case of the ranges presented for probability the range presented to correlate with the impact expressions by the two responding groups is totally different. The range proposed by the consultants is more on the safe side.

Figure 4-2 shows the percentage of respondent that chose the respective range for specific expression. The portion the figure expressing the response of the contractor shows that the respondents had better agreement in choosing the range for the expressions VH and H where 70% and 50% of the respondent chose the range. The fifty percent of the responding consultants chose the ranges for the impact expressions of VH,SH, L, and VL.

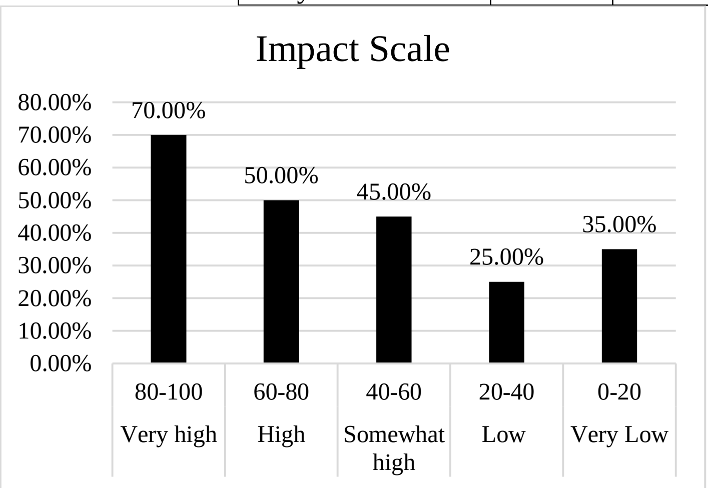
Similar understanding can be concluded from the charts presented in Table 4-22 showing number of ranges for each expression along with the proportions gathered. Columns in Table 4-22 contain responses from each group of respondents whereas the rows represent the five expressions of impact. The chart for each expression presents the different ranges proposed for that specific expression in relation with the respective percentage of the group that choose that range. The contractors and consultants seem to have a decreased level of consensus to that of the probability.

Table 4-20: Scale for impact expression- in form of range

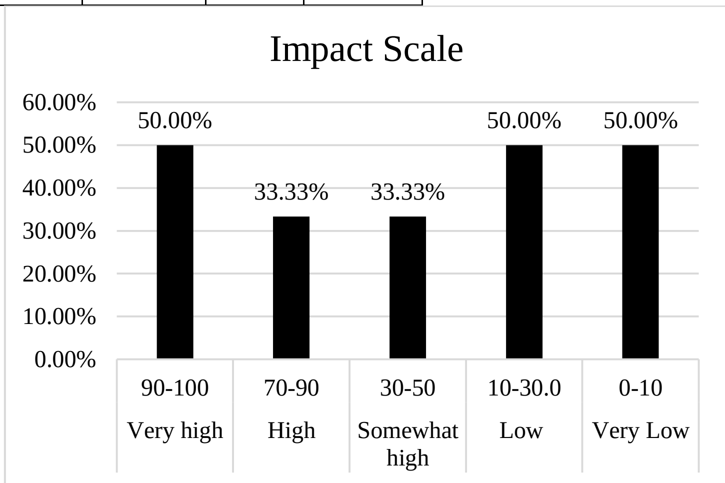
Impact Expression	Contractor			Consultant		
	Scale	No. of Resp.	% of Resp.	Scale	No. of Resp.	% of Resp.
Very high	80-100	14	70	90-100	3	50
High	60-80	10	50	70-90	2	33.33
Somewhat High	40-60	9	45	30-70	3	50
Low	20-40	5	25	10-30	3	50
Very low	0-20	7	35	0-10	3	50

Table 4-21: Singe value for impact expressions

Impact Expression	Contractor			Consultant		
	Single value	No. of Resp.	% of Resp.	Single value	No. of Resp.	% of Resp.
Very high	90	7	35	95	3	50
High	80	10	50	80	3	50
Somewhat High	50	7	35	40	2	11.76
Low	40	7	35	30	3	17.65
Very low	5	7	35	5	3	17.65



Contractor

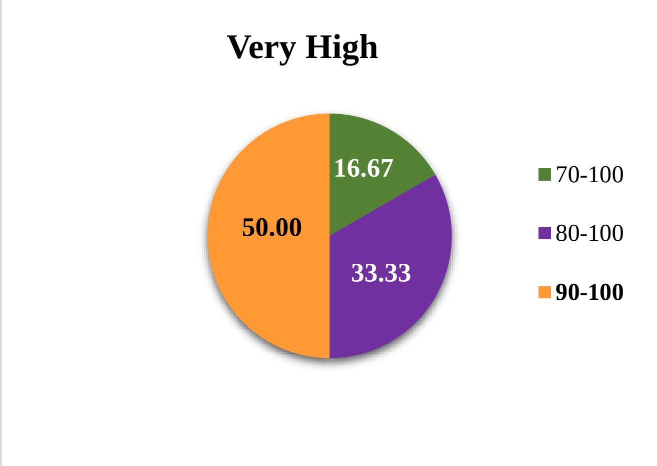


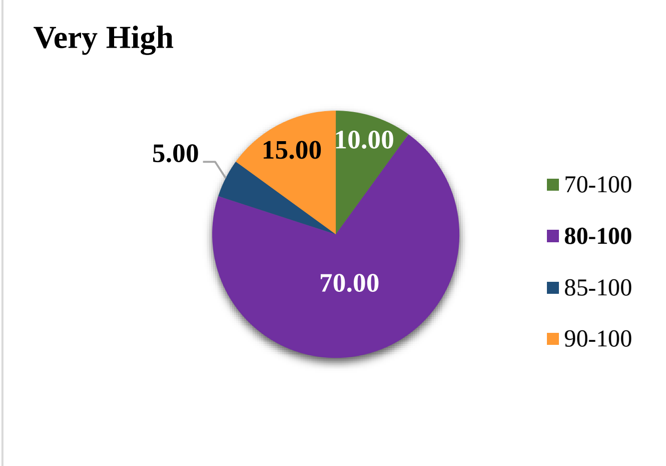
Consultant

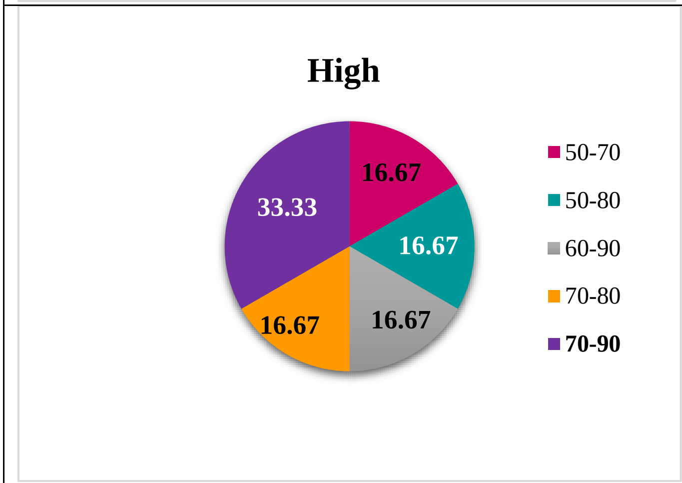
Figure 4-2: Response rate for range of value impact scale

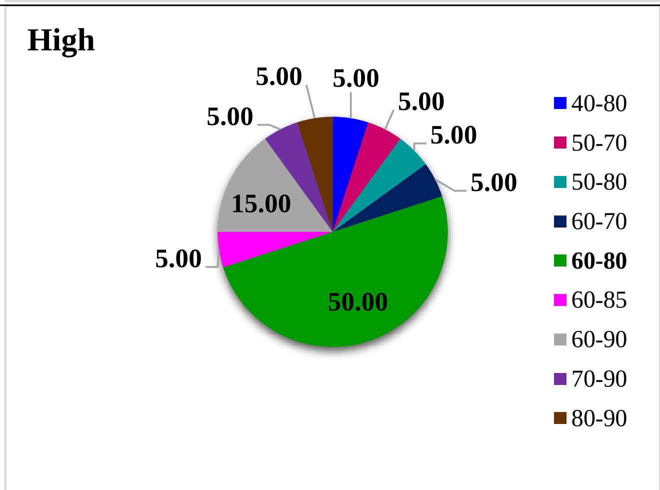
Table 4-22: Distribution of impact scale

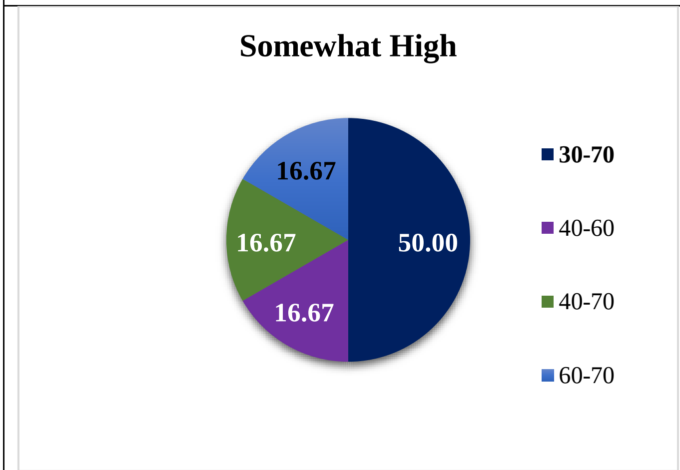
Consultant	Contractor

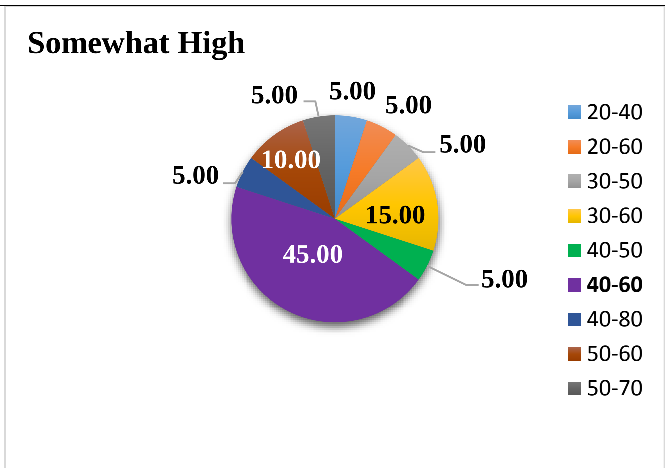












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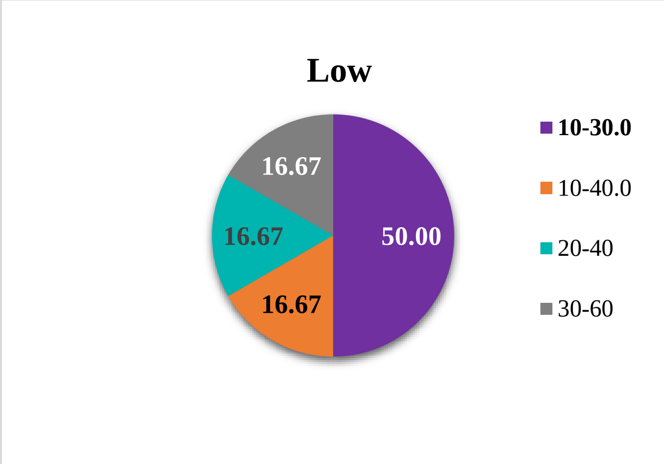
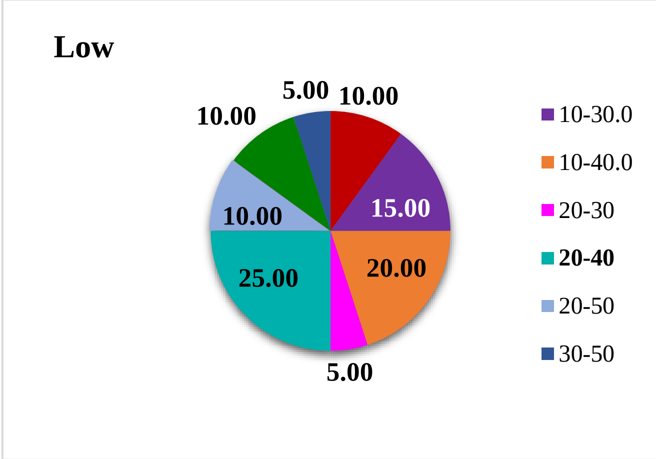
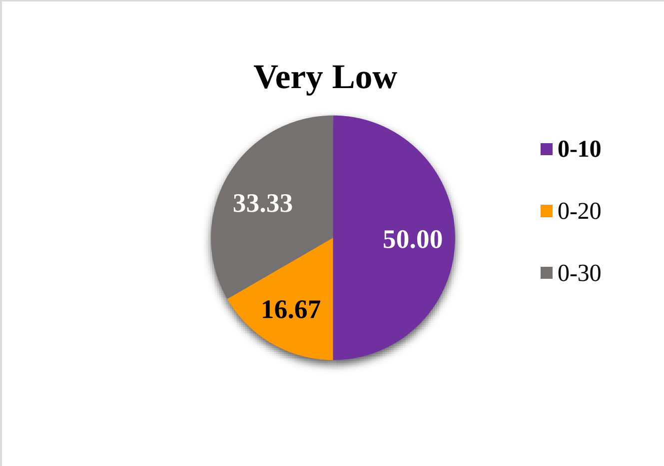
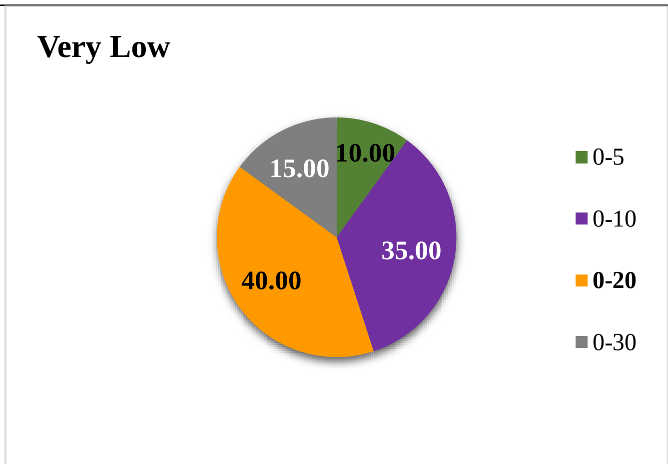
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

4.5. Summary of Discussion

There is lack of formal risk management practice at most building construction projects in Addis Ababa. Though the survey group responded that they are aware of the principles and necessary steps both group identified “lack of awareness” as the highly rated reason that lies behind not having formal risk management. This response shade a light on the fact that development of risk management practice is not directly dependent on year of experience of the organization and level of awareness the employees have. It is rather dependent on the risk attitude of the organization.

Different methods for estimating project duration have been report in literature. The reviewed methods are based on different principles ranging from use of deterministic method; the use of linear regression model; to the much resent ones bases on artificial intelligence. These methods of project duration estimation factors such as project type, project area, estimating project price, and estimated project duration are identified as dependent variables [34]. On the contrary the response from the questionnaire reviled that the practice is dependent an equation considering cost of the project.

The analysis result clearly shows that majority of the respondents agree on the type of risk identification methods used. The “Brain-storming” method for identifying risk that was recognized as the usually used method by literature was also given the same rank of use by responding contractors and consultants [5, 22]. This method is followed by the use of "Experts opinion" and use of "Checklist".

A review of the practice of contingency allocation in Nigeria revealed that this method of percentage addition is the popular one in the industry. The more recent methods such as the Monte Carlo simulation and those dependent on artificial intelligence are less famous [45]. Traditional percentage estimation was recognized as being the method applied to estimate contingency. The research revealed that the reason why professionals in the construction industry predominantly use the deterministic method (traditional percentage method) was the ease of its application and unavailability of any other tested and approved framework.

Assessment of the risk factors in building construction projects with respect to the severity of that results from materialization of the risk factors was made. The result of this assessment of the cumulative response of contractors and consultants was made to select the top ten risk factors, having sever consequence and presented in Table 4-23.

Table 4-23: Ranking of the risk factor considering severity of consequence

No	Weighted Average
1	Price inflation of construction materials
2	Delay in payment to contractor for work done
3	Unrealistic project duration
4	Inadequate program scheduling
5	Shortage of fund
6	Mistakes and discrepancies in design documents
7	Delay in subcontractors work
8	Shortage of material in the market
9	Inadequate design team experience
10	Exchange rate fluctuation

The scale to be used for interpreting the five respective expression for probability and impact was assessed from the responses of the contractors and consultants. The responses for probability and impact range and point estimation are as presented in

Table **4-24** and Table 4-25. Summary of the scale for probability expressions shows that similar ranges were proposed for the expressions of 'Very Likely' and 'Likely'. The range proposed by the consultants and contractors, for expression of impact, are completely different. This difference in range estimation for probability and impact show that this step needs to be defined for each organization or project team because it is subjective.

Table 4-24: Scale for probability expressions

Probability Expression	Contractor		Consultant	
	Range	Pt. estimate	Range	Pt. estimate
Very likely	80-100	90	80-100	90
Likely	60-80	70	60-80	70
Somewhat Likely	40-60	60	30-60	55
Unlikely	20-40	20	10-30	20
Very unlikely	0-20	5	0-10	5

Table 4-25: Scale for Impact expressions

Probability Expression	Contractor		Consultant	
	Range	Pt. estimate	Range	Pt. estimate
Very high	80-100	90	90-100	95
High	60-80	80	70-90	80
Somewhat High	40-60	50	30-70	40
Low	20-40	40	10-30	30
Very low	0-20	5	0-10	5

Chapter 5. CASE STUDY

5.1. Introduction

A case study for the risk analysis of regional primary hospital project is provided in this chapter to illustrate the CII risk analysis approach and provide a guide to the process of risk analysis. The case study is based on actual project which is in the construction stage. Since organizing a risk management team and going through an actual process was not possible the case study was carried out based on inputs received from the contractor, a demonstration of CII from literature is used to show a hypothetical procedure. In order to make the demonstration clear, the steps presented by CII are presented in following sections on the assumption that a risk management team guided by a facilitator were involved in process.

In the actual project, quantitative risk analysis was not undertaken while determining the project cost and schedule. Rather, the contingency was simply determined by taking an amount equal to 5% of the total project cost. In order to illustrate the application of the risk analysis process of CII, the qualitative risk analysis of this project was to carried out by considering as if this ongoing project is in its preliminary design phase.

5.2. Description of the Project

The regional primary hospital project (herein after called "Project") is located in the Southeastern region of Ethiopia. The main content of the project includes construction of sixteen blocks and other civil works in the site. The Project owner is Regional State Health Bureau which functions under the Federal Ministry of Health of Ethiopia. The value of the Ministry includes putting the community first. One of the Ministry's strategic objectives is to serve the community by working to improve its health status through provision of improved health infrastructure. The implementation of the Project is believed to enhance the health care service at different regions.

The total construction period of the Project is 20 months or 600 calendar days. The general scope of work comprises the following:

- Design, construction and completion of all civil works related to the project
- Furnishing as-built drawings of the project
- Furnishing operation and maintenance manuals of the project

A more detailed description of the Project including schedule and budget, Project stakeholders, owners' measure of success and Project constraints and limitations are summarized in Table 5-1 .

Table 5-1: Project description

No	Description	List
1	Project schedule and budget	• Schedule: the project should be completed in 20 months
		• Budget: 35 million ETB
2	Project stakeholders	• Regional Health Bureau (Consultant) • Regional Government • Regional land administration
3	Owners' measure of success	• Completion of project on/under budget and schedule • Positive public, media and stakeholder perception
4	Project constraints and limitations	• Schedule • Limited budget

The project cost incorporates the direct cost of civil works and construction management and consulting expense. The detailed expenses for the project which can be used as a base estimate are provided in Table 5-2 including a five percent contingency.

The overall stage of construction is comprised of the following four stages, including establishment/planning stage, preparation stage of construction (which involves preparation for procurement, construction of access road, and civil works), main construction stage (construction of building blocks, and civil site work), and completion stage (removal of temporary works and commissioning). Table 5-3 presents information such as the expected activities to be carried out in these different stages, duration, and predecessors of each activity.

Table 5-2: Baseline estimate of the project

Item No.	Description	Estimated Cost
1	Excavation and earthwork	1,755,536.28
2	Stone masonry	1,523,289.60
3	Substructure concrete work	2,402,770.52
4	Superstructure concrete works	1,075,439.63
5	Block works	935,316.90
6	Roofing works	889,316.10
7	Carpentry & Joinery	984,211.38
8	Metal works	613,029.60
9	Finishing works	4,380,990.39
10	Glazing works	196,031.82
11	Painting work	469,549.55
12	Sanitary installation	1,405,832.40
13	Electrical installation	2,108,215.80
14	Civil site work	10,453,360.95
	Total	29,192,890.91
	Contingency (5%)	1,459,644.55
	Amount with contingency	30,652,535.46
	VAT (15%)	4,597,880.32
	Total	**35,250,415.78**

Table 5-3: Detailed description of activities

Activity Name	Activity Description	Duration (days)	Dependencies
A	Site investigation	30	-
B	Preparation of design	55	A
C	Approval of permits	70	A
D	Land acquisition and expropriation	35	C
E	Bid invitation and tendering	30	C
F	Access road construction	8	D
G	Mobilization	40	D
H	Site clearing and excavation	160	F,G
I	Substructure concrete work	170	H
J	Stone masonry	90	I
K	Superstructure concrete works	155	J
L	Block works	210	K
M	Carpentry & Joinery	90	K
N	Roofing work	90	M
O	Metal works	65	L
P	Finishing works	225	L
Q	Glazing works	60	P
R	Painting work	170	P
S	Sanitary installation	300	L
T	Electrical installation	300	L
U	Civil site work	262	F,G

5.3. Application of Level 1: Risk Identification

The risk management team that is formed to conduct the workshop will identify risks and opportunities of the project. Exercising workshop to brainstorm through risks is the most common risk identification method. Workshops are useful in generating teamwork and share understanding of the risks faced. To make the process successful it generally agreed that workshops need to be facilitated. The facilitator could be an external consultant, who does not work for the organization, or an internal facilitator. A facilitator who has a very good knowledge in risk management and relevant training shall be selected. The participants in the workshop could include project manager, project team members, subject matter experts, stakeholders, operation heads, consultants, other project managers, environmental consultants, and end users.

All-important preliminary data and assumptions about the schedule, design, and cost has to be gathered by the risk management team. The objective of such a workshop is to identify and describe project risks and opportunities, categorize the identified risks, determine the project phase at which the risk could occur and category of impact. Objectives of the workshop could be issued to the participants prior to the workshop to ensure common understanding. Diagnostic questions can be issued to participants to trigger their thought process, or prepare lists. Voting software could be used to make the process easy but it is not mandatory.

The list of risks that are identified through the workshop are then summarized using risk registers. Table 5-4 shows the way that the risk register is structured. The risk register including all the identified risks is provided in Annex G.

Table 5-4: Detail description of activities

No	Status	Date Identified	Brief Risk Description	Detail Risk Description	Project Phase	Category of Impact
1	Active	12/2/2016	Price inflation of construction materials	The cost of materials in the market increases from what was considered during cost estimation.	Planning	Cost
2	Active	12/2/2016	Unrealistic project duration	Unrealistic estimation of project duration presenting a demand for accelerating the resulting in creased	Planning	Cost
3	Active	12/2/2016	Delay in response to design information	Long time gap between request to clarification and response.	Planning	Schedule
4	Active	12/2/2016	Shortage of materials in the market	Unstable market condition with respect to availability desired material throughout the project life.	Planning	Schedule
5	Active	12/2/2016	Inadequate or insufficient site information	Type and level of detail of the information available about the site.	Planning	Cost

Since the probability of occurrence and impact of risk are not quantified at this level, the contingency is determined by taking 5% of the total project cost. Therefore, a total of 1,459,644.55 ETB was budgeted to manage the identified risks.

5.4. Application of Level 2: Deterministic risk analysis

A second workshop is then conducted using the same facilitator and team to determine the subjective verbal expression of the likelihood, impact and overall severity of the risk factors being encountered and prioritize the risk factors based on their severity. In order to quantify risk using deterministic analysis, the meaning of “impact”, “probability” and “severity” has to be defined first hand in collaboration with the owner. An illustration of the description, corresponding values of budget impact level, probability and consequence of risk factor are summarised in Table 5-5, Table 5-6,and Table 5-7 respectively.

Moreover, the expressions used for assessing consequence of risk factor are very limited and the values used to distinguish between them are not indicated at all. The values for budget impact were adjusted by taking the baseline estimate of the project into consideration.

Table 5-5: Assessment of impact on work package cost

Verbal Expression	Description	Budget Impact		Value for severity
		Low	High	
Very high	The impact is totally unacceptable to the organization	61	100	80
High	Serious threat to the organization	41	60	60
Somewhat high	Considerably affect cost	31	40	35
Low	Moderately affect cost	11	30	20
Very Low	Small effect on costs	0	10	5

Table 5-6: Assessment of probability of occurrence

Verbal Expression	Description	Low	High	Value for severity
Very likely	Almost certain that it will happen	81	100	100
Likely	More than 50-50 chance	61	80	75
Somewhat likely	Less than 50-50 chance	31	60	45
Unlikely	Small likelihood but could well happen	11	30	25
Very unlikely	Not expected to happen	0	10	10

Table 5-7: Assessment of consequence of risk factor

Total Severity	Category	Response
Over 10,000	Intolerable	Must eliminate or transfer risk, it may jeopardize the entire organization or its cost may be manifold that of the project
2,500-10,000	Serious	Expected cost to the project is very high. This risk must be eliminated or transferred before proceeding with the project. Attempt to avoid or transfer risk
500-2500	Important	Consider eliminating or transferring. If accepted then manage proactively.
15-500	Acceptable	Accept and manage
0-15	Negligible	The expected cost of this risk is too small to justify any mitigation effort. Accept and ignore it.

The verbal expression and respective quantitative values for probability and impact of the risk factors identified in the previous level are determined based expert opinion from the workshop and historical data (whenever available). Table 5-5 and Table 5-6 present the ranges of scores for respective verbal expressions of probability and impact. The complete list of the register tool is provided in Annex H. Table 0-11 presents qualitative expressions for respective risks along with the three point scores for each expression of probability. These three point scores for each verbal expressions are derived from the ranges provided in Table 5-6 . Similarly, Table 0-12 presents the respective qualitative expressions along with the three point scores for each expression of impact. The three point scores are derived from the ranges provided in Table 5-5. The severities of risks are determined by multiplying the probability and impact scores given for risks (from Table 0-11 and Table 0-12) and it is presented by columns three to five of Table 0-13. A sample of the deterministic sheet of the risk register tool is provided in Table 5-8, where the number of risks included was limited for the sake of briefness.

For this particular illustration, the concrete work of the project was considered, both substructure and supper structure concrete works. Hence, the impact deterministic risk analysis ranking presented by Table 0-12 is carried out keeping in mind the impact each risk would have if they were to materialize. The information presented by Table 0-13, severity and cost impact, especially the cost impact shown on columns six to eight were determined by multiplying the cost of concrete work by the severity scores. This was necessary, since the team was not familiar with estimating the impact of risks in a manner shown by Table 5-7.

Table 5-8: Deterministic risk ranking

No	Brief Description	Most likely Impact		Most likely Probability		Risk Value
		Qualitative value	Quantitative value	Qualitative value	Quantitative value	
1	Price inflation of construction materials	SH	0.35	SL	0.45	0.16
2	Shortage of materials in market	L	0.2	SL	0.45	0.09
3	Shortage of fund	H	0.5	SL	0.45	0.23
4	Materials damage during transportation	H	0.5	VU	0.1	0.05
5	Long waiting time for approval of drawings	SH	0.35	U	0.25	0.09
6	Mistakes and discrepancies in design documents	SH	0.35	SL	0.45	0.16
7	Delay in payment to contractor for work done	SH	0.35	SL	0.45	0.16
8	Inaccurate material estimation	L	0.2	SL	0.45	0.09
9	Unrealistic project duration	L	0.2	VL	1	0.20
10	Inadequate or insufficient site information	SH	0.35	U	0.25	0.09

The contingency for the risks was then determined by summing up the risk values in column seven of Table 0-13. Therefore, based on the deterministic risk analysis, a contingency of 11,552,004.04 is required to manage the risks identified. Furthermore, attention should be given to the Serious and Important risks.

5.5. Application of Level 3: Probabilistic risk analysis

Due to the social importance of the Project a probabilistic analysis should be carried out in order to allocate reasonable contingency for the risks and determine the project completion date more confidently. The third workshop is conducted using the same facilitator and team to determine a three point estimate for each risk (i.e. optimistic, most likely and pessimistic). The mean value determined in Level 2 was used as a point of reference to estimate the “pessimistic” and “optimistic” values. Historic data is used in determining these values whenever available. A sample probabilistic risk register incorporating the three point estimates of limited number of risks is provided in Table 5-9 where the three cost values are determined multiplying the respective three point of severity with cost of concrete work. The probabilistic risk register including all the risks is presented by Table 0-15 in Annex I. The three point estimates provided with Table 0-13 in Annex H were used to run a Monte Carlo Simulation (MCS). The procedure followed in carrying out MCS using RiskAmp excel add-in is expressed in Annex I. These three point estimates of impact focused on the cost impact on work package i.e., concrete work of the project. Consideration of the effect of the occurrence of risks on the project work packages would give the required contingency to be allocated to each work package. Finally, the summation of contingency allocated for each work package would give the total contingency of the project.

Consideration of only the concrete work package was made to give a brief illustration. The simulation result for the contingency of the risks is shown in Figure 5-1. The risk allowance ranges between 9,895,215.65 and 13,035,991.84. The mean value for the risk allowance is 11,535,715.42. The total project cost ranges between 44,951,322.54 and 48,563,215.16. The mean value for the total project cost 46,837,897.28.

Table 5-9: Probability risk analysis

No	Brief risk description	Category of Impact	Cost (ETB)		
			Optimistic (Min.)	Most likely	Pessimistic (Max.)
1	Price inflation of construction materials	Cost	334,256.00	547,818.10	834,770.44
2	Shortage of materials in market	Cost & Duration	118,606.97	313,038.91	626,077.83
3	Shortage of fund	Cost & Duration	442,080.51	782,597.28	1,252,155.65
4	Materials damage during transportation	Cost & Duration	-	173,910.51	208,692.61
5	Long waiting time for approval of drawings	Cost & Duration	118,606.97	304,343.39	417,385.22
6	Mistakes and discrepancies in design documents	Cost & Duration	334,256.00	547,818.10	834,770.44
7	Delay in payment to contractor for work done	Cost & Duration	334,256.00	547,818.10	834,770.44
8	Inaccurate material estimation	Cost	118,606.97	313,038.91	626,077.83
9	Unrealistic project duration	Cost	309,908.52	695,642.03	1,043,463.05
10	Inadequate or insufficient site information	Cost	118,606.97	304,343.39	417,385.22

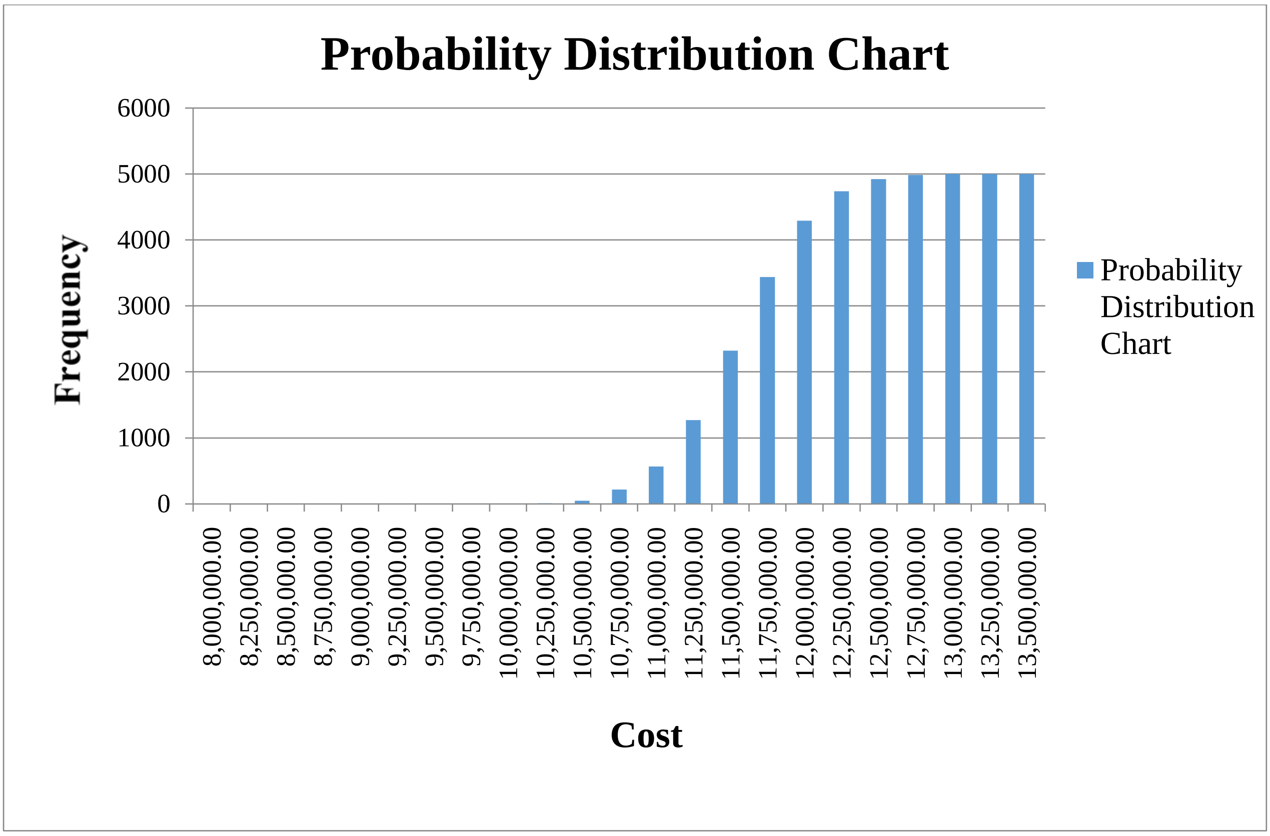


Figure 5-1: Probability Distribution Chart

Chapter 6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

1. Assessment made on the practice of risk management at building construction projects in Addis Ababa reveals:
    - The practice of risk management was found to be ignored though the organizations were not newly established and had employees that are aware of the necessary step for risk management. The survey conducted brought to light a small evidence of risk management practice.
    - The traditional method of contingency estimation was recognized as the method used to estimate contingency for projects in Ethiopia. In this method, cost contingency is considered be as random percentage of baseline cost.

2. The review of risk management processes showed there is a universal consensus about the basic steps of risk management. The universally accepted steps of risk management are planning or initiation, risk identification, risk analysis, risk response or treatment.

3. Probabilistic contingency estimating methods are found to be advantageous over the deterministic methods due to the consideration give to randomness the risk involved. Assessment of the practice of contingency estimation reveled that the use of the traditional percentage estimating method is high.

4. The scale for probability and impact of risks of building construction projects was developed after collecting the data through the questionnaire survey. Five scale expressions were provided. In carrying out risk analysis impact scales to the respective expressions are presented in form of impact values (i.e. in terms of cost or time). Since the participants are not familiar to such a process the research involved determining the impact in terms of percentage of cost of project work packages. Hence, percentages were used to correlate to the verbal expressions of probability of occurrence and impact on project cost.

5. The whole risk management process can be practiced to forward a response, in the form of contingency determination, by addressing individual risks resulting high impact. The sum of contingency allocated to each risk factor will result total project contingency.

6.2. Recommendations

The following recommendations are forwarded as a result of the findings of this research and are believed to enhance the practice of the building construction industry.

1. The practice of risk management has to be given attention, as it will provide solution to the cost and duration estimation problems the industry is facing. The responsible regulatory authority shall place the practice of risk management as a necessary condition for firms that are active in the construction industry.

2. The construction industry has to start introducing more reliable methods of estimating duration, cost, and grow out of the traditional method of estimation which may seem to be simpler but are error pron.

3. The use of probabilistic contingency estimating methods is recommended as they were found to be advantageous over the deterministic methods.

4. As the review of risk management processes showed there is a universal consensus about the basic steps of risk management the construction industry has to step into this global union. The necessary development required to carry out the universally accepted steps of risk management (i.e., planning or initiation, risk identification, risk analysis, risk response or treatment) is necessary. The development could start with development of a manual showing the principles and address the necessary steps.

5. Recommended area for future study is investigating the effect of input modeling on simulation result.

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ANNEXES

Annex A: Process of Risk Management

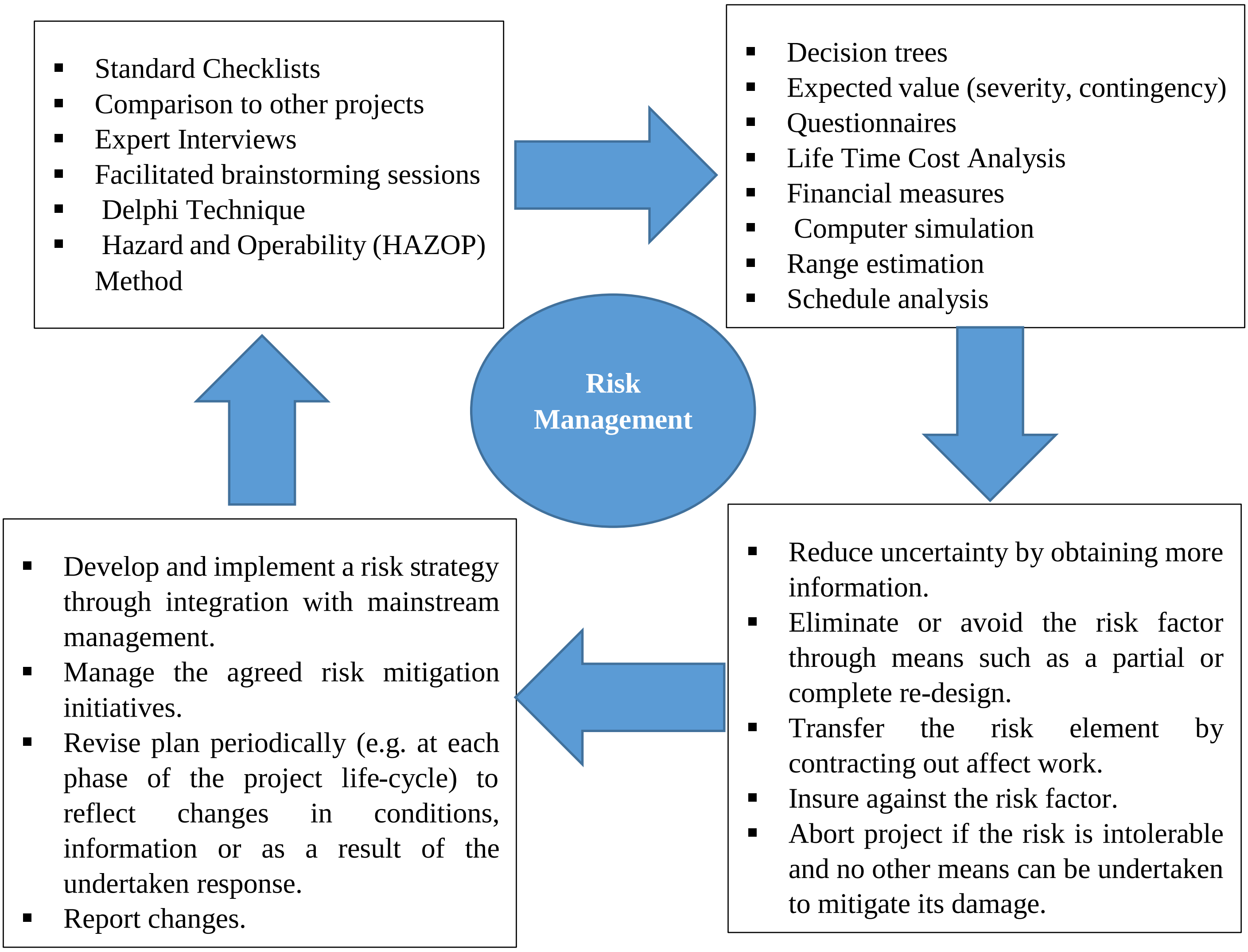

Figure 0-1: Risk analysis process [2]

Annex B: PMBOK Risk Management Overview

Figure 0-2: Overview of project risk management [5]

Annex C: CII Risk Management Process

Table 0-1: Risk management process [19]

Application of Level 1- Risk Identification	**Application of Level 2- Deterministic Risk Analysis**	**Application of Level 3- Probabilistic Risk Analysis**
• Proposes conducting a facilitated risk identification workshop which will help to identify, categorize, and document the risks of the project. • Preliminary data for the workshop including the project scope, description, cost estimation, construction schedule any allowances and contingencies made as they were developed shall be gather by the project team. • Start the workshop by asking the team to express their key issues and concerns for the project. Allow a structured brainstorming and discussion sessions about project risks. • Includes an examination of the assumptions considered during estimation of cost and schedule. • Bring in checklist to insure that the team didn't miss any commonly encountered risks.	• Prioritize the identified risks • Define the meanings of "impact" and "probability" for the project. • Qualitative assessment of the likelihood and consequences of each identified risks. • Define the ranges of probability of occurrence and impact for the identified risks. This can be done using historical data when it's available and most frequently building team consensus. • To increase confidence and help assess a reasonable contingency value, the team members could refer to their historical values for contingency on similar projects.	• Use many of the project members that were used in the previous two workshops. • Using the mean value from Level 2 as a point of reference for the most likely value use three-point estimates for the analysis (i.e., worst, best, and most likely case). • Historical data can be used whenever available, but in most cases, the best case, worst case, and most likely values are estimated by team consensus. • Fill the best case, worst case, and most likely values into the probability risk register sheet. Probability risk register also contains: - Brief description of risks - Category of impact - Three-point estimates of the impacts
Output: Risk Register • Identifying and describing the risks • Project phase at which the risk could occur • Category of impact	**Output: Risk Register** • Frequency and impact rating • Mean values for the each risks and when summed up RMV for the project • This sum of the mean values shall only be used as a point of reference. [Overlapping risks= High contingency value & Eliminating Risks=Low contingency value]	**Output: Simulation** • Using the three point estimates filled in the probability risk register sheet the Monte Carlo Simulation is then run to calculate the ranges and confidence for the project's cost and schedule.

Annex D: Rank of Risks in Building Construction

Table 0-2: Probability ranking of risk factors by Consultants

No	Risk Categories	Risk Factors in Construction	Score			Relative Importance Index	Rank
			1	2	3		
1	ER	Delays in subcontractors work	1	3	2	0.72	3
2		Skilled Labor shortage	3	2	1	0.56	6
3		Permits delayed or take longer than expected	2	1	3	0.72	3
4		Price inflation of construction materials	1	2	3	0.78	2
5		Exchange rate fluctuation	1	2	3	0.78	2
6		Shortage of materials in market	0	4	2	0.78	2
7		Location restriction	5	1	0	0.39	8
8		Adverse weather	5	1	0	0.39	8
9		Earthquake	6	0	0	0.33	9
10		Fire	6	0	0	0.33	9
11		War	6	0	0	0.33	9
12		Radioactive material	6	0	0	0.33	9
13		Frequent changes in law	5	0	1	0.44	7
14		Theft	6	0	0	0.33	9
15	OR	Shortage of plant/equipment	2	3	1	0.61	5
16		Shortage of fund	2	1	3	0.72	3
17		Strikes and labor disputes	5	1	0	0.39	8
18		Materials damage during transportation	4	2	0	0.44	7
19		Long waiting time for approval of drawings	2	2	2	0.67	4
20		Unavailability of sufficient professionals	1	5	0	0.61	5
21		Client/owner incompetency	1	3	2	0.72	3
22	TR	Mistakes and discrepancies in design documents	1	3	2	0.72	3
23		Delay in payment to contractor for work done	0	5	1	0.72	3
24		Lack of clear definition of scope	3	1	2	0.61	5
25		General occurrence of accident	4	2	0	0.44	7
26		Poor construction method	1	3	2	0.72	3
27		Variation	1	4	1	0.67	4
28		Uncertain ground conditions	3	2	1	0.56	6
29		Change order	2	4	0	0.56	6
30		Long waiting time for approval of test samples	2	2	2	0.67	4
31		Delay in response for design information	2	4	0	0.56	6
32		Interference by client	1	4	1	0.67	4
33		Poor site manag’t & supervision by the consultant	2	2	2	0.67	4
34		Inadequate contractor experience	1	3	2	0.72	3
35		Inadequate design team experience	1	3	2	0.72	3
36		Inaccurate prediction of equipment productivity	2	4	0	0.56	6
37		Low labor productivity	2	3	1	0.61	5
38	PMR	Inaccurate material estimation	1	3	2	0.72	3
39		Unrealistic project duration	1	2	3	0.78	2
40		Financial problem resulting from incorrect estimation	1	1	4	0.83	1
41		Inadequate program scheduling	1	1	4	0.83	1
42		Inadequate or insufficient site information	2	1	3	0.72	3
43		Pressure to deliver project on an accelerated schedule	2	1	3	0.72	3
44		Occurrence of dispute	3	1	2	0.61	5
45		Continuity of key resources	2	3	1	0.61	5
46		Coordination of entities	2	1	3	0.72	3
47		Insufficient insurance	4	2	0	0.44	7

Table 0-3: Probability ranking of risk factors by Contractors

No	Risk Categories	Risk Factors in Construction	Score 1	Score 2	Score 3	Relative Importance Index	Rank
1	ER	Delays in subcontractors work	0	12	8	0.80	7
2		Skilled Labor shortage	5	9	6	0.68	13
3		Permits delayed or take longer than expected	6	8	6	0.67	14
4		Price inflation of construction materials	0	6	14	0.90	3
5		Exchange rate fluctuation	4	8	8	0.73	10
6		Shortage of materials in market	2	15	3	0.68	13
7		Location restriction	11	8	1	0.50	22
8		Adverse weather	12	7	1	0.48	23
9		Earthquake	20	0	0	0.33	27
10		Fire	20	0	0	0.33	27
11		War	20	0	0	0.33	27
12		Radioactive material	20	0	0	0.33	27
13		Frequent changes in law	16	4	0	0.40	26
14		Theft	10	8	2	0.53	21
15	OR	Shortage of plant/equipment	8	7	5	0.62	17
16		Shortage of fund	5	7	8	0.72	11
17		Strikes and labor disputes	16	3	1	0.42	25
18		Materials damage during transportation	12	7	1	0.48	23
19		Long waiting time for approval of drawings	2	6	12	0.83	5
20		Unavailability of sufficient professionals	8	6	6	0.63	16
21		Client/owner incompetency	4	12	3	0.65	15
22	TR	Mistakes and discrepancies in design documents	1	7	12	0.85	4
23		Delay in payment to contractor for work done	0	3	17	0.95	1
24		Lack of clear definition of scope	4	9	7	0.72	11
25		General occurrence of accident	8	10	2	0.57	19
26		Poor construction method	3	9	8	0.75	9
27		Variation	1	9	10	0.82	6
28		Uncertain ground conditions	5	11	3	0.63	16
29		Change order	1	7	12	0.85	4
30		Long waiting time for approval of test samples	5	9	6	0.68	13
31		Delay in response for design information	1	8	11	0.83	5
32		Interference by client	4	10	6	0.70	12
33		Poor site manag’t & supervision by the consultant	1	13	6	0.75	9
34		Inadequate contractor experience	8	6	6	0.63	16
35		Inadequate design team experience	2	12	6	0.73	10
36		Inaccurate prediction of equipment productivity	6	10	4	0.63	16
37		Low labor productivity	5	9	6	0.68	13
38	PMR	Inaccurate material estimation	4	9	7	0.72	11
39		Unrealistic project duration	1	3	16	0.92	2
40		Financial problem resulting from incorrect estimation	2	4	9	0.62	17
41		Inadequate program scheduling	1	8	11	0.83	5
42		Inadequate or insufficient site information	1	14	5	0.73	10
43		Pressure to deliver project on an accelerated schedule	9	2	9	0.67	14
44		Occurrence of dispute	9	9	2	0.55	20
45		Continuity of key resources	7	11	2	0.58	18
46		Coordination of entities	2	13	5	0.72	11
47		Insufficient insurance	14	5	1	0.45	24

Table 0-4: Summary probability ranking of risk factors

No	Risk Categories	Risk Factors in Construction	RII		Weighted Average	Rank
			Consultant	Contractor		
1	ER	Delays in subcontractors work	0.72	0.80	0.78	7
2		Skilled Labor shortage	0.56	0.68	0.65	28
3		Permits delayed or take longer than expected	0.72	0.67	0.68	22
4		Price inflation of construction materials	0.78	0.90	0.87	3
5		Exchange rate fluctuation	0.78	0.73	0.74	11
6		Shortage of materials in market	0.78	0.68	0.71	19
7		Location restriction	0.39	0.50	0.47	38
8		Adverse weather	0.39	0.48	0.46	40
9		Earthquake	0.33	0.33	0.33	44
10		Fire	0.33	0.33	0.33	44
11		War	0.33	0.33	0.33	44
12		Radioactive material	0.33	0.33	0.33	44
13		Frequent changes in law	0.44	0.40	0.41	42
14		Theft	0.33	0.53	0.49	37
15	OR	Shortage of plant/equipment	0.61	0.62	0.62	31
16		Shortage of fund	0.72	0.72	0.72	16
17		Strikes and labor disputes	0.39	0.42	0.41	42
18		Materials damage during transportation	0.44	0.48	0.47	38
19		Long waiting time for approval of drawings	0.67	0.83	0.79	6
20		Unavailability of sufficient professionals	0.61	0.63	0.63	30
21		Client/owner incompetency	0.72	0.65	0.67	25
22	TR	Mistakes and discrepancies in design documents	0.72	0.85	0.82	5
23		Delay in payment to contractor for work done	0.72	0.95	0.90	1
24		Lack of clear definition of scope	0.61	0.72	0.69	20
25		General occurrence of accident	0.44	0.57	0.54	36
26		Poor construction method	0.72	0.75	0.74	11
27		Variation	0.67	0.82	0.78	7
28		Uncertain ground conditions	0.56	0.63	0.62	31
29		Change order	0.56	0.85	0.78	7
30		Long waiting time for approval of test samples	0.67	0.68	0.68	22
31		Delay in response for design information	0.56	0.83	0.77	10
32		Interference by client	0.67	0.70	0.69	20
33		Poor site manag't & supervision by the consultant	0.67	0.75	0.73	13
34		Inadequate contractor experience	0.72	0.63	0.65	28
35		Inadequate design team experience	0.72	0.73	0.73	13
36		Inaccurate prediction of equipment productivity	0.56	0.63	0.62	31
37		Low labor productivity	0.61	0.68	0.67	25
38	PMR	Inaccurate material estimation	0.72	0.72	0.72	16
39		Unrealistic project duration	0.78	0.92	0.88	2
40		Financial problem resulting from incorrect estimation	0.83	0.62	0.67	25
41		Inadequate program scheduling	0.83	0.83	0.83	4
42		Inadequate or insufficient site information	0.72	0.73	0.73	13
43		Pressure to deliver project on an accelerated schedule	0.72	0.67	0.68	22
44		Occurrence of dispute	0.61	0.55	0.56	35
45		Continuity of key resources	0.61	0.58	0.59	34
46		Coordination of entities	0.72	0.72	0.72	16
47		Insufficient insurance	0.44	0.45	0.45	41

Table 0-5: Impact ranking of risk factors by Consultants

No	Risk Categories	Risk Factors in Construction	Score			Relative Importance Index	Rank
			1	2	3		
1	ER	Delays in subcontractors work	0	2	4	0.89	2
2		Skilled Labor shortage	2	2	2	0.67	6
3		Permits delayed or take longer than expected	1	2	3	0.78	4
4		Price inflation of construction materials	0	3	3	0.83	3
5		Exchange rate fluctuation	1	4	1	0.67	6
6		Shortage of materials in market	0	2	4	0.89	2
7		Location restriction	4	2	0-	0.44	10
8		Adverse weather	5	1	0	0.39	11
9		Earthquake	4	1	1	0.50	9
10		Fire	4	1	1	0.50	9
11		War	4	1	1	0.50	9
12		Radioactive material	5	1	0	0.39	11
13		Frequent changes in law	4	0	2	0.56	8
14		Theft	6	0	0	0.33	12
15	OR	Shortage of plant/equipment	2	4	0	0.56	8
16		Shortage of fund	1	1	4	0.83	3
17		Strikes and labor disputes	3	3	0	0.50	9
18		Materials damage during transportation	4	2	0	0.44	10
19		Long waiting time for approval of drawings	1	3	2	0.72	5
20		Unavailability of sufficient professionals	1	4	1	0.67	6
21		Client/owner incompetency	2	2	2	0.67	8
22	TR	Mistakes and discrepancies in design documents	1	3	2	0.72	5
23		Delay in payment to contractor for work done	1	2	3	0.78	4
24		Lack of clear definition of scope	3	1	2	0.61	7
25		General occurrence of accident	3	2	1	0.56	8
26		Poor construction method	1	3	2	0.72	5
27		Variation	1	3	2	0.72	5
28		Uncertain ground conditions	3	1	2	0.61	7
29		Change order	2	3	1	0.61	7
30		Long waiting time for approval of test samples	2	4	0	0.56	8
31		Delay in response for design information	1	4	1	0.67	6
32		Interference by client	2	1	3	0.72	5
33		Poor site manag’t & supervision by the consultant	3	2	1	0.56	8
34		Inadequate contractor experience	2	1	3	0.72	5
35		Inadequate design team experience	1	2	3	0.78	4
36		Inaccurate prediction of equipment productivity	1	4	1	0.67	6
37		Low labor productivity	2	2	2	0.67	6
38	PMR	Inaccurate material estimation	0	0	6	1	1
39		Unrealistic project duration	2	0	4	0.78	4
40		Financial problem resulting from incorrect estimation	1	1	4	0.83	3
41		Inadequate program scheduling	1	3	2	0.72	5
42		Inadequate or insufficient site information	1	2	3	0.78	4
43		Pressure to deliver project on an accelerated schedule	1	3	2	0.72	5
44		Occurrence of dispute	3	1	2	0.61	7
45		Continuity of key resources	3	2	1	0.56	8
46		Coordination of entities	3	1	2	0.61	7
47		Insufficient insurance	4	2	0	0.44	10

Table 0-6: Impact ranking of risk factors by Contractors

No	Risk Categories	Risk Factors in Construction	Score			Relative Importance Index	Rank
			1	2	3		
1	ER	Delays in subcontractors work	1	10	8	0.75	6
2		Skilled Labor shortage	4	5	10	0.73	7
3		Permits delayed or take longer than expected	3	13	3	0.63	13
4		Price inflation of construction materials	0	6	13	0.85	2
5		Exchange rate fluctuation	4	5	10	0.73	7
6		Shortage of materials in market	2	6	11	0.78	4
7		Location restriction	4	15	0	0.57	17
8		Adverse weather	3	10	6	0.68	10
9		Earthquake	8	1	10	0.67	11
10		Fire	7	3	9	0.67	11
11		War	9	1	9	0.63	13
12		Radioactive material	8	3	8	0.63	13
13		Frequent changes in law	7	7	5	0.60	15
14		Theft	7	6	6	0.62	14
15	OR	Shortage of plant/equipment	5	8	6	0.65	12
16		Shortage of fund	1	5	13	0.83	3
17		Strikes and labor disputes	8	6	5	0.58	16
18		Materials damage during transportation	7	10	2	0.55	18
19		Long waiting time for approval of drawings	2	14	3	0.65	12
20		Unavailability of sufficient professionals	4	13	2	0.60	15
21		Client/owner incompetency	3	9	7	0.70	9
22	TR	Mistakes and discrepancies in design documents	2	7	10	0.77	5
23		Delay in payment to contractor for work done	1	4	14	0.85	2
24		Lack of clear definition of scope	1	11	7	0.73	7
25		General occurrence of accident	6	9	4	0.60	15
26		Poor construction method	1	12	6	0.72	8
27		Variation	4	9	6	0.67	11
28		Uncertain ground conditions	4	6	9	0.72	8
29		Change order	3	9	7	0.70	9
30		Long waiting time for approval of test samples	4	12	3	0.62	14
31		Delay in response for design information	2	12	5	0.68	10
32		Interference by client	3	8	8	0.72	8
33		Poor site manag’t & supervision by the consultant	2	8	9	0.75	6
34		Inadequate contractor experience	2	5	11	0.77	5
35		Inadequate design team experience	1	9	9	0.77	5
36		Inaccurate prediction of equipment productivity	4	12	3	0.62	14
37		Low labor productivity	4	8	7	0.68	10
38	PMR	Inaccurate material estimation	1	11	7	0.73	7
39		Unrealistic project duration	0	6	13	0.85	2
40		Financial problem resulting from incorrect estimation	0	5	9	0.62	14
41		Inadequate program scheduling	0	11	8	0.77	5
42		Inadequate or insufficient site information	2	11	6	0.70	9
43		Pressure to deliver project on an accelerated schedule	3	9	7	0.70	9
44		Occurrence of dispute	3	8	8	0.72	8
45		Continuity of key resources	2	14	3	0.65	12
46		Coordination of entities	4	9	6	0.67	11
47		Insufficient insurance	5	11	2	0.55	18

Table 0-7: Summary impact ranking of risk factors

No	Risk Categories	Risk Factors in Construction	RII		Weighted Average	Rank
			Consultant	Contractor		
1	ER	Delays in subcontractors work	0.89	0.75	0.78	7
2		Skilled Labor shortage	0.67	0.73	0.72	12
3		Permits delayed or take longer than expected	0.78	0.63	0.67	27
4		Price inflation of construction materials	0.83	0.85	0.85	1
5		Exchange rate fluctuation	0.67	0.73	0.72	12
6		Shortage of materials in market	0.89	0.78	0.81	5
7		Location restriction	0.44	0.57	0.54	45
8		Adverse weather	0.39	0.68	0.62	36
9		Earthquake	0.50	0.67	0.63	31
10		Fire	0.50	0.67	0.63	31
11		War	0.50	0.63	0.60	38
12		Radioactive material	0.39	0.63	0.58	42
13		Frequent changes in law	0.56	0.60	0.59	40
14		Theft	0.33	0.62	0.55	44
15	OR	Shortage of plant/equipment	0.56	0.65	0.63	31
16		Shortage of fund	0.83	0.83	0.83	2
17		Strikes and labor disputes	0.50	0.58	0.56	43
18		Materials damage during transportation	0.44	0.55	0.53	46
19		Long waiting time for approval of drawings	0.72	0.65	0.67	27
20		Unavailability of sufficient professionals	0.67	0.60	0.62	36
21		Client/owner incompetency	0.67	0.70	0.69	20
22	TR	Mistakes and discrepancies in design documents	0.72	0.77	0.76	9
23		Delay in payment to contractor for work done	0.78	0.85	0.83	2
24		Lack of clear definition of scope	0.61	0.73	0.71	17
25		General occurrence of accident	0.56	0.60	0.59	40
26		Poor construction method	0.72	0.72	0.72	12
27		Variation	0.72	0.67	0.68	23
28		Uncertain ground conditions	0.61	0.72	0.69	20
29		Change order	0.61	0.70	0.68	23
30		Long waiting time for approval of test samples	0.56	0.62	0.60	38
31		Delay in response for design information	0.67	0.68	0.68	23
32		Interference by client	0.72	0.72	0.72	12
33		Poor site manag’t & supervision by the consultant	0.56	0.75	0.71	17
34		Inadequate contractor experience	0.72	0.77	0.76	9
35		Inadequate design team experience	0.78	0.77	0.77	8
36		Inaccurate prediction of equipment productivity	0.67	0.62	0.63	31
37		Low labor productivity	0.67	0.68	0.68	23
38	PMR	Inaccurate material estimation	1	0.73	0.79	6
39		Unrealistic project duration	0.78	0.85	0.83	2
40		Financial problem resulting from incorrect estimation	0.83	0.62	0.67	27
41		Inadequate program scheduling	0.72	0.77	0.76	9
42		Inadequate or insufficient site information	0.78	0.70	0.72	12
43		Pressure to deliver project on an accelerated schedule	0.72	0.70	0.71	17
44		Occurrence of dispute	0.61	0.72	0.69	20
45		Continuity of key resources	0.56	0.65	0.63	31
46		Coordination of entities	0.61	0.67	0.65	30
47		Insufficient insurance	0.44	0.55	0.53	46

Table 0-8: Severity ranking of risk factors by Consultants

No	Risk Categories	Risk Factors in Construction	Severity rating by Consultant	Rank
1	ER	Delays in subcontractors work	5.83	5
2		Skilled Labor shortage	3.67	16
3		Permits delayed or take longer than expected	5.67	6
4		Price inflation of construction materials	6.17	3
5		Exchange rate fluctuation	5.00	9
6		Shortage of materials in market	6.33	2
7		Location restriction	1.67	24
8		Adverse weather	1.33	26
9		Earthquake	1.50	25
10		Fire	1.50	25
11		War	1.50	25
12		Radioactive material	1.17	27
13		Frequent changes in law	2.67	20
14		Theft	1.00	28
15	OR	Shortage of plant/equipment	3.17	19
16		Shortage of fund	6.00	4
17		Strikes and labor disputes	1.83	23
18		Materials damage during transportation	1.83	23
19		Long waiting time for approval of drawings	4.67	11
20		Unavailability of sufficient professionals	3.83	15
21		Client/owner incompetency	4.67	11
22	TR	Mistakes and discrepancies in design documents	4.83	10
23		Delay in payment to contractor for work done	5.17	8
24		Lack of clear definition of scope	4.17	14
25		General occurrence of accident	2.33	21
26		Poor construction method	5.00	9
27		Variation	4.50	12
28		Uncertain ground conditions	3.67	16
29		Change order	3.17	19
30		Long waiting time for approval of test samples	3.67	16
31		Delay in response for design information	3.33	18
32		Interference by client	4.67	11
33		Poor site management & supervision by the consultant	3.83	15
34		Inadequate contractor experience	5.17	8
35		Inadequate design team experience	5.50	7
36		Inaccurate prediction of equipment productivity	3.50	17
37		Low labor productivity	3.83	15
38	PMR	Inaccurate material estimation	6.50	1
39		Unrealistic project duration	6.00	4
40		Financial problem resulting from incorrect estimation	6.17	3
41		Inadequate program scheduling	5.83	5
42		Inadequate or insufficient site information	5.67	6
43		Pressure to deliver project on an accelerated schedule	5.17	8
44		Occurrence of dispute	3.67	16
45		Continuity of key resources	3.33	18
46		Coordination of entities	4.33	13
47		Insufficient insurance	2.00	22

Table 0-9: Severity ranking of risk factors by Contractors

No	Risk Categories	Risk Factors in Construction	Severity rating by Contractor	Rank
1	ER	Delays in subcontractors work	5.45	8
2		Skilled Labor shortage	4.65	20
3		Permits delayed or take longer than expected	3.85	29
4		Price inflation of construction materials	7.10	2
5		Exchange rate fluctuation	5.15	10
6		Shortage of materials in market	4.95	16
7		Location restriction	2.55	40
8		Adverse weather	3.00	38
9		Earthquake	2.00	44
10		Fire	2.00	44
11		War	1.90	46
12		Radioactive material	1.90	46
13		Frequent changes in law	2.25	43
14		Theft	3.15	37
15	OR	Shortage of plant/equipment	3.70	31
16		Shortage of fund	5.55	6
17		Strikes and labor disputes	2.30	42
18		Materials damage during transportation	2.60	39
19		Long waiting time for approval of drawings	5.10	13
20		Unavailability of sufficient professionals	3.55	33
21		Client/owner incompetency	4.25	28
22	TR	Mistakes and discrepancies in design documents	5.85	4
23		Delay in payment to contractor for work done	7.35	1
24		Lack of clear definition of scope	4.85	17
25		General occurrence of accident	3.30	36
26		Poor construction method	5.00	15
27		Variation	5.05	14
28		Uncertain ground conditions	4.35	26
29		Change order	5.50	7
30		Long waiting time for approval of test samples	3.85	29
31		Delay in response for design information	5.25	9
32		Interference by client	4.70	19
33		Poor site management & supervision by the consultant	5.15	10
34		Inadequate contractor experience	4.60	22
35		Inadequate design team experience	5.15	10
36		Inaccurate prediction of equipment productivity	3.50	34
37		Low labor productivity	4.45	25
38	PMR	Inaccurate material estimation	4.65	20
39		Unrealistic project duration	7.00	3
40		Financial problem resulting from incorrect estimation	4.55	23
41		Inadequate program scheduling	5.70	5
42		Inadequate or insufficient site information	4.75	18
43		Pressure to deliver project on an accelerated schedule	4.55	23
44		Occurrence of dispute	3.65	32
45		Continuity of key resources	3.40	35
46		Coordination of entities	4.30	27
47		Insufficient insurance	2.35	41

Table 0-10: Summary Severity ranking of risk factors

No	Risk Categories	Risk Factors in Construction	Severity		Weighted Average	Rank
			Consultant	Contractor		
1	ER	Delays in subcontractors work	5.83	5.45	5.54	7
2		Skilled Labor shortage	3.67	4.65	4.42	24
3		Permits delayed or take longer than expected	5.67	3.85	4.27	28
4		Price inflation of construction materials	6.17	7.10	6.88	1
5		Exchange rate fluctuation	5.00	5.15	5.12	10
6		Shortage of materials in market	6.33	4.95	5.27	8
7		Location restriction	1.67	2.55	2.35	40
8		Adverse weather	1.33	3.00	2.62	38
9		Earthquake	1.50	2.00	1.88	44
10		Fire	1.50	2.00	1.88	44
11		War	1.50	1.90	1.81	46
12		Radioactive material	1.17	1.90	1.73	47
13		Frequent changes in law	2.67	2.25	2.35	40
14		Theft	1.00	3.15	2.65	37
15	OR	Shortage of plant/equipment	3.17	3.70	3.58	33
16		Shortage of fund	6.00	5.55	5.65	5
17		Strikes and labor disputes	1.83	2.30	2.19	43
18		Materials damage during transportation	1.83	2.60	2.42	39
19		Long waiting time for approval of drawings	4.67	5.10	5.00	12
20		Unavailability of sufficient professionals	3.83	3.55	3.62	32
21		Client/owner incompetency	4.67	4.25	4.35	25
22	TR	Mistakes and discrepancies in design documents	4.83	5.85	5.62	6
23		Delay in payment to contractor for work done	5.17	7.35	6.85	2
24		Lack of clear definition of scope	4.17	4.85	4.69	21
25		General occurrence of accident	2.33	3.30	3.08	36
26		Poor construction method	5.00	5.00	5.00	12
27		Variation	4.50	5.05	4.92	16
28		Uncertain ground conditions	3.67	4.35	4.19	29
29		Change order	3.17	5.50	4.96	14
30		Long waiting time for approval of test samples	3.67	3.85	3.81	30
31		Delay in response for design information	3.33	5.25	4.81	19
32		Interference by client	4.67	4.70	4.69	21
33		Poor site manag’t & supervision by the consultant	3.83	5.15	4.85	18
34		Inadequate contractor experience	5.17	4.60	4.73	20
35		Inadequate design team experience	5.50	5.15	5.23	9
36		Inaccurate prediction of equipment productivity	3.50	3.50	3.50	34
37		Low labor productivity	3.83	4.45	4.31	26
38	PMR	Inaccurate material estimation	6.50	4.65	5.08	11
39		Unrealistic project duration	6.00	7.00	6.77	3
40		Financial problem resulting from incorrect estimation	6.17	4.55	4.92	16
41		Inadequate program scheduling	5.83	5.70	5.73	4
42		Inadequate or insufficient site information	5.67	4.75	4.96	14
43		Pressure to deliver project on an accelerated schedul	5.17	4.55	4.69	21
44		Occurrence of dispute	3.67	3.65	3.65	31
45		Continuity of key resources	3.33	3.40	3.38	35
46		Coordination of entities	4.33	4.30	4.31	26
47		Insufficient insurance	2.00	2.35	2.27	42

Annex E: Checklist for Risk Identification

SECTION I: General Information about the project

Project name: Enter the name

Name of client: Enter name.

Name of consultant: Enter name. Category: Enter grade.

Name of contractor: Enter name. Grade: Enter name. Category: Enter grade.

Building type: Enter type.

Project status: In progress ☐ Enter project status.

Where it is located: Enter project address.

Number of floors: Enter floor no. Area it covers: Enter the area in sq.m.

Project cost Estimation: Enter project cost in ETB.

Additional description of the project:

SECTION II: Checklist for identification risk in building construction projects

No.	Risk Category	Brief Risk Description	Detail Risk Description	Category of Impact		
				Cost	Time	Quality
1	External Risk	Delays in subcontractors work		☐	☐	☐
2		Skilled Labor shortage		☐	☐	☐
3		Permits delayed or take longer than expected		☐	☐	☐
4		Price inflation of construction materials		☐	☐	☐
5		Exchange rate fluctuation		☐	☐	☐
6		Shortage of materials in market		☐	☐	☐
7		Location restriction		☐	☐	☐
8		Adverse weather		☐	☐	☐
9		Earthquake		☐	☐	☐
10		Fire		☐	☐	☐
11		War		☐	☐	☐
12		Radioactive material		☐	☐	☐
13		Frequent changes in law		☐	☐	☐
14		Theft		☐	☐	☐
15	Organizational Risk	Shortage of plant/equipment		☐	☐	☐
16		Shortage of fund		☐	☐	☐
17		Strikes and labor disputes		☐	☐	☐
18		Materials damage during transportation		☐	☐	☐
19		Long waiting time for approval of drawings		☐	☐	☐
20		Unavailability of sufficient professionals		☐	☐	☐
21		Client/owner incompetency		☐	☐	☐
22	Technical Risk	Mistakes and discrepancies in design documents		☐	☐	☐
23		Delay in payment to contractor for work done		☐	☐	☐
24		Lack of clear definition of scope		☐	☐	☐
25		General occurrence of accident		☐	☐	☐
26		Poor construction method		☐	☐	☐
27		Variation		☐	☐	☐
28		Uncertain ground conditions		☐	☐	☐
29		Change order		☐	☐	☐
30		Long waiting time for approval of test samples		☐	☐	☐
31		Delay in response for design information		☐	☐	☐
32		Interference by client		☐	☐	☐
33		Poor site management & supervision by the consultant		☐	☐	☐
34		Inadequate contractor experience		☐	☐	☐
35		Inadequate design team experience		☐	☐	☐
36		Inaccurate prediction of equipment productivity		☐	☐	☐
37		Low labor productivity		☐	☐	☐
38	Project Management Risk	Inaccurate material estimation		☐	☐	☐
39		Unrealistic project duration		☐	☐	☐
40		Financial problem resulting from incorrect estimation		☐	☐	☐
41		Inadequate program scheduling		☐	☐	☐
42		Inadequate or insufficient site information		☐	☐	☐
43		Pressure to deliver project on an accelerated schedule		☐	☐	☐
44		Occurrence of dispute		☐	☐	☐
45		Continuity of key resources		☐	☐	☐
46		Coordination of entities		☐	☐	☐
47		Insufficient insurance		☐	☐	☐

To identify additional risk specific to the project arrange risk statements in a three-part as follows:

‘As a result of <definite cause>, <uncertain event> may occur, which would lead to <effect on objective(s)>’

No	Definite Cause	Uncertain Event	Category of impact
Risk item number.	Enter the cause.	Enter the uncertain event.	Enter the affected objective.
Risk item number.	Enter the cause.	Enter the uncertain event.	Enter the affected objective.
Risk item number.	Enter the cause.	Enter the uncertain event.	Enter the affected objective.

Annex F: Questionnaire

Introduction

Construction projects are unavoidably unique, works with nature and in a changing environment makes them uncertain. Hence risk[1]cannot be avoided but it is recommended to recognize, assess and manage it. This reason brings about the essence of risk management to ensure successful project delivery. Risk management is an important project management planning and control tool which plays a vital role in improving decision-making that is active throughout the life of a project. Its objective is to increase and decrease the probability and impact of positive and negative events respectively.

This thesis research is intended to identify common risks at building construction projects, detect practiced contingency determining methods, and establish scales for determining probability of occurrence and impact (consequence) of risk. The development of scales for probability of occurrence and impact of risk will be handy for professionals involved in the construction project life cycle.

This paper could not achieve its meant purpose without the involvement of the relevant stakeholders. Thanking you in advance for sharing your valuable time, despite your busy schedule, I am kindly requesting your priceless feedback.

If you have any question feel free to contact me [091 195 0208 Hana Mekuria]

SECTION I: GENERAL INFORMATION

I) Questions with respect to the Company in concern:

Company name: ____

Address:____

Category: ____________ Grade: _____________

Year of establishment: __________________________________

General experience of the firm in the construction industry: _____________________

Experience of the firm with the current Grade: _____________________

Rank the type of work usually undertaken:

☐ Commercial/ industrial building ☐ Public/ community building

☐ Other, please specify:

____

____

[1] Risk is defined as an uncertain event or condition that if it occurs has a positive or negative impact on at least one project objective that could include scope, schedule, cost, and quality.

II) Information with respect to the respondent:

Name:____

Current position of the respondent in the company:_____________________________________

Professional background: ____

Year of experience

a. In the construction industry: ____________________

b. Within the cited firm: _________________________

In how many building projects have you been involved in:_______________________

SECTION II: BASIC RISK MANAGEMENT: AWARENESS

2.1. Are you aware of the concept of risk management?

☐Yes ☐No

2.2. How do you describe the level ofyour awareness of risk management principle?

☐You only know what it means.

☐You are aware of the principles and necessary steps

☐You are well acquainted with the steps that can be implemented in risk management

2.3. Indicate how you have gained this awareness about the concept of risk management principles

☐Word of mouth ☐Through study ☐From training

☐From practice ☐Don't know about it

☐Other means, please specify: ____

2.4. Does yourcompany has formal risk management practice at organization and project level?

☐Yes ☐ No

2.5. If your answer to question 2.4 is No, what do you think is the reason:

☐ It is not necessary ☐ It is expensive ☐ Time consuming

☐ Lack of awareness ☐ Fear of the need to hire additional staff

☐ Other, please specify: ____

2.6. If your answer to question 2.4 is Yes, then what method does your company use to deal with risks that arise?

____

____

____

____

2.7. At what stage of project life-cycle do you perform risk management? [Choose all that apply] **consultant**

- ☐ Planning stage
- ☐ End of preliminary designing
- ☐ End of conceptual design
- ☐ End of final design
- ☐ Time of tendering
- ☐ During construction stage
- ☐ After completion of construction
- ☐ Other, please specify: ____________________

2.8. At what stage of project life-cycle do you perform the risk management? [Choose all that apply] **contractor**

- ☐ Before submitting bid document
- ☐ During planning
- ☐ During construction

2.9. Identify who performs the risk management process?

- ☐ Risk manager in your organization
- ☐ Department personnel
- ☐ Consultant [Design/ Supervision]
- ☐ Independent risk consultant
- ☐ Insurance Companies
- ☐ Other, please specify: _______________________

2.10. Which of the following methods do you often use to identify risks associated with a project? Rank them on a scale of 1-5 where 1=least use and 5=most use.

No	METHOD	RANK				
		1	2	3	4	5
1	Brain-storming					
2	Checklist					
3	Expert opinion					
4	Risk records					
5	Records					

SECTION III: CHECKLIST VERIFICATION

3.1. If risks are categorized into four major groups as presented in Table 1, rank the likelihood (probability) of risk factors in construction projects. Rank them on a scale of 1-3 where 1=Less likely, 2=Likely, 3=Highly likely.

3.2. If risks are categorized into four major groups as presented in Table 2, rank the impact (consequence) of risk factors in construction projects. Rank them on a scale of 1-3 where 1=Low level of impact, 2=Medium level of impact, 3=High level of impact.

Table 1: Rank the likelihood (probability) of risk factors

No	Risk Categories	Risk Factors in Construction	Rank		
			1	2	3
1	External Risks	Delays in subcontractors work			
2		Labor shortage			
3		Permits delayed or take longer than expected			
4		Price inflation of construction materials			
5		Exchange rate fluctuation			
6		Shortage of materials in market			
7		Location restriction			
8		Adverse weather			
9		Earthquake			
10		Fire			
11		War			
12		Radioactive material			
13		Frequent changes in law			
14		Theft			
15	Organizational Risks	Shortage of plant/equipment			
16		Shortage of fund			
17		Strikes and labor disputes			
18		Materials damage during transportation			
19		Long waiting time for approval of drawings			
20		Unavailability of sufficient professionals			
21		Client/owner incompetency			
22	Technical Risks	Mistakes and discrepancies in design documents			
23		Delay in payment to contractor for work done			
24		Lack of clear definition of scope			
25		General occurrence of accident occurrence			
26		Poor construction method			
27		Variation			
28		Uncertain ground conditions			
29		Change order			
30		Long waiting time for approval of test samples			
31		Delay in response for design information			
32		Interference by client			
33		Poor site management and supervision by the consultant			
34		Inadequate contractor experience			
35		Inadequate design team experience			
36		Inaccurate prediction of equipment productivity			
37		Low labour productivity			
38	Project Management Risks	Inaccurate material estimation			
39		Unrealistic project duration			
40		Financial problem resulting from incorrect estimation			
41		Inadequate program scheduling			
42		Inadequate or insufficient site information			
43		Pressure to deliver project on an accelerated schedule			
44		Occurrence of dispute			
45		Continuity of key resources			
46		Coordination of entities			
47		Insufficient insurance			

Table 2: Rank the impact (consequence) of risk factors

No	Risk Categories	Risk Factors in Construction	Rank		
			1	2	3
1	External Risks	Delays in subcontractors work			
2		Labor shortage			
3		Permits delayed or take longer than expected			
4		Price inflation of construction materials			
5		Exchange rate fluctuation			
6		Shortage of materials in market			
7		Location restriction			
8		Adverse weather			
9		Earthquake			
10		Fire			
11		War			
12		Radioactive material			
13		Frequent changes in law			
14		Theft			
15	Organizational Risks	Shortage of plant/equipment			
16		Shortage of fund			
17		Strikes and labor disputes			
18		Materials damage during transportation			
19		Long waiting time for approval of drawings			
20		Unavailability of sufficient professionals			
21		Client/owner incompetency			
22	Technical Risks	Mistakes and discrepancies in design documents			
23		Delay in payment to contractor for work done			
24		Lack of clear definition of scope			
25		General occurrence of accident occurrence			
26		Poor construction method			
27		Variation			
28		Uncertain ground conditions			
29		Change order			
30		Long waiting time for approval of test samples			
31		Delay in response for design information			
32		Interference by client			
33		Poor site management and supervision by the consultant			
34		Inadequate contractor experience			
35		Inadequate design team experience			
36		Inaccurate prediction of equipment productivity			
37		Low labour productivity			
38	Project Management Risks	Inaccurate material estimation			
39		Unrealistic project duration			
40		Financial problem resulting from incorrect estimation			
41		Inadequate program scheduling			
42		Inadequate or insufficient site information			
43		Pressure to deliver project on an accelerated schedule			
44		Occurrence of dispute			
45		Continuity of key resources			
46		Coordination of entities			
47		Insufficient insurance			

SECTION IV: ESTIMATION

4.1. What are the steps your company considers in estimating project cost and duration?

____
____
____
____
____
____
____
____
____
____
____

4.2. Which contingency estimating methods does your company apply? Rank them on a scale of 1-5 where 1=least use and 5=most use.

No	**Contingency Estimating Methods**	**RANK**				
		1	**2**	**3**	**4**	**5**
1	Traditional percentage					
2	Individual risks-expected value					
3	Range Estimating					
4	Factor Rating					
5	Monte Carlo Simulation					
6	Advanced Estimating Models					

SECTION V: PROBABILITY OF OCCURRENCE

QUALITATIVE EXPRESSIONS IN TERMS OF SINGLE VALUES

Choose the appropriate range of values that you believe best represents the probability of occurrence for each descri ptor. Please answer the following questions by checking one of the following options.

5.1. If someone told you an outcome was VERY LIKELY, what value would best represent the probability of that outcome occurring?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

5.2. If someone told you an outcome was LIKELY, what value would best represent the probability of the outcome occurring?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

5.3. If someone told you an outcome was SOMEWHAT LIKELY, what value would best represent the probability of the outcome occurring?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

5.4. If someone told you an outcome was UNLIKELY, what value would best represent the probability of the outcome occurring?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

5.5. If someone told you an outcome was VERY UNLIKELY, what value would best represent the probability of the outcome occurring?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

QUALITATIVE EXPRESSIONS IN TERMS OF RANGES

Choose the appropriate range of values that you believe best represents the probability of occurrence for each descri ptor. Please answer the following questions by checking TWO OR MORE boxes.

5.6. If someone told you an outcome was VERY LIKELY, what range of values would best represent the probability of that outcome occurring?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

5.7. If someone told you an outcome was LIKELY, what range of values would best represent the probability of that outcome occurring?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

5.8. If someone told you an outcome was SOMEWHAT LIKELY, what range of values would best represent the probability of that outcome occurring?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

5.9. If someone told you an outcome was UNLIKELY, what range of values would best represent the probability of that outcome occurring?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

5.10. If someone told you an outcome was VERY UNLIKELY, what range of values would best represent the probability of that outcome occurring?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

PREFERENCE FOR QUALITATIVE EXPRESSIONS

5.11. Which method did you find was easier to use to describe the probability of an outcome?

☐No preference ☐Responding using a range of values ☐Responding using a single value

UNDERSTANDING LIKELIHOOD

Answer the following by checking as many or as few boxes that seem appropriate.

5.12. Suppose someone told you an event had a 99% chance of occurring; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very Likely
☐ Likely
☐ Somewhat Likely
☐ Unlikely
☐ Extremely Unlikely

5.13. Suppose someone told you an event had a 90% chance of occurring; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very Likely
☐ Likely
☐ Somewhat Likely
☐ Unlikely
☐ Extremely Unlikely

5.14. Suppose someone told you an event had an 80% chance of occurring; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very Likely
☐ Likely
☐ Somewhat Likely
☐ Unlikely
☐ Extremely Unlikely

5.15. Suppose someone told you an event had a 70% chance of occurring; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very Likely
☐ Likely
☐ Somewhat Likely
☐ Unlikely
☐ Extremely Unlikely

5.16. Suppose someone told you an event had a 60% chance of occurring; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very Likely
☐ Likely
☐ Somewhat Likely
☐ Unlikely
☐ Extremely Unlikely

5.17. Suppose someone told you an event had a 50% chance of occurring; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very Likely ☐ Somewhat Likely ☐ Extremely Unlikely

☐ Likely ☐ Unlikely

5.18. Suppose someone told you an event had a 40% chance of occurring; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very Likely ☐ Somewhat Likely ☐ Extremely Unlikely

☐ Likely ☐ Unlikely

5.19. Suppose someone told you an event had a 30% chance of occurring; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very Likely ☐ Somewhat Likely ☐ Extremely Unlikely

☐ Likely ☐ Unlikely

5.20. Suppose someone told you an event had a 20% chance of occurring; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very Likely ☐ Somewhat Likely ☐ Extremely Unlikely

☐ Likely ☐ Unlikely

5.21. Suppose someone told you an event had a 10% chance of occurring; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very Likely ☐ Somewhat Likely ☐ Extremely Unlikely

☐ Likely ☐ Unlikely

5.22. Suppose someone told you an event had a 1% chance of occurring; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very Likely ☐ Somewhat Likely ☐ Extremely Unlikely

☐ Likely ☐ Unlikely

SECTION VI: IMPACT ON PROJECT COST

QUALITATIVE EXPRESSIONS IN TERMS OF SINGLE VALUES

Choose the appropriate value that you believe best represents the impact of an outcome for each description. Please answer the following questions by checking one of the following options.

6.1. If someone told you an outcome was EXTREMELY HIGH, what value would best represent the impact of that outcome on the project cost?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

6.2. If someone told you an outcome was HIGH, what value would best represent the impact of the outcome on the project cost?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

6.3. If someone told you an outcome was SOMEWHAT HIGH, what value would best represent the impact of the outcome on the project cost?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

6.4. If someone told you an outcome was LOW, what value would best represent the impact of the outcome on the project cost?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

6.5. If someone told you an outcome was VERY LOW, what value would best represent the impact of the outcome on the project cost?

☐0	☐20	☐30	☐45	☐60	☐75	☐90
☐5	☐25	☐35	☐50	☐65	☐80	☐95
☐10	☐15	☐40	☐55	☐70	☐85	☐100

QUALITATIVE EXPRESSIONS IN TERMS OF RANGES

Choose the appropriate range of values that you believe best represents the impact on project cost for each description. Please answer the following questions by checking TWO OR MORE boxes.

6.6. If someone told you an outcome was EXTREMELY HIGH, what range of values would best represent the impact of that outcome on project cost?

☐0 ☐20 ☐30 ☐45 ☐60 ☐75 ☐90

☐5 ☐25 ☐35 ☐50 ☐65 ☐80 ☐95

☐10 ☐15 ☐40 ☐55 ☐70 ☐85 ☐100

6.7. If someone told you an outcome was HIGH, what range of values would best represent the impact of that outcome on project cost?

☐0 ☐20 ☐30 ☐45 ☐60 ☐75 ☐90

☐5 ☐25 ☐35 ☐50 ☐65 ☐80 ☐95

☐10 ☐15 ☐40 ☐55 ☐70 ☐85 ☐100

6.8. If someone told you an outcome was SOMEWHAT HIGH, what range of values would best represent the impact of that outcome on project cost?

☐0 ☐20 ☐30 ☐45 ☐60 ☐75 ☐90

☐5 ☐25 ☐35 ☐50 ☐65 ☐80 ☐95

☐10 ☐15 ☐40 ☐55 ☐70 ☐85 ☐100

6.9. If someone told you an outcome was LOW, what range of values would best represent the impact of that outcome on project cost?

☐ 0 ☐ 20 ☐ 30 ☐ 45 ☐ 60 ☐ 75 ☐ 90

☐ 5 ☐ 25 ☐ 35 ☐ 50 ☐ 65 ☐ 80 ☐ 95

☐ 10 ☐ 15 ☐ 40 ☐ 55 ☐ 70 ☐ 85 ☐ 100

6.10. If someone told you an outcome was VERY LOW, what range of values would best represent the impact of that outcome on project cost?

☐ 0 ☐ 20 ☐ 30 ☐ 45 ☐ 60 ☐ 75 ☐ 90

☐ 5 ☐ 25 ☐ 35 ☐ 50 ☐ 65 ☐ 80 ☐ 95

☐ 10 ☐ 15 ☐ 40 ☐ 55 ☐ 70 ☐ 85 ☐ 100

PREFERENCE FOR QUALITATIVE EXPRESSIONS

6.11. Which method did you find was easier to use to describe the impact of an outcome on project cost?

☐ No preference ☐ Responding using a range of values ☐ Responding using a single value

UNDERSTANDING IMPACT

Answer the following by checking as many or as few boxes that seem appropriate.

6.12. Suppose someone told you an event had a 99% impact on project cost; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

- ☐ Very High
- ☐ High
- ☐ Somewhat High
- ☐ Low
- ☐ Very Low

6.13. Suppose someone told you an event had a 90% impact on project cost ; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

- ☐ Very High
- ☐ High
- ☐ Somewhat High
- ☐ Low
- ☐ Very Low

6.14. Suppose someone told you an event had an 80% impact on project cost; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

- ☐ Very High
- ☐ High
- ☐ Somewhat High
- ☐ Low
- ☐ Very Low

6.15. Suppose someone told you an event had a 70% impact on project cost ; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

- ☐ Very High
- ☐ High
- ☐ Somewhat High
- ☐ Low
- ☐ Very Low

6.16. Suppose someone told you an event had a 60% impact on project cost ; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

- ☐ Very High
- ☐ High
- ☐ Somewhat High
- ☐ Low
- ☐ Very Low

6.17. Suppose someone told you an event had a 50% impact on project cost ; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very High ☐ Low
☐ High ☐Very Low
☐ Somewhat High

6.18. Suppose someone told you an event had a 40% impact on project cost; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very High ☐ Low
☐ High ☐ Very Low
☐ Somewhat High

6.19. Suppose someone told you an event had a 30% impact on project cost; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very High ☐ Low
☐ High ☐ Very Low
☐ Somewhat High

6.20. Suppose someone told you an event had a 20% impact on project cost ; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very High ☐ Low
☐ High ☐ Very Low
☐ Somewhat High

6.21. Suppose someone told you an event had a 10% impact on project cost; which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very High ☐ Low
☐ High ☐ Very Low
☐ Somewhat High

6.22. Suppose someone told you an event had a 1% impact on project cost ;which of the following expressions would you use to describe that probability? Check as many or as few that seem appropriate.

☐ Very High

☐ High

☐ Somewhat High

☐ Low

☐ Very Low

If you have any suggestion and comment:

----------**The End**----------

Thank You for Your Time

Annex G: Level 1- Risk Identification

No.	Status	Brief Risk Description	Detail Risk Description	Project Phase	Category of Impact
1	Active	Delays in subcontractors work	Likelihood that low performance of subcontractor causes delay.		Schedule
2	Active	Labor shortage	Increase in cost due to transport and arranging living area for labor force brought from elsewhere because of labor shortage of the project area.		Cost
3	Active	Permits delayed or take longer than expected	The inability of getting permits and requirements resulting in delay.		Schedule
4	Active	Price inflation of construction materials	The effect of increase in material cost on project cost and progress.		Cost
5	Active	Exchange rate fluctuation	The fluctuation of foreign currency exchange rate from what was agreed upon.		Cost
6	Active	Shortage of materials in market	The effect on having very limited availability of materials in the market.		Cost and schedule
7	Active	Location restriction	Likelihood that the restriction will create difficulties during construction during construction (e.g. a site located in congested urban area with existing structures on both sides)		Cost
8	Active	Adverse weather			Cost and schedule
9	Active	Earthquake			Cost and schedule
10	Active	Fire			Cost and schedule
11	Active	War			Cost and schedule
12	Active	Radioactive material			Cost
13	Active	Frequent changes in law			Schedule
14	Active	Theft			Cost
15	Active	Shortage of plant/equipment			Schedule
16	Active	Shortage of fund			Schedule
17	Active	Strikes and labor disputes			Schedule
18	Active	Materials damage during transportation			Cost
19	Active	Long waiting time for approval of drawings			Schedule
20	Active	Unavailability of sufficient professionals			Cost
21	Active	Client/owner incompetency	The familiarity and skill the client has about construction project processes.		Cost and schedule
22	Active	Mistakes and discrepancies in design documents			Cost and schedule
23	Active	Delay in payment to contractor for work done			Schedule
24	Active	Lack of clear definition of scope	Whether the project requirements keep changing or is the project scope well defined.		Cost and schedule
25	Active	General occurrence of accident	Probability of the occurrence of health and safety problems at site.		Cost and schedule
26	Active	Poor construction method	Deployment of poor construction method on the construction process.		Cost and schedule

No.	Status	Brief Risk Description	Detail Risk Description	Project Phase	Category of Impact
27	Active	Variation			Cost and schedule
28	Active	Uncertain ground conditions	Likelihood that the ground (geotechnical) conditions will present problem to the construction of underground part of the structure.		Cost and schedule
29	Active	Change order			Cost and schedule
30	Active	Long waiting time for approval of test samples	Delay caused due to waiting time to receive test samples approval.		Schedule
31	Active	Delay in response for design information	Delay in getting response for design information.		Schedule
32	Active	Interference by client			Schedule
33	Active	Poor site management and supervision by the consultant			Cost
34	Active	Inadequate contractor experience	Experience of this resource with similar projects.		Schedule
35	Active	Inadequate design team experience	Experience of this resource with similar projects.		Cost
36	Active	Inaccurate prediction of equipment productivity			Cost and schedule
37	Active	Low labor productivity			Cost and schedule
38	Active	Inaccurate material estimation			Cost
39	Active	Unrealistic project duration	Unrealistic estimation of project duration presenting a demand for accelerating the project.		Cost
40	Active	Financial problem resulting from incorrect estimation			Cost
41	Active	Inadequate program scheduling			Cost and schedule
42	Active	Inadequate or insufficient site information			Cost
43	Active	Pressure to deliver project on an accelerated schedule			Cost
44	Active	Occurrence of dispute			Schedule
45	Active	Continuity of key resources	The effect presence of resources through out the project life, especially of key management team.		Schedule
46	Active	Coordination of entities	How would the coordination of the different entities involved affect the project?		Cost and schedule
47	Active	Insufficient insurance	The risk of having an insufficient insurance.		Cost

Annex H: Level 2- Deterministic Risk Analysis

Table 0-11: Probability-Deterministic risk analysis

No	Risk Factors in Construction	Rank	Qualitative expression	Optimistic (Min)	Most likely	Pessimistic (Max)
1	Delays in subcontractors work	3	SL	0.31	0.45	0.6
2	Skilled Labor shortage	1	VU	0	0.1	0.1
3	Permits delayed or take longer than expected	2	U	0.11	0.25	0.3
4	Price inflation of construction materials	3	SL	0.31	0.45	0.6
5	Exchange rate fluctuation	1	VU	0	0.1	0.1
6	Shortage of materials in market	3	SL	0.31	0.45	0.6
7	Location restriction	4	L	0.61	0.75	0.8
8	Adverse weather	3	SL	0.31	0.45	0.6
9	Earthquake	1	VU	0	0.1	0.1
10	Fire	1	VU	0	0.1	0.1
11	War	2	U	0.11	0.25	0.3
12	Radioactive material	1	VU	0	0.1	0.1
13	Frequent changes in law	1	VU	0	0.1	0.1
14	Theft	2	U	0.11	0.25	0.3
15	Shortage of plant/equipment	2	U	0.11	0.25	0.3
16	Shortage of fund	3	SL	0.31	0.45	0.6
17	Strikes and labor disputes	2	U	0.11	0.25	0.3
18	Materials damage during transportation	1	VU	0	0.1	0.1
19	Long waiting time for approval of drawings	2	U	0.11	0.25	0.3
20	Unavailability of sufficient professionals	3	SL	0.31	0.45	0.6
21	Client/owner incompetency	1	VU	0	0.1	0.1
22	Mistakes and discrepancies in design documents	3	SL	0.31	0.45	0.6
23	Delay in payment to contractor for work done	3	SL	0.31	0.45	0.6
24	Lack of clear definition of scope	2	U	0.11	0.25	0.3
25	General occurrence of accident	1	VU	0	0.1	0.1
26	Poor construction method	1	VU	0	0.1	0.1
27	Variation	3	SL	0.31	0.45	0.6
28	Uncertain ground conditions	3	SL	0.31	0.45	0.6
29	Change order	2	U	0.11	0.25	0.3
30	Long waiting time for approval of test samples	3	SL	0.31	0.45	0.6
31	Delay in response for design information	2	U	0.11	0.25	0.3
32	Interference by client	1	VU	0	0.1	0.1
33	Poor site management & supervision by the consultant	2	U	0.11	0.25	0.3
34	Inadequate contractor experience	2	U	0.11	0.25	0.3
35	Inadequate design team experience	2	U	0.11	0.25	0.3
36	Inaccurate prediction of equipment productivity	1	VU	0	0.1	0.1
37	Low labor productivity	3	SL	0.31	0.45	0.6
38	Inaccurate material estimation	3	SL	0.31	0.45	0.6
39	Unrealistic project duration	5	VL	0.81	1	1
40	Financial problem resulting from incorrect estimation	2	U	0.11	0.25	0.3
41	Inadequate program scheduling	3	SL	0.31	0.45	0.6
42	Inadequate or insufficient site information	2	U	0.11	0.25	0.3
43	Pressure to deliver project on an accelerated schedule	3	SL	0.31	0.45	0.6
44	Occurrence of dispute	3	SL	0.31	0.45	0.6
45	Continuity of key resources	2	U	0.11	0.25	0.3
46	Coordination of entities	3	SL	0.31	0.45	0.6
47	Insufficient insurance	1	VU	0	0.1	0.1

Table 0-12: Impact-Deterministic risk analysis

No	Risk Factors in Construction	Rank	Qualitative expression	Optimistic (Min)	Most likely	Pessimistic (Max)
1	Delays in subcontractors work	3	SH	0.31	0.35	0.4
2	Skilled Labor shortage	3	SH	0.31	0.35	0.4
3	Permits delayed or take longer than expected	2	L	0.11	0.2	0.3
4	Price inflation of construction materials	3	SH	0.31	0.35	0.4
5	Exchange rate fluctuation	3	SH	0.31	0.35	0.4
6	Shortage of materials in market	2	L	0.11	0.2	0.3
7	Location restriction	2	L	0.11	0.2	0.3
8	Adverse weather	3	SH	0.31	0.35	0.4
9	Earthquake	4	H	0.41	0.5	0.6
10	Fire	5	VH	0.61	0.8	1
11	War	3	SH	0.31	0.35	0.4
12	Radioactive material	5	VH	0.61	0.8	1
13	Frequent changes in law	3	SH	0.31	0.35	0.4
14	Theft	3	SH	0.31	0.35	0.4
15	Shortage of plant/equipment	3	SH	0.31	0.35	0.4
16	Shortage of fund	4	H	0.41	0.5	0.6
17	Strikes and labor disputes	3	SH	0.31	0.35	0.4
18	Materials damage during transportation	4	H	0.41	0.5	0.6
19	Long waiting time for approval of drawings	3	SH	0.31	0.35	0.4
20	Unavailability of sufficient professionals	3	SH	0.31	0.35	0.4
21	Client/owner incompetency	3	SH	0.31	0.35	0.4
22	Mistakes and discrepancies in design documents	3	SH	0.31	0.35	0.4
23	Delay in payment to contractor for work done	3	SH	0.31	0.35	0.4
24	Lack of clear definition of scope	2	L	0.11	0.2	0.3
25	General occurrence of accident	2	L	0.11	0.2	0.3
26	Poor construction method	2	L	0.11	0.2	0.3
27	Variation	2	L	0.11	0.2	0.3
28	Uncertain ground conditions	3	SH	0.31	0.35	0.4
29	Change order	2	SH	0.31	0.35	0.4
30	Long waiting time for approval of test samples	1	VL	0	0.5	0.1
31	Delay in response for design information	2	L	0.11	0.2	0.3
32	Interference by client	3	SH	0.31	0.35	0.4
33	Poor site management & supervision by the consultant	3	SH	0.31	0.35	0.4
34	Inadequate contractor experience	4	H	0.41	0.5	0.6
35	Inadequate design team experience	4	H	0.41	0.5	0.6
36	Inaccurate prediction of equipment productivity	2	L	0.11	0.2	0.3
37	Low labor productivity	3	SH	0.31	0.35	0.4
38	Inaccurate material estimation	2	L	0.11	0.2	0.3
39	Unrealistic project duration	2	L	0.11	0.2	0.3
40	Financial problem resulting from incorrect estimation	2	L	0.11	0.2	0.3
41	Inadequate program scheduling	3	SH	0.31	0.35	0.4
42	Inadequate or insufficient site information	3	SH	0.31	0.35	0.4
43	Pressure to deliver project on an accelerated schedule	3	SH	0.31	0.35	0.4
44	Occurrence of dispute	3	SH	0.31	0.35	0.4
45	Continuity of key resources	2	L	0.11	0.2	0.3
46	Coordination of entities	2	L	0.11	0.2	0.3
47	Insufficient insurance	3	SH	0.31	0.35	0.4

Table 0-13: Severity and Cost impact

1	2	3	4	5	6	7	8
No	**Risk Factors in Construction**	**Severity**			**Cost**		
		Optimistic (Min)	**Most likely**	**Pessimistic (Max)**	**Optimistic (Min)**	**Most likely**	**Pessimistic (Max)**
1	Delays in subcontractors work	0.10	0.16	0.24	-	-	-
2	Skilled Labor shortage	0.00	0.04	0.04	0.00	121,737.36	139128.41
3	Permits delayed or take longer than expected	0.01	0.05	0.09	-	-	-
4	Price inflation of construction materials	0.10	0.16	0.24	334256.00	547,818.10	834770.44
5	Exchange rate fluctuation	0.00	0.04	0.04	0.00	121,737.36	139128.41
6	Shortage of materials in market	0.03	0.09	0.18	118606.97	313,038.91	626077.83
7	Location restriction	0.07	0.15	0.24	233387.90	521,731.52	834770.44
8	Adverse weather	0.10	0.16	0.24	334256.00	547,818.10	834770.44
9	Earthquake	0.00	0.05	0.06	0.00	173,910.51	208692.61
10	Fire	0.00	0.08	0.10	0.00	278,256.81	347821.02
11	War	0.03	0.09	0.12	118606.97	304,343.39	417385.22
12	Radioactive material	0.00	0.08	0.10	0.00	278,256.81	347821.02
13	Frequent changes in law	0.00	0.04	0.04	0.00	121,737.36	139128.41
14	Theft	0.03	0.09	0.12	118606.97	304,343.39	417385.22
15	Shortage of plant/equipment	0.03	0.09	0.12	-	-	-
16	Shortage of fund	0.13	0.23	0.36	-	-	-
17	Strikes and labor disputes	0.03	0.09	0.12	-	-	-
18	Materials damage during transportation	0.00	0.05	0.06	0.00	173,910.51	208692.61
19	Long waiting time for approval of drawings	0.03	0.09	0.12	-	-	-
20	Unavailability of sufficient professionals	0.10	0.16	0.24	334256.00	547,818.10	834770.44
21	Client/owner incompetency	0.00	0.04	0.04	0.00	121,737.36	139128.41
22	Mistakes and discrepancies in design documents	0.10	0.16	0.24	334256.00	547,818.10	834770.44
23	Delay in payment to contractor for work done	0.10	0.16	0.24	-	-	-
24	Lack of clear definition of scope	0.01	0.05	0.09	42086.34	173,910.51	313038.91
25	General occurrence of accident	0.00	0.02	0.03	-	-	-
26	Poor construction method	0.00	0.02	0.03	0.00	69,564.20	104346.30
27	Variation	0.03	0.09	0.18	118606.97	313,038.91	626077.83
28	Uncertain ground conditions	0.10	0.16	0.24	334256.00	547,818.10	834770.44
29	Change order	0.03	0.09	0.12	118606.97	304,343.39	417385.22
30	Long waiting time for approval of test samples	0.00	0.23	0.06	-	-	-
31	Delay in response for design information	0.01	0.05	0.09	-	-	-
32	Interference by client	0.00	0.04	0.04	0.00	121,737.36	139128.41
33	Poor site manag't & supervision by the consultant	0.03	0.09	0.12	118606.97	304,343.39	417385.22
34	Inadequate contractor experience	0.05	0.13	0.18	-	-	-
35	Inadequate design team experience	0.05	0.13	0.18	156867.28	434,776.27	626077.83
36	Inaccurate prediction of equipment productivity	0.00	0.02	0.03	0.00	69,564.20	104346.30
37	Low labor productivity	0.10	0.16	0.24	334256.00	547,818.10	834770.44
38	Inaccurate material estimation	0.03	0.09	0.18	118606.97	313,038.91	626077.83
39	Unrealistic project duration	0.09	0.20	0.30	309908.52	695,642.03	1043463.05
40	Financial problem resulting from incorrect estimation	0.01	0.05	0.09	42086.34	173,910.51	313038.91
41	Inadequate program scheduling	0.10	0.16	0.24	334256.00	547,818.10	834770.44
42	Inadequate or insufficient site information	0.03	0.09	0.12	118606.97	304,343.39	417385.22

1	2	3	4	5	6	7	8
No	Risk Factors in Construction	Severity			Cost		
		Optimistic (Min)	Most likely	Pessimistic (Max)	Optimistic (Min)	Most likely	Pessimistic (Max)
43	Pressure to deliver project on an accelerated schedule	0.10	0.16	0.24	334256.00	547,818.10	834770.44
44	**Occurrence of dispute**	0.10	0.16	0.24	334256.00	547,818.10	834770.44
45	Continuity of key resources	0.01	0.05	0.09	42086.34	73,910.51	313038.91
46	Coordination of entities	0.03	0.09	0.18	118606.97	313,038.91	626077.83
47	Insufficient insurance	0.00	0.04	0.04	0.00	121,737.36	139128.41
						11,652,004.04	

- **Note**: Since this study is specifically focused on cost impact of risks in, risk factors whose impact was categorized as schedule are left blank.

Table 0-14: Summary of deterministic risk analysis

No	Brief Risk Description	Most Likely Probability		Most Likely Impact		Risk Value (ETB)
		Qualitative value	Quantitative value	Qualitative value	Quantitative value	
1	Delays in subcontractors work	SL	0.45	SH	0.35	-
2	Skilled Labor shortage	VU	0.1	SH	0.35	121,737.36
3	Permits delayed or take longer than expected	U	0.25	L	0.2	-
4	Price inflation of construction materials	SL	0.45	SH	0.35	547,818.10
5	Exchange rate fluctuation	VU	0.1	SH	0.35	121,737.36
6	Shortage of materials in market	SL	0.45	L	0.2	313,038.91
7	Location restriction	L	0.75	L	0.2	521,731.52
8	Adverse weather	SL	0.45	SH	0.35	547,818.10
9	Earthquake	VU	0.1	H	0.5	173,910.51
10	Fire	VU	0.1	VH	0.8	278,256.81
11	War	U	0.25	SH	0.35	304,343.39
12	Radioactive material	VU	0.1	VH	0.8	278,256.81
13	Frequent changes in law	VU	0.1	SH	0.35	121,737.36
14	Theft	U	0.25	SH	0.35	304,343.39
15	Shortage of plant/equipment	U	0.25	SH	0.35	-
16	Shortage of fund	SL	0.45	H	0.5	-
17	Strikes and labor disputes	U	0.25	SH	0.35	-
18	Materials damage during transportation	VU	0.1	H	0.5	173,910.51
19	Long waiting time for approval of drawings	U	0.25	SH	0.35	-
20	Unavailability of sufficient professionals	SL	0.45	SH	0.35	547,818.10
21	Client/owner incompetency	VU	0.1	SH	0.35	121,737.36
22	Mistakes and discrepancies in design documents	SL	0.45	SH	0.35	547,818.10
23	Delay in payment to contractor for work done	SL	0.45	SH	0.35	-
24	Lack of clear definition of scope	U	0.25	L	0.2	173,910.51
25	General occurrence of accident	VU	0.1	L	0.2	-
26	Poor construction method	VU	0.1	L	0.2	69,564.20
27	Variation	SL	0.45	L	0.2	313,038.91
28	Uncertain ground conditions	SL	0.45	SH	0.35	547,818.10
29	Change order	U	0.25	SH	0.35	304,343.39
30	Long waiting time for approval of test samples	SL	0.45	VL	0.5	-
31	Delay in response for design information	U	0.25	L	0.2	-
32	Interference by client	VU	0.1	SH	0.35	121,737.36
33	Poor site management & supervision by the consultant	U	0.25	SH	0.35	304,343.39
34	Inadequate contractor experience	U	0.25	H	0.5	-
35	Inadequate design team experience	U	0.25	H	0.5	434,776.27
36	Inaccurate prediction of equipment productivity	VU	0.1	L	0.2	69,564.20
37	Low labor productivity	SL	0.45	SH	0.35	547,818.10
38	Inaccurate material estimation	SL	0.45	L	0.2	313,038.91
39	Unrealistic project duration	VL	1	L	0.2	695,642.03
40	Financial problem resulting from incorrect estimation	U	0.25	L	0.2	173,910.51
41	Inadequate program scheduling	SL	0.45	SH	0.35	547,818.10
42	Inadequate or insufficient site information	U	0.25	SH	0.35	304,343.39
43	Pressure to deliver project on an accelerated schedule	SL	0.45	SH	0.35	547,818.10
44	Occurrence of dispute	SL	0.45	SH	0.35	547,818.10
45	Continuity of key resources	U	0.25	L	0.2	73,910.51
46	Coordination of entities	SL	0.45	L	0.2	313,038.91
47	Insufficient insurance	VU	0.1	SH	0.35	121,737.36

Annex I: Level 3- Probabilistic Risk Analysis Input

Table 0-15: Input for probabilistic risk analysis

No	Risk Factors in Construction	Category of Impact	Cost Impact (ETB)		
			Optimistic (Min)	Most likely	Pessimistic (Max)
1	Delays in subcontractors work	Duration	-	-	-
2	Skilled Labor shortage	Cost	0.00	121,737.36	139128.41
3	Permits delayed or take longer than expected	Duration	-	-	-
4	Price inflation of construction materials	Cost	334256.00	547,818.10	834770.44
5	Exchange rate fluctuation	Cost	0.00	121,737.36	139128.41
6	Shortage of materials in market	Cost	118606.97	313,038.91	626077.83
7	Location restriction	Cost	233387.90	521,731.52	834770.44
8	Adverse weather	Cost	334256.00	547,818.10	834770.44
9	Earthquake	Cost	0.00	173,910.51	208692.61
10	Fire	Cost	0.00	278,256.81	347821.02
11	War	Cost	118606.97	304,343.39	417385.22
12	Radioactive material	Cost	0.00	278,256.81	347821.02
13	Frequent changes in law	Cost	0.00	121,737.36	139128.41
14	Theft	Cost	118606.97	304,343.39	417385.22
15	Shortage of plant/equipment	Duration	-	-	-
16	Shortage of fund	Duration	-	-	-
17	Strikes and labor disputes	Duration	-	-	-
18	Materials damage during transportation	Cost	0.00	173,910.51	208692.61
19	Long waiting time for approval of drawings	Duration	-	-	-
20	Unavailability of sufficient professionals	Cost	334256.00	547,818.10	834770.44
21	Client/owner incompetency	Cost	0.00	121,737.36	139128.41
22	Mistakes and discrepancies in design documents	Cost	334256.00	547,818.10	834770.44
23	Delay in payment to contractor for work done	Duration	-	-	-
24	Lack of clear definition of scope	Cost	42086.34	173,910.51	313038.91
25	General occurrence of accident	Duration	-	-	-
26	Poor construction method	Cost	0.00	69,564.20	104346.30
27	Variation	Cost	118606.97	313,038.91	626077.83
28	Uncertain ground conditions	Cost	334256.00	547,818.10	834770.44
29	Change order	Cost	118606.97	304,343.39	417385.22
30	Long waiting time for approval of test samples	Duration	-	-	-
31	Delay in response for design information	Duration	-	-	-
32	Interference by client	Cost	0.00	121,737.36	139128.41
33	Poor site manag’t & supervision by the consultant	Cost	118606.97	304,343.39	417385.22
34	Inadequate contractor experience	Duration	-	-	-
35	Inadequate design team experience	Cost	156867.28	434,776.27	626077.83
36	Inaccurate prediction of equipment productivity	Cost	0.00	69,564.20	104346.30
37	Low labor productivity	Cost	334256.00	547,818.10	834770.44
38	Inaccurate material estimation	Cost	118606.97	313,038.91	626077.83
39	Unrealistic project duration	Cost	309908.52	695,642.03	1043463.05
40	Financial problem resulting from incorrect estimation	Cost	42086.34	173,910.51	313038.91
41	Inadequate program scheduling	Cost	334256.00	547,818.10	834770.44
42	Inadequate or insufficient site information	Cost	118606.97	304,343.39	417385.22
43	Pressure to deliver project on an accelerated schedule	Cost	334256.00	547,818.10	834770.44
44	Occurrence of dispute	Cost	334256.00	547,818.10	834770.44
45	Continuity of key resources	Cost	42086.34	73,910.51	313038.91
46	Coordination of entities	Cost	118606.97	313,038.91	626077.83
47	Insufficient insurance	Cost	0.00	121,737.36	139128.41

Procedure used to carry out the simulation

Using the three values of cost presented on Table 0-15 as an input for the Monte Carlo simulation done using an excel add in called RiskAmp with a 5000 times simulation run. The parameters of mean, minimum, and maximum are determined using equations “=SimulationMean( )”, “=SimulationMin ( )”, and “=SimulationMax ( )” where the bracket represents the cells containing the three point estimates of cost. Consideration of the top twenty most sever risks whose most likely impact ranging from 434,776.26 to 782,597.28 was taken. Beta-PERT distribution is used by this MCS to generate random values.

The values for mean, minimum, and maximum after carrying out the simulation and using which the amount with contingency VAT and total project cost are determined as shown below.

Baseline Cost Estimate	**29,192,890.91**				
		Contingency	**Amount with Contingency**	**VAT (15%)**	**Total**
	Minimum	9,895,215.65	39,088,106.56	5,863,215.98	44,951,322.54
	Mean	11,535,715.42	40,728,606.33	6,109,290.95	46,837,897.28
	Maximum	13,035,991.84	42,228,882.75	6,334,332.41	48,563,215.16