بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

EVALUATING THE IMPACT OF RISK MANAGRMENT ON TIME AND COST PERFORMANCE OF CONSTRUCTION PROJECTS IN KHARTOUM STATE

تقويم اثر ادارة المخاطر علي اداء التكلفة و الزمن في مشاريع التشييد بولاية الخرطوم

A thesis submitted in partial fulfillment of the requirements for the Degree of Master of Science in Civil engineering (Construction Engineering)

Prepared by:

Mohamed Abd alrhman Mohamed Ahmed

Supervisor:

Dr. Eltahir Abu Elgassim Mohamed Elshaikh

August 2020

الآية

قال تعالى:

{ فَمَآ أُوتِيتُم مِّن شَىْءٍ فَمَتَٰعُ ٱلْحَيَوٰةِ ٱلدُّنْيَا ۖ وَمَا عِندَ ٱللَّهِ خَيْرٌ وَأَبْقَىٰ لِلَّذِينَ ءَامَنُوا۟ وَعَلَىٰ رَبِّهِمْ يَتَوَكَّلُونَ }

صدق الله العظيم

(سورة : الشورى : الآية 36)

Dedication

Dedicated to my family & to the memory of my father

Acknowledgement

I would like to thank Allah for giving me the strength to finish this research. I would like to express my deepest gratitude to Dr. **Eltahir Abu Elgassim Mohamed Elshaikh** for his guidance throughout this research. His knowledge, experience and wisdom is a continual source of inspiration. His support and motivation throughout is very much appreciated.

I would also like to especially thank my family for putting up with the many hours of work required to conduct this research.

Conducting this research has been a long, challenging, exciting and knowledge gaining experience. Throughout this journey there have been many others who have been supportive. I'd especially like to thank those organizations and Project Managers who took the time to participate in the research. I trust that the findings will be of benefit to you and the project management discipline and that they will provide insights for further investigation into the intricacies of managing risk in complex project environments, to continually improve project delivery into the future.

Abstract

Risk management is an important field and consider relatively a new field of construction industry. so it requires more attention to bring high benefit of construction industry. Construction projects are facing a number of risks which have negative effects on project objects such as time, cost and quality. The main objective of this research is to know how risk management is practiced in Sudanese construction project, also identify risk factors and evaluate their impact on (time and cost) performance and known Risk Responses strategies which were implemented in construction project on Khartoum state.

The research objectives have been achieved through closed questionnaires survey on Khartoum state. The result obtained from data analysis were interpreted and discussed thoroughly.

And this was then complemented by an industry survey, where (92) participants took part in a stratified sample comprising (35) consultants, (50) contractors and (7) projects owner. The data was analyzed calculating, frequency of occurrence, relative importance index and Cronbach's Alpha coefficient.

The output that were directed to respondents concluded that there is lack of knowledge about analysis and evaluation of risk factors and Risk Responses strategies. also the output concluded that the most risk factors which have highest effect on time performance in construction projects are: Decrease in productivity of workers, Financial failure of the contractor, Delay from consultant to approve executed works, poor communication between involved parties, Complex of design, Delay in payment from client, client required are not clarified, not completing information at the tender stage, Financial inflation and Exchange rate fluctuation.

And the most risk factors which have highest effect on cost performance in construction projects are: the scope of work for the contractor is not well defined, Poor resource management, client required are not clarified, Change of Scope by Owner, not completing information at the tender stage, Financial inflation, Exchange rate fluctuation.

also the output concluded that the most preventive actions which were implemented in Sudanese construction projects are: Depend on subjective judgment on produce a proper program and Refer to previous and ongoing similar projects for accurate program.

And the most Mitigative actions were: Change the sequence of work by overlapping activities, Coordinate closely with subcontractors and Close supervision to subordinates for minimizing abortive work.

The result of this study recommended that Contracting companies should compute and adding cost reserves contingence to quotation and schedule reserves to time estimation. This trend has to be supported by organizations like Sudanese Contractors Union, and other organizations concerned about the construction industry, Expert techniques such as @Risk system, which integrates with time schedules and spread sheets software, should be learned and applied obtain adequate risk estimation.

Assign responsibility for risk mitigation activities, and monitor progress through a formal tracking system.

المستخلص

تعتبر إدارة المخاطر مجالا مهما وجديدا نسبياً في صناعة التشييد، مما يتتطلب إنتباها اكثر للحصول علي فائدة اكبر من صناعة التشييد. مشاريع التشييد تواجه الكثير من المخاطر التي لها الاثر السالب علي اهداف المشروع مثل الزمن، التكلفة والجودة. الهدف الرئيسي من هذا البحث هو معرفة واقع ممارسة ادارة المخاطر لمشاريع التشييد في السودان و تحديد عوامل المخاطر واثرها علي اداء (التكلفة والزمن) ،وتهدف الدراسة ايضا لمعرفة واقع طرق الاستجابة لهذة المخاطر في مشاريع التشييد بولاية الخرطوم.

وقد تم تحقيق اهداف هذا البحث من خلال الاستبيانات المغلقة داخل ولاية الخرطوم. النتائج التي تم الحصول عليها من تحليل البيانات حيث تم تفسيرها ومناقشتها بدقة.

تم تصميم إستبيان للعاملين بمشاريع التشييد بولاية الخرطوم و كان العدد المعتمد لممشاركين في الإستبيان (92) مشارك و كانو كالاتي: (35) إستشاري ، (50) مقاول و(7) كملاك. تم تحليل النتائج عبر إستخدام (التردد , الوزن المرجح ومعامل الثبات).

وخلصت النواتج الموجهة إلي المشاركين إلي أن هنالك نقص في معرفة تحليل وتقييم المخاطر وطرق الاستجابة لها ، كما خلصت النتائج من أن عوامل المخاطر التي لها الاثر الاكبر علي اداء الزمن هي: انخفاض القدرة الانتاجية للعمال، نقص الموارد المالية لدي المقاول ، تأخيير الاستشاري لاستلام الاعمال المنجزة،ضعف التواصل بين المشاركيين في المشروع ، تعقيد التصاميم، التأخر في تدفق الدفعات النقدية من قبل صاحب العمل، عدم وضوح رغبات صاحب العمل، عدم إكتمال المعلومات في مرحلة العطاء، معدل التضحم و التغيير في أسعار العملات.

وأن عوامل المخاطر التي لها الاثر الاكبر علي اداء التكلفة هي : نطاق العمل للمقاول غير محددة بشكل جيد، سوء ادارة الموارد، عدم وضوح رغبات صاحب العمل، التغيير في مجال العمل بواسطة صاحب العمل، عدم إكتمال المعلومات في مرحلة العطاء، معدل التضحم ، التغيير في أسعار العملات.

وكما خلصت نواتج البحث الي أن اكثر الطرق المستخدمة لتدارك آثار المخاطر في مرحلة ما قبل التنفيذ المطبقة في مشاريع التشييد في السودان هي: الاعتماد علي الخبرة العملية في عمل برنامج عمل قابل للتنفيذ ، الرجوع الي المشاريع المشابهة المنفذة او الجاري تنفيذها والحصول علي المعلومات لانتاج برنامج عمل دقيق.

وأن اكثر الطرق المستخدمة لتدارك آثار المخاطر اثناء مرحلة التنفيذ هي : تغيير تتابع عمليات التنفيذ او التداخل بينها، التنسيق التام مع مقاولي الباطن و الاشراف الدقيق علي الاعمال لتلاشي رفض الاعمال واعادة التننفيذ.

و أوصت نتائج هذه الدراسة ان شركات المقاولات عليها بإضافة إحتياطي من التكلفة الي تكلفة المشروع واضافة إحتياطي زمني إلي جدولة المشروع لمواجهة المخاطر وتتم هذه العملية وفقا لاساس علمي ؛ ويكون متفق عليه من اتحاد المقاوليين السودانيين او اي جهات ذات صلة بصناعة التشييد.

كما يجب تعَلم وإستخدام الانظمة الحديثة (برامج كمبيوتر متكاملة مثل برنامج برايمافيرا لتحليل المخاطر).

كما يجب تحديد الجهه المسؤلة لتدارك اي خطر محدد وفقاً لنظام رقابة رسمي اثناء تنفيذ المشروع.

Table of Contents

List of Tables

List of Figures

CHAPTER I

Introduction

CHAPTER I

Introduction

1.1General Introduction

Construction industry is one of the largest industries in the world. Developing countries, such as Sudan, dedicate a significant share of their annual budgets for the construction sector. It can be defined as: "Service industry for the rest of the economic sectors and industries and usually offer their products as certain and specific objectives of the request.

The construction industry plays vital roles in transforming the aspirations and the needs of its people into reality by implementing various physical structures. A construction project is commonly acknowledged as successful when it is completed on time, within budget, and in accordance with specifications and to stakeholder's satisfaction.

Construction is a risky business. Each construction project is unique and comes with its own set of challenges and opportunities. Identifying and managing risks can be tricky, but not impossible with careful planning and execution. When a risk turns into reality it can disrupt and derail a project. In order to avoid disaster, you need to be able to properly assess, control and monitor risks once they've been identified.

There are two sectors in construction: residential and commercial. Depending on the sector, there can be up to four different types of projects:

- Residential home building and renovation
- Heavy industrial construction
- Commercial and institutional construction

- Engineering construction

1.2Research Problem

Sudanese construction project suffer from high risks that lead to failure in meeting projects scope, time and cost. from review of the literature, there was no evidence which shows that risk management process is applied appropriately and effectively in Sudanese construction project.

1.3Research objective

The research aims are:

1- Understanding how risk management is practiced in Sudanese construction project.

2- Evaluating the impact of risk management on (cost and time) performance in construction project.

3- Ranking risk factors-related responsibilities for clients, contractors and consultant in order to manage risks effectively.

4- To investigate and recommend the effective risk management Responses strategies.

1.4 Research Hypothesis

1. Risk factors are prevalent on all construction projects in Khartoum state - Sudan.

2. Risk factors affect cost and time performance of construction project dramatically.

3. The affect of risk factors can be under control if a proper risk management strategies are applying.

1.5Research Methodology

The qualitative method will be used in the study for description analysis of data. The sources of data and influences and opinions from the researcher will play an important role in the study and in the description and analysis of data and result. The questionnaire survey will be used and also interviews for collection of qualitative data.

1.6Area of study

Khartoum state is the capital of the Republic of Sudan triangular located in central of Sudan. It consists of Khartoum, which is located at the intersection of the White Nile and Blue Nile, Khartoum, Khartoum North and Omdurman are main cities. The three cities linked together a number of bridges and an estimated population of Khartoum by more than eight million people.

1.7Research Contents

Chapter One: Introduction- Chapter one covers the overall introduction of the research, the problem statement, objectives and methodology to reach these objectives, research hypotheses and area of study.

Chapter Two: Literature Review and previous studies-This chapter covers all literature review about construction project and explores previous studies related to definition of risk, risk management and impact of apply risk management on cost and time performance.

Chapter Three: Data Collection– Discussing survey approach and the method of Collecting data, it also discusses the designing of the questionnaire, the sample size and methods using in the results analysis and discussing.

Chapter Four: Results analysis and discussion -The overall survey results are presented for each part.

Chapter five: Conclusion and Recommendations - Conclusion will be drawn based upon data analysis, linking them to the problem statement and to the objectives of study.

CHAPTER II

Literature Review and Previous Studies

CHAPTER II

Literature Review and Previous Studies

2.1 Introduction

In order to have a better understanding of what we mean by risk, risk can be defined as exposure to loss/gain or the likelihood of an event of loss/gain multiplied by its corresponding magnitude [1].

Project risks are of two categories, known and unknown. Known risks are recognized and can be analyzed, which makes planning and preparing response possible. It's not possible to proactively unravel an Unknown risk. Therefore, to anticipate and provide a risk reserve becomes necessary [2].

Risk can be reduced, managed, transferred, shared or accepted but cannot be overlooked [3].

In construction perspective, risks are generally considered as incidences that influence the principal objectives of a particular project (time, cost, quality) [4]. As a result of its construction activities that are perceived to be unique, the construction industry is exposed to greater risks in comparison with other industries. It has unique features as: projects taken long periods, with processes that are complicated, financial intensity, environment that are abominable and organization structures that are dynamic [5]. Also, when dealing with risks, most construction industries are known for their poor reputation, this is because may projects do not meet their cost targets and proposed deadlines, which in turn adversely affects each of its participants (Contractors, clients the public and others) [6].

Risk management can be defined an organized and comprehensive method tailored toward “analyzing”, “identifying” and “responding” to risk factors in order to achieve the project goals [4].

Having a good understanding of risks allows the parties involved to take steps in order to reduce their negative impacts [7]. The lack of a project risk management approach that is effective has a lot of unpleasant effects on the project participants as a result of deficiency of actions to prevent the uncertainty and risks that are present in a project [8]. Risk identification and assessment is a crucial risk management process. It is not possible to manage all the risks in a construction project. However, it is important to focus on the vital risks. Attempting to identify all the risks can be a waste of time and counterproductive [7]. It was observed that, majority of decisions on construction risk management are done based on intuition, previous experience, and the manger’s professional judgment. As a result of ignorance and doubts on the sustainability, formal methods available are not been applied for the activities of the construction [9].

In developing countries, construction projects are liable to a lot of unknown factors [10]. Numerous project challenges are prevented through the implementation of effective risk management in projects [11]. Various publications on risk management are available both online on the internet and in hard copies in books and journals, little information is known on the applications of risk management in practice, most especially in developing countries [12] and the process of risk management has not been adequately focused [11].

Risks aren’t always a negative. Being able to effectively identify and manage risks can lead to increased profits, establishing good relationships with clients that results in more projects and being able to expand your business into new markets and sectors.

Risk analysis and management are an important part of the decision-making process in construction industry.

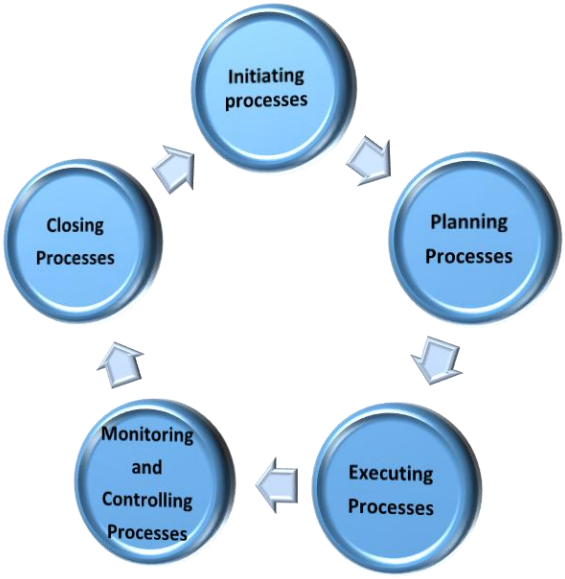
Project definition:

A project can be defined as a temporary endeavor with clearly specified goals that are characterized by project phases, deadlines, and use of a large number of different types of limited resources. It consists of a complex system of activities that should be coordinated and managed to achieve project goals. Managing the projects essentially involves balancing project goals, alterations, risks, and limitations during a project life cycle [13].

Project life cycle

A project life cycle is the series of phases that a project passes through from its start to its completion [4]. It provides the basic framework for managing the project. This basic framework applies regardless of the specific project work involved. The phases may be sequential, iterative, or overlapping. All projects can be mapped to the generic life cycle shown in Figure 2-1.

Figure 2.1 project life cycle



Construction project:

Construction industry in general as well as construction project activity is risky [14]. There is a variety of different types of construction projects, depending on the different construction sectors. There are two sectors in construction: residential and commercial. Depending on the sector, there can be up to four different types of projects:

- Residential home building and renovation
- Heavy industrial construction
- Commercial and institutional construction

- Engineering construction

That means there are a wide variety of types of construction projects that require construction management in order to be successful. Construction management might be required for a simple home to a large bridge, from engineering a dam build to an airport seismic retrofit project. Construction project managers, then, manage the beginning and end of a project build, often managing on-site to ensure the safe, successful construction.

2.2 RISK:

Risk is a multifaceted concept [15], which is defined as the probability of a damaging event occurring in the project, affecting its objectives ([16] [17]) however not always associated with negative results. Risk may also represent opportunities, but the fact that most of the risk usually has negative results has led individuals to only consider the negative side of risk ([17] [18]).

Today, risk management is an integral part of project management ([19]; [20]), where one of the most difficult activities is determining what are the project's risks and how should they be prioritized [21]. This is a key process and most of project managers know that risk management is essential for good project management ([17]; [22]; [23]).

Risk is an integral part of each project phase, and thus risk management is an essential part of the decision-making process at every stage of a project. The success or failure of a project largely depends on the approach to possible risk in which the appearance of risk could affect productivity, quality, deadlines, and/or project cost. Traditionally, risks were managed intuitively with the goal of dealing with the consequences. Today, the use standards and methodologies, such as PMBoK by PMI or ISO 31000, allows for a possibility to proactively

manage risks. That is, although it is not possible to eliminate risks, they can be reduced, transferred, accepted, or avoided.

2.3 PROJECT RISK MANAGEMENT

One of the major roles undertaken by a project manager is the management of the risk of a project. However, this duty is particularly complex and inefficient if good risk management has not been done from the beginning of the project. An effective and efficient risk management approach requires a proper and systematic methodology and, more importantly, knowledge and experience.

Project Risk Management includes the processes of conducting risk management planning, identification, analysis, response planning, response implementation, and monitoring risk on a project [4].

In general, the risk management process consists of 7 phases. These procedures are incorporated into a project and are performed iteratively until the end stage of the project lifecycle. Various techniques and tools are continuously being developed with the aim of supporting and enhancing risk management activities.

The objectives of project risk management are to increase the probability and/or impact of positive risks and to decrease the probability and/or impact of negative risks, in order to optimize the chances of project success.

The Project Risk Management processes are:

- **Plan Risk Management**

The process of defining how to conduct risk management activities for a project.

- **Identify Risks**

The process of identifying individual project risks as well as sources of overall project risk, and documenting their characteristics.

- **Perform Qualitative Risk Analysis**

The process of prioritizing individual project risks for further analysis or action by assessing their probability of occurrence and impact as well as other characteristics.

- **Perform Quantitative Risk Analysis**

The process of numerically analyzing the combined effect of identified individual project risks and other sources of uncertainty on overall project objectives.

- **Plan Risk Responses**

The process of developing options, selecting strategies, and agreeing on actions to address overall project risk exposure, as well as to treat individual project risks.

- **Implement Risk Responses**

The process of implementing agreed-upon risk response plans.

- **Monitor Risks**

The process of monitoring the implementation of agreed-upon risk response plans, tracking identified risks, identifying and analyzing new risks, and evaluating risk process effectiveness throughout the project.

Figure 2-2 provides an overview of the Project Risk Management processes.

- **Risk Factors**

When assessing risk, it's necessary to determine the following [24]:

• The probability that a risk event will occur (how likely)

• The range of possible outcomes (impact or amount at stake)

• Expected timing for it to occur in the project life cycle (when)

• The anticipated frequency of risk events from that source (how often)

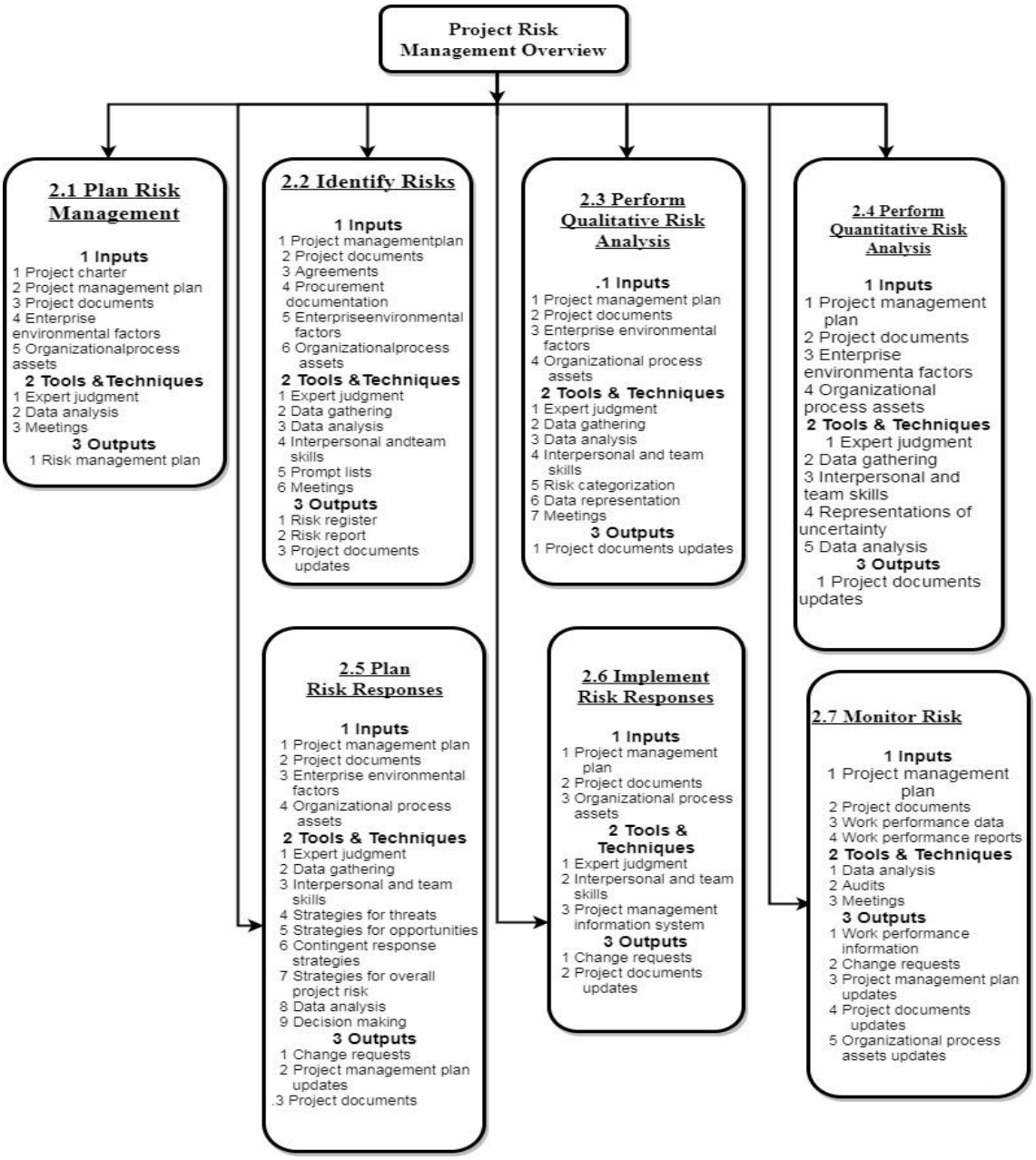


Figure 2.2 Project Risk Management Overview [4].

2.3.1 Plan Risk Management

The risk management plan may include:

• Risk strategy:

Is an overall approach to managing risk throughout the life of the project.

• Methodology:

This section of the plan defines how risk management will be performed to meet the needs of the specific project. Low-priority projects will likely warrant less of a risk management effort than high-priority projects.

• Roles and responsibilities:

Tim section explains who will do what risk management work. Did you realize that stakeholders outside the project team may have roles and responsibilities regarding risk management?

• Funding

This section includes the cost of the risk management process. Yes, there is a cost of doing risk management, but overall, risk management saves the project time and money by avoiding or reducing threats and by taking advantage of opportunities. this section also includes plan for utilizing reserves in response to risks on the project.

• Timing

This section of the plan talks about when to do risk management for the project. Risk management should start .as soon as you have the appropriate inputs and should be repeated throughout the life of the project, since new risks can be identified as the project progresses and the degree of risk can change over the course of a project. Also note that time needs to be allocated in the schedule for risk management activities.

• Stakeholder risk appetite / thresholds remember that risk appetite is a high-level description of an individual or group's openness to risk. thresholds are measurable amounts of risk that an individual or group are willing to accept within a specific category-such as risk to the project schedule, budget, or the achievement of a particular project objective the risk appetites and thresholds of key stakeholders are documented and considered in the risk management plan. This information is also considered when ranking risks based on probability and impacts, and when prioritizing which risks will be addressed in risk response planning.

• Definitions of probability and impact

• Reporting

This section of the plan describes reports related to the risk management effort on the project that will be created, what they will include, and to whom they will be sent. In addition, the composition of the risk register for the project is defined here.

• Tracking

The tracking section of the plan describes how the risk management process will be audited and how the results of risk management efforts will be documented.

• Risk categories

A standard list of risk categories can help ensure areas of risk are not forgotten on your projects. These categories are broad, common areas or sources of risk that the company or similar projects have experienced. They can include things such as technology changes, lack of resources, regulatory hurdles or cultural issues. Organizations and project management offices should maintain standard lists of risk categories that all projects can use to help identify and group individual project risks. When leading risk identification efforts, you should make sure each category is considered. A risk breakdown structure (RBS) is an organizational chart that can help you 1dentify and document risk categories.

Risk can be classified or categorized in many ways, including:

• External Regulatory, environmental, or governmental issues; market shifts; problems with project sites, etc.

• Internal Changes to schedule or budget; scope changes; inexperienced team members; issues with people·, staffing, materials, and equipment, etc.

• Technical Changes in technology; technical processes, or interfaces, etc.

• Commercial Customer stability, terms and conditions within contracts, vendors, etc.

• Unforeseeable only a small portion of risks (about 10 percent) are actually unforeseeable.

2.3.2 Identify Risks

Tools and Techniques of Identify Risks

- **Brainstorming**

Can be of use for projects involving new risks, new management arrangements or for developing initial checklists. This may be useful in risk management workshops.

Brainstorming is usually done in a meeting where one idea helps generate another.

Tools such as the risk breakdown structure, risk categories, and prompt lists can help to identify risks.

- **Checklist Analysis**

Over time, organizations may compile lists of risks encountered on projects, which they review to help them identify relevant sources of risk for current projects. This technique also includes reviewing a checklist of generic risk categories, which used to help identify specific risks to the project from each category.

Checklists Know potential points that can fail in previous projects and thus is very helpful in risk identification. This allows project managers to know the risks present and makes them to be involved in the process of risk identification,

which will ultimately lead to greater acceptance of any means implemented to minimize the risks.

- **Interviewing**

Also called "expert interviewing" Historical data analysis for projects that appear similar and examine similar past or present projects, risk analysis, lessons learned or project evaluations are other methods available for getting feedback about risks involved in a project.

- **Root Cause Analysis**

In root cause analysis, the identified risks are reorganized by their root causes to help identify more risks.

- **Assumption Analysis**

Identifying and analyzing assumptions that have been made on the project, and whether those assumptions are valid, may lead to the identification of more risks.

- **Constraint Analysis**

Constraints such as schedule or budget limitations are examined to determine

The level of risk they pose.

- **Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis**

This analysis examines the project to identify its strengths and weaknesses as well as the opportunities and threats that could originate from those strengths and weaknesses.

- **Documentation Reviews**

What is and is not included in project documentation, such as the project charter, contracts, and planning documentation, can help identify risks. Those involved in risk identification might look at project documentation, as well .as lessons learned, articles, and other sources, to help uncover risks. This technique used to be an RNIC Trick of the Trade for risk management and has proven to be so beneficial that it has now become standard practice.

- **Prompt Lists**

This is a list of categories that have been identified as possible sources of risk to the project. The project team can use a prompt list when identifying risks to individual elements of the project as well as risks to the overall project.

- **Facilitation**

Facilitation skills are used by the project manager in conducting meetings to identify individual and overall project risks.

Outputs of Identify Risks:

- **Risk Register**

The risk register is one of document for the entire risk management process that will be constantly updated with information as the risk management processes are completed.

2.3.3 Perform Qualitative Risk Analysis

Perform Qualitative Risk Analysis is the process of prioritizing individual project risks for further analysis or action by assessing their probability of occurrence and impact as well as other characteristics.

As you begin this process, you should have a long list of risk documented in the risk register.

To perform this analysis, the following must be determined:

• The probability of each risk occurring, using a standard scale (common subjective analysis scales include Low, Medium, High and 1 to 5)

• The impact (the amount at stake or the positive or negative consequences) of each risk occurring using a standard scale, such as Low, Medium, High or l to 5.

The key benefit of this process is that it focuses efforts on high-priority risks.

Risk Data Quality Assessment

Before you can use the risk information collected on the project, you must analyze the precision of the data. You assess the accuracy and reliability of the data, and determine if the risk is valid and whether more research is need to understand the risk.

A risk data quality assessment may include determining the following for each risk:

• Extent of the understanding of the risk

• Data available about the risk

• Quality of the data

• Reliability and integrity of the data

Probability and Impact Matrix

A probability and impact matrix is a data representation technique that can be used during this process. Because qualitative risk analysis is based on subjective evaluation, the rating of any one risk can vary depending on the bias of the person doing the rating and how risk averse they are.

The risk matrix shows the combination of impact and probability that in turn yield a risk priority (shown by the red, yellow, and green color).

Organizations frequently have a standard rating system to promote a common understanding of what each risk rating means.

The probability and impact matrix may be used to sort or rate risks to determine which ones warrant an immediate response (and will therefore be moved on through the risk process) and which ones should be put on the watch list.

Probabilities	Impacts				
	Very Low	Low	Medium	High	Very High
Very High	Low	Medium	Medium	High	High
High	Low	Medium	Medium	High	High
Medium	Low	Low	Medium	Medium	High
Low	Low	Low	Medium	Medium	High
Very Low	Low	Low	Low	Low	Medium

Figure 2.3 Probability and impact matrix

Risk Rating Descriptors and Required Action

Risk rating	Required action
Low	Requires less attention to be paid, should be put on the watch list
Medium	Requires a good amount of attention, should be put on the watch list
High	Requires the most attention, warrant an immediate response

2.3.4 Perform Quantitative Risk Analysis

Perform Quantitative Risk Analysis process involve numerically analyzing the probability and impact (the amount at stake or the consequences) of risks that ranked highest in qualitative risk analysis. Quantitative risk analysis also looks at how risks could affect the objective of the project.

The key benefit of this process is that it quantifies overall project risk exposure and can also provide additional quantitative risk information to support risk response planning.

This process is performed throughout the project.

The purpose of quantitative risk analysis is to:

• Determine which risk events warrant a response.

• Determine overall project risk (risk exposure).

• Determine the quantified probability of meeting project objectives

• Determine cost and schedule reserves.

• Identify risks requiring the most attention.

• Create realistic and achievable cost, schedule, or scope targets.

Inputs to Perform Quantitative Risk Analysis

These puts include the project management plan and scope, schedule, and cost baselines.

Tools and Techniques of Quantitative Risk Analysis

Quantitative probability and impact can be determined in a variety of ways that make use of some or all of the following:

• Expert judgment from trained risk specialists and team members

• Data-gathering techniques, such as interviewing

• Data analysis techniques, such as simulation; (like Monte Carlo), sensitivity analysis, decision tree analysis, and influence diagrams

• Interpersonal and team skills

• Representations of uncertainty

• Cost and schedule estimating

• Use of historical records from previous projects

Monte Carlo Simulation:

Monte Carlo simulation, or probability simulation, is a technique used to understand the impact of risk and uncertainty in financial, project management, cost, and other forecasting models.

Uncertainty in Forecasting Models

When you develop a forecasting model – any model that plans ahead for the future – you make certain assumptions. These might be assumptions about the investment return on a portfolio, the cost of a construction project, or how long it will take to complete a certain task. Because these are projections in to the future, the best you can do is estimate the expected value.

You can't know with certainty what the actual value will be, but based on historical data, or expertise in the field, or past experience, you can draw an estimate. While this estimate is useful for developing a model, it contains some inherent uncertainty and risk, because it's an estimate of an unknown value.

Estimating Ranges of Values

In some cases, it's possible to estimate a range of values. In a construction project, you might estimate the time it will take to complete a particular job; based on some expert knowledge, you can also estimate the absolute maximum time it might take, in the worst possible case, and the absolute minimum time,

in the best possible case. The same could be done for project costs. In a financial market, you might know the distribution of possible values through the mean and standard deviation of returns.

By using a range of possible values, instead of a single guess, you can create a more realistic picture of what might happen in the future. When a model is based on ranges of estimates, the output of the model will also be a range.

This is different from a normal forecasting model, in which you start with some fixed estimates – say the time it will take to complete each of three parts of a project – and end up with another value – the total time for the project. If the same model were based on ranges of estimates for each of the three parts of the project, the result would be a range of times it might take to complete the project. When each part has a minimum and maximum estimate, we can use those values to estimate the total minimum and maximum time for the project.

What Monte Carlo Simulation can tell you?

When you have a range of values as a result, you are beginning to understand the risk and uncertainty in the model. The key feature of a Monte Carlo simulation is that it can tell you – based on how you create the ranges of estimates – how likely the resulting outcomes are.

How It Works:

In a Monte Carlo simulation, a random value is selected for each of the tasks, based on the range of estimates. The model is calculated based on this random value. The result of the model is recorded, and the process is repeated. A typical

Monte Carlo simulation calculates the model hundreds or thousands of times, each time using different randomly-selected values.

When the simulation is complete, we have a large number of results from the model, each based on random input values. These results are used to describe the likelihood, or probability, of reaching various results in the model

• It usually done with a computer program because of the intricacies of the calculations

• Evaluates the overall risk in the project

• determines the probability of completing the project on any specific day or for any specific cost.

• Determines the probability of any activity actually being on the critical path.

• Takes into account path convergence (places in the network diagram where many paths converge in to one activity).

• Translates uncertainties into impacts to the total project

• Can be used to assess cost and schedule impacts

• Results in a probability distribution

Sensitivity Analysis

Sensitivity analysis is a technique to analyze and compare the potential impacts of identified risks. A tornado diagram may be used to graphically depict the results of this analysis.

Risks are represented by horizontal bars: the longest and uppermost bar represents the greatest risk, and progressively shorter horizontal bars beneath represent lower-ranked risks.

Tornado graphs help us to identify key risk drivers and Pin point the task or risk event that's preventing their schedules from performing as expected.

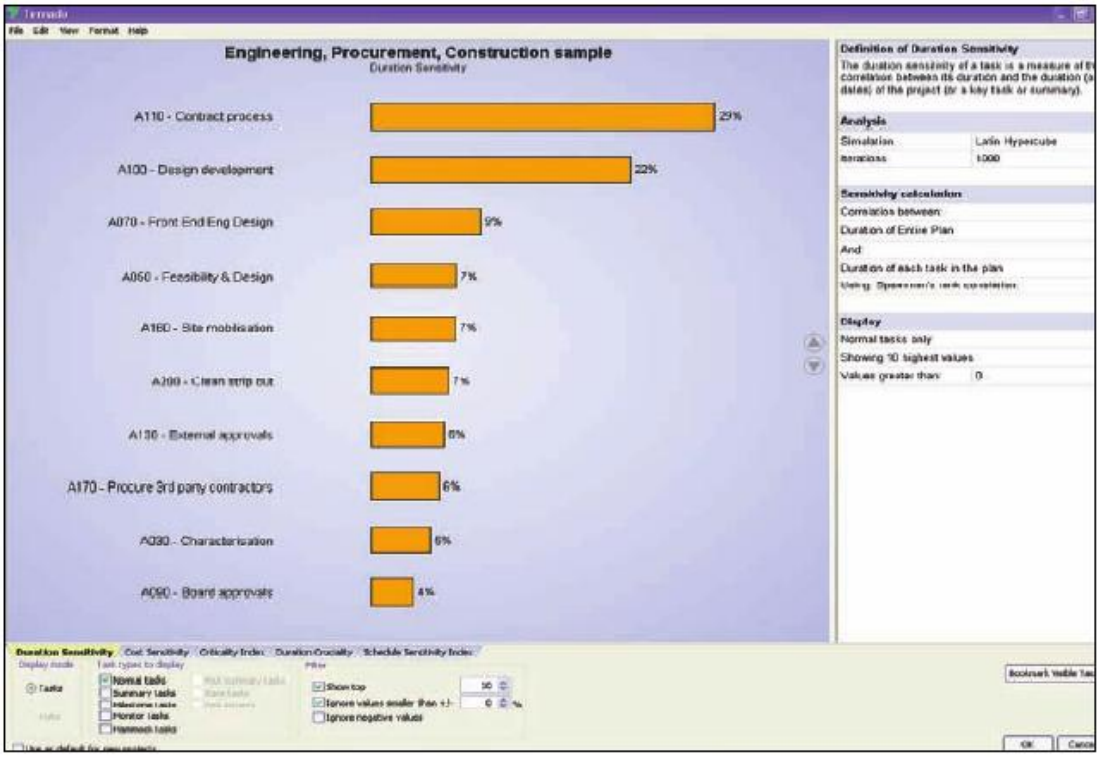


Figure 2.4 Tornado graph

Outputs of Perform Quantitative Risk Analysis

The Perform Quantitative Risk Analysis process results in updates to the risk register and other project documents.

Risk Register Updates

The risk register and the risk report are updated to add the results of quantitative risk analysis, including:

• Prioritized list of quantified individual project risks,

What risks are most likely to cause trouble in terms of their effect on the critical path? What risks need the most contingency reserve?

• The quantified probability of meeting project objectives for example, "we only have an 80 percent chance of completing the project within the six months required by the customer:" Or "we only have a 75 percent chance of completing the project within the $800,000 budget."

• Trends in quantitative risk analysis as you repeat quantitative risk analysis during project planning and when changes are proposed, you can track changes to the overall risk of the project and see any trends.

• Initial contingency time and cost reserves needed for example, "The project requires an additional $50,000 and two months of time to accommodate the risks on the project." Reserves will be finalized during Plan Risk Responses

• Assessment of overall project risk exposure Use overall project success (how likely it is that the project will achieve all key objectives) and any variables that

may still affect the project to fully understand, at high level, the overall risk exposure of the project.

• Possible realistic and achievable completion dates and project costs, with confidence levels, versus the time and cost objectives for the project for example, "We are 95 percent confident that we can complete this project on May 25th for $989,000

• Recommended risk responses after quantitative risk analysis is performed, the risk register may include suggested responses to overall project risks and individual project risk.

2.3.5 Plan Risk Responses

Plan Risk Responses is the process of developing options, selecting strategies, and agreeing on actions to address overall project risk exposure as well as to treat individual project risks.

The key benefit of this process is that it identifies appropriate ways to address overall project risk and individual project risks.

The Plan Risk Responses process involves figuring out,

What are we going to do about each top risks?

In risk response planning, you find ways to reduce or eliminate threats, and you find ways to make opportunities more likely or increase their impact.

The projects risk responses may include doing one or a combination of the following for each top risk:

• Do something to eliminate the threats before they happen.

• Do something to make sure the opportunities happen.

• Decrease the probability and/ or impact of threats.

• Increase the probability and/or impact of opportunities.

For the remaining (residual) threats that cannot be eliminated:

• Do something if the risk happens (contingency plans). Contingency plans should be measurable so you can evaluate their effectiveness.

• Do something if contingency plans are not effective or are only partially effective (fallback plans).

Risk Response Strategies

The choices of response strategies for threats include:

• Avoid

Eliminate the threat by eliminating the cause, such as removing the work package or changing the person assigned to do work.

Avoiding the threat might even involve expanding the scope of the project.

Imagine for example, your project team estimates there's a 75 percent likelihood of a threat occurring, but an additional level of testing or, an additional activity would likely prevent this threat; expanding the scope of the project in this way would help avoid the threat.

On an overall project level, if the threat is beyond the organization's risk threshold, the project manager will need to take action to make the project acceptable. This could include removing pieces of the project that are too risky in order to avoid cancelling the entire project.

• Mitigate

Reduce the probability and/ or the impact of an individual or overall project threat, thereby making it a smaller risk and possibly removing it from the list of top risks on the project. Options for reducing the probability arc considered separately from options for reducing the impact.

Any reduction will make a difference, but the option with the most probability and/ or impact reduction is often the option selected.

• Transfer (deflect, allocate)

Make a party outside of the project responsible for the threat by purchasing insurance, performance bonds, warranties, or guarantees, or by outsourcing the work. Here is where the strong connection between risk and procurement (contracts) begins. In the world of properly practiced project management, risk analysis is completed before a contract is signed, and transference of risk is included m the terms and conditions of the contract.

Avoidance and mitigation are generally used for high-priority, high-impact risks. Transference, escalation, and acceptance may be appropriate for low-priority, low-impact risks as well as those with higher impact.

The choices of response strategies for opportunities include:

• Exploit (the reverse of avoid) Add work or change to the project to make sure the opportunity occurs.

This could be on the individual project risk level or on the overall project risk level.

• Enhance (the reverse of mitigate) Increase the likelihood (probability) and/ or positive impact of the opportunity occurring.

This could be related to the overall approach to scope and schedule, resources used, and project re planning as well as to individual project risks.

• Share Allocate ownership or partial ownership of the individual or overall project opportunity to third party (forming a partnership, team, or joint venture) that is best able to achieve the opportunity.

Response strategies for both threats and opportunities include:

• Escalate A threat or an opportunity should be escalated if it is outside the scope of the project or beyond the project manager's authority.

Any risks that are escalated will typically be managed at the program or portfolio level- not at the project level. Remember that escalated risk needs to be accepted by the program or portfolio manager, at which point, data on the escalation is documented, and the risk is no longer monitored at the project level.

• Accept Passive acceptance means to no nothing and to essentially say, "lf it happens, it happens."

This leaves actions to be determined as needed (workarounds) if the risk occurs. Active acceptance involves creating contingency plans to be implemented if the risk occurs and allocating time and cost reserves to the project.

Whether responding to threats or opportunities:

• Strategies must be timely.

• The effort selected must be appropriate to the severity of the risk-avoid spending more money preventing the risk than the impact of the risk would cost if it occurred.

• One response can be used to address more than one risk.

• More than one response can be used to address the same risk.

• A response can address the root cause of risk and thereby address more than one risk.

• The team, other stakeholders, and experts should be involved the selecting a strategy.

Outputs of Plan Risk Responses:

The outputs of the Plan Risk Response process are change requests, updates to the project management plan, and project documents updates.

Project Management Plan Updates

The effort spent in risk management can result in updates to the project management plan.

After careful consideration and evaluation, planned risk responses may require changes to management plans that have been drafted in planning-at the overall project risk level as well as at the individual project risk level.

Risk Register Updates

The risk register is updated to add the results of risk response planning, including:

• Residual risks

These are the risks that remain after risk response planning. After you have avoided, exploited, mitigated, enhanced, transferred, shared, escalated, and accepted risks (and created related contingency plans and fall back plans), there will still be risks that remain. Those residual risks that are passively accepted should be properly documented and reviewed throughout the project to see if their ranking has changed.

• Contingency plans Contingency plans are plans describing the specific actions that will be taken if the opportunity or threat occurs.

• Fallback plans

These plans are specific actions that will be taken if the contingency plans are not effective.

Think how prepared you will feel if you have plans for what to do if a risk occurs and what to do if the original plan does not work.

• Risk owners

A key concept in risk response planning is that the project manager does not have to do it all, and neither does the team. Each risk must be assigned to someone who will help lead the development of the risk response and who will be assigned to carry out the risk response or "own" the risk.

The risk owner can be a stakeholder other than a team member.

Think about how the application if risk management could change real-world projects. The risk occurs; the risk owner takes the preapproved action determined in project planning and informs the project manager. No meeting is needed -Just action -this can be very powerful.

• Secondary risks

Any new risks created by the implementation of selected risk responses should also be analyzed as part of risk response planning. Frequently, a response to one risk will create the possibility of new risks that would otherwise not have occurred. For example, if a portion of the project work is out sourced to a seller because the project team does not have the expertise to complete the work efficiently, there may be a secondary risk of the seller going out of business. This was not a risk to the project prior to outsourcing. 'The discovery of secondary risks may require additional risk response planning.

• Risk triggers

These are events that trigger the contingency response.

The early warning signs for each risk on a project should be identified so risk owners know when to take action.

• Contracts Before a contract is finalized, the project manager should have completed a risk analysis and included contract terms and conditions required to mitigate threats and enhanced opportunities.

Any contracts issued to deal with risks should be noted in the risk register.

• Reserves (contingency)

Having reserves for time and cost is a required part of project management.

You cannot come up with a schedule or budget for the project without them.

Time and cost each have two types of reserves: contingency reserves and management reserves. Contingency reserves account for "known unknowns" (or simply "knowns"); these are items you identified in risk management. Management reserves account for "unknown unknowns" (or simply "unknowns"); these are items you did not or could not identify in risk management. Projects can have both kinds of reserves shown in the diagram in figure 2.5

Contingence reserve are calculated and become part of the cost baseline. Management reserve are estimated (percent of the project cost), and then these reserves are added to the cost baseline to get the project budget.

The project manager has control of the cost baseline and can approve use of the contingency reserves, but management approval is needed to use management reserves.

Make sure you understand that reserves are not an additional cost to a project.

The risk management process should result in a decrease to the project's estimated time and cost. As threats arc eliminated or their probability or impact reduced, there should be a reduction to the project's schedule and budget.

Contingency reserves are allocated for the contingency plans and fallback plans to deal with the associated, accepted opportunities and threats that remain after the risk management planning processes have been completed. No matter what you do, risks will remain in the project, and there should be a time or cost allotment for them, just as time or cost is allotted to work activities on the project.

To calculate the contingency reserve for several risk events, which may be a combination of opportunities and threats we use the equation for expected value (P x I).

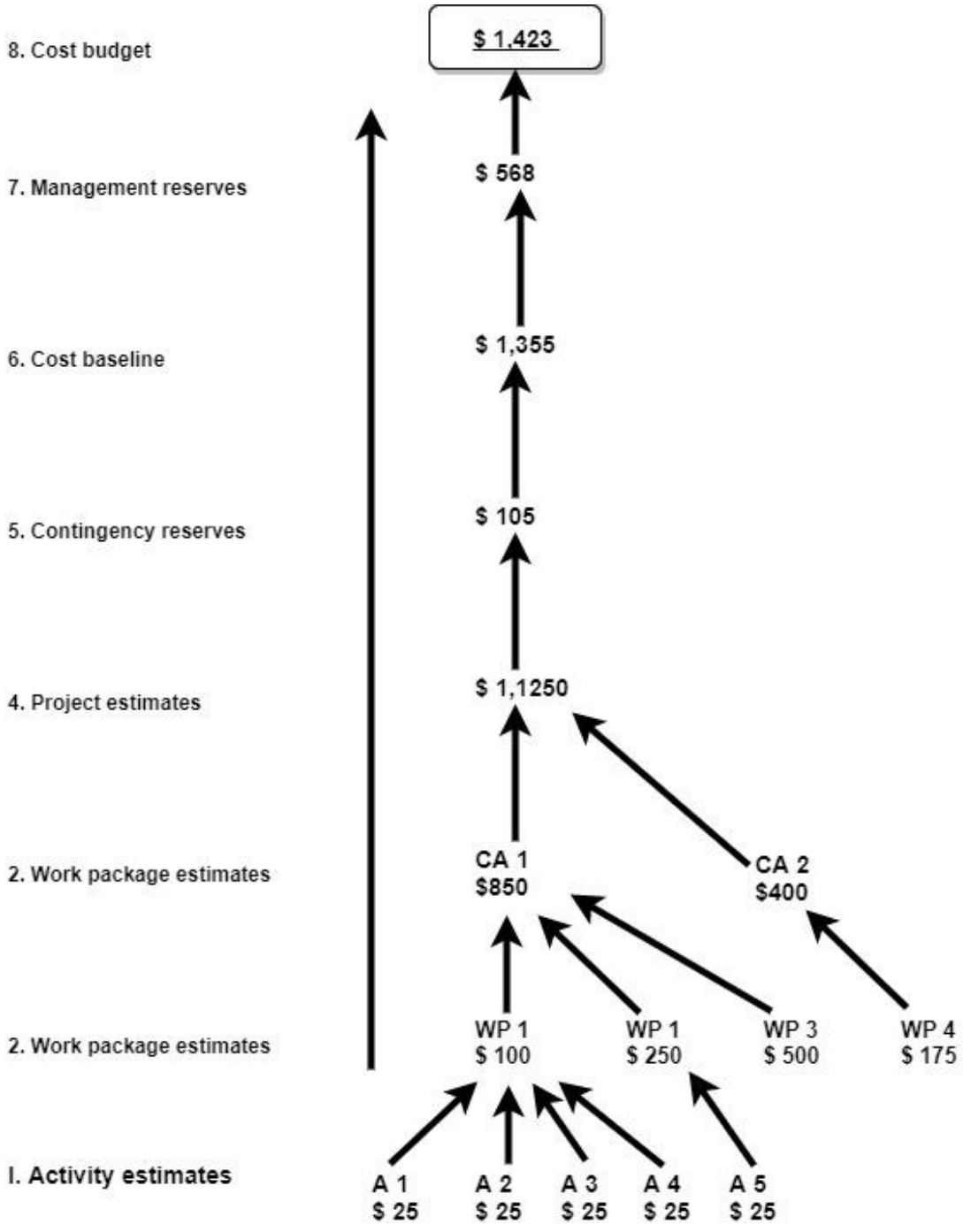


Figure 2.5 creating a budget [24]

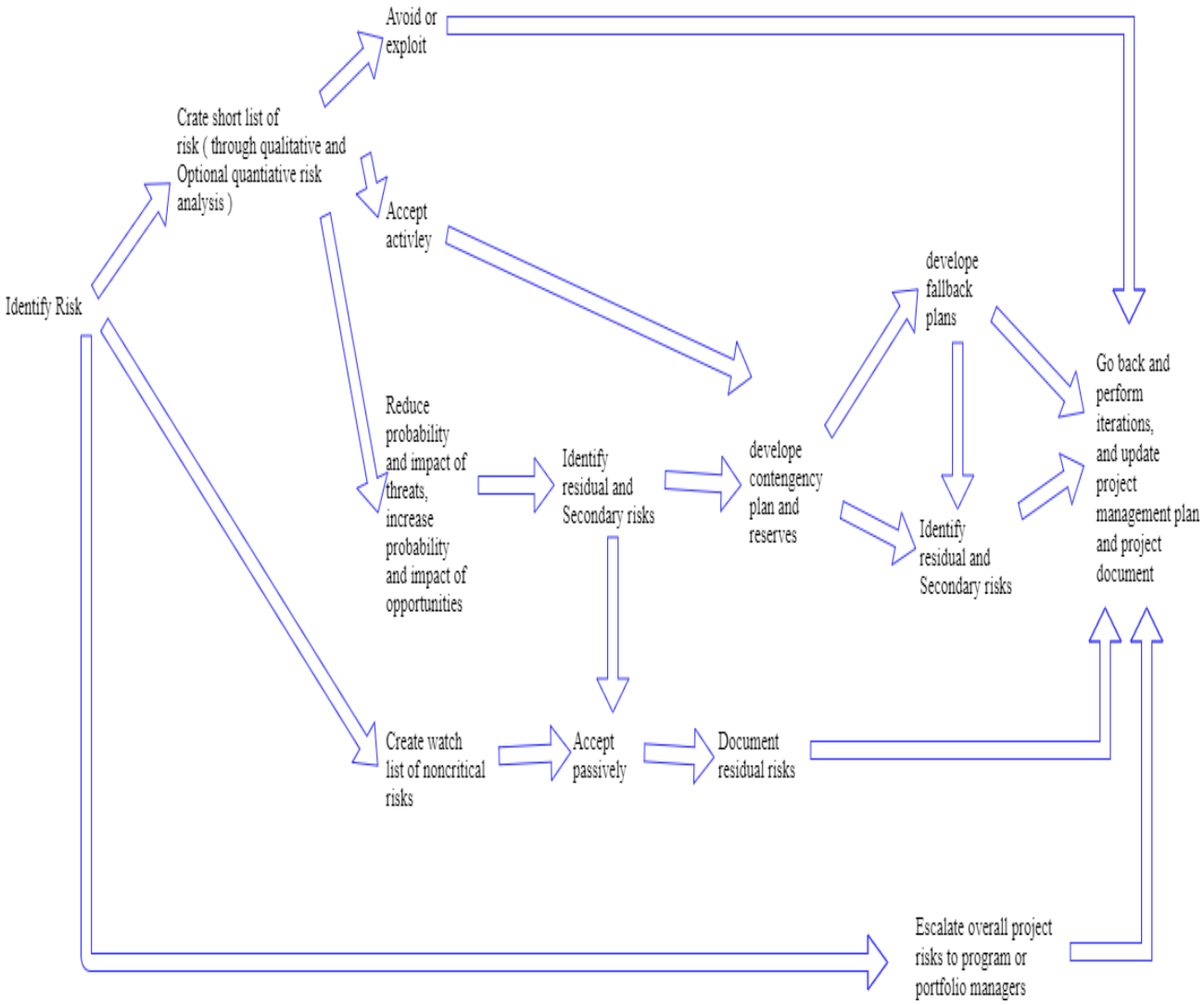


Figure 2.6 a flow chart of the risk process from Identify Risks through Plan Risk Responses [24].

2.3.6 Implement Risk Responses

When the preliminary work has been done well, the Implement Risk Responses process can be handled smoothly, since the previously documented plans allow for timely and effective responses to risk events.

Project documents arc updated as a result of the Implement Risk Responses process. The risk register and risk report are updated with information on responses taken, describing details on how will the responses addressed the risk and suggesting changes to future risk response plans.

2.3.7 Monitor Risks

The following is our list of actions involved in monitoring risks:

• Look for the occurrence of risk triggers.

• Monitor residual risks.

• Identify new risks and then analyze and plan for them. (Remember, risk can be identified anytime during the project, along with plans for how to handle the newly identified risks.)

• Evaluate the effectiveness of the risk management plan.

Is it working? Does it need adjustment?

• Develop new risk responses. If a plan no longer seems like it will work, based on experience or new information, an alternate risk response or responses may be more appropriate.

This review and analysis may lead to change requests.

• Collect and communicate risk status: "four identified risks occurred last month, and all risk response plans were implemented successfully. Next month eight other risks may occur.

Risk reserves are still considered adequate for covering the identified risks on this project."

• Communicate with stakeholders about risks: "Remember that one of the major risks on the project could occur next week.

• Determine if assumptions are still valid.

• Ensure proper risk management procedures are being followed.

• Revisit the watch list to see if additional risk responses need to be determined." this change to the product scope might increase the impact of risk X, currently on our watch list. Let's analyze it."

• Recommend corrective actions to adjust to the severity of actual risk events: "this risk did not have the impact we expected, so let's adjust the contingency plan and change what we will do if the risk reoccurs.

• Look for any unexpected effects or consequences of risk events: "We did not expect this risk to damage the construction site. We need to decide how to fix the damage after we finish implementing the already agreed-upon contingency plan.

• Reevaluate risk identification and qualitative and quantitative risk analysis when the project deviates from the baseline: "the project cost is over the cost baseline (or over the schedule baseline). This implies we missed some major risks. Let's hold another risk identification session."

• Update risk management and response plans.

• Look at the changes, including recommended corrective actions, to see if they lead to identifying more risks "we keep having to take Corrective action related to this problem. Let's look for the root cause and identify any risks to the remainder of the project that relate to the problem."

• Submit change requests to integrated change control.

• Update the project management plan and project documents with approved changes and any relevant information from the analysis of work performance data.

• Create a database of risk data and lessons learned that may be use throughout the organization on other projects.

• Perform variance and trend analysis on project performance data.

• Use contingency reserves and just for approved changes.

• Update the risk register and risk report with current risk exposure.

• Reevaluate assumptions and constraints, capture new issues, and update existing ones.

• Close out risks.

Other work that is part of the Monitor Risks process is outlined in the following sections.

Workarounds

If the project has deviated from the baselines, the team may take corrective action to bring it back in line. Recommendations for such corrective actions may include workarounds.

Whereas contingency responses are developed in advance, workarounds are unplanned responses developed to deal with the occurrence of unanticipated events or problems on a project (or to deal with risks that had been accepted because of unlikelihood of occurrence and/ or minimal impact). Project managers who do not perform risk management spend a lot of their time creating workarounds.

Risk Reassessments

It is important to determine whether any changes or adjustments need to be made to what was planned based on information that becomes apparent once work begins. Reassessing risk is a good topic for a team meeting or even a separate meeting.

The results of such reassessments are part of risk reviews along with newly identified risks, closing risks, additional qualitative or quantitative risk analysis of new and/ or previously identified risks, and further risk response planning.

Reserve Analysis

While the work is being done, reserve analysis is simply a matter of checking to see how much reserve remains and how much might be needed.

Reserves must be protected throughout the project life cycle.

A workaround needs to be created to keep the project on track, and management reserves will be used to hire experts to fix the problem and keep the project close to the current schedule.

Reserves are not a free amount of time or cost that can be used at will by the project manager for any needs! If you are inexperienced with risk management, make sure you understand how reserves are used and protected.

2.4 Technical Performance Analysis

The success of a construction project depends on its performance, which is measured base on timely completion, within the budget, required quality standard and customer satisfaction.

Technical performance analysis uses project data to compare planned versus actual completion of technical requirements determine if there is any variance from what was planned. Any variance could indicate possible risks to the project, either opportunities or threats.

2.4.1 Project Uncertainty, Risk Management and EVM

All projects include varying degrees of uncertainty.

EVM also addresses uncertainty, particularly the uncertainty surrounding time and cost performance.

The use of EVM measures, variances and indicators provides management with useful advance warnings as to the degree of risk that time and cost objectives will be met. It can also identify sources of past performance successes and

difficulties, by calculating indices and variances on the performance of specific groups (vendors, departments, etc.) or types of activities (e.g. control accounts, work packages).

This establishes an important link between risk management and procurement management. It is also clear that since procurement arrangements (contracts, agreements, purchase orders, etc.) are made in advance of the work to be performed, those could represent an important factor in any cost re-estimating work that may take place during the course of the project. Such re-estimating occurs both manually and by formula in

An important strength of EVM lies in its rigorous examination of what has already occurred on a project.

One of the perceived weaknesses of EVM is its reliance on a key assumption, that future performance can be predicted from past performance patterns. By comparison, project risk management (PRM) identifies potential future risks and benefits, together with their probability of occurrence, and uses that information to assess the range of project outcomes. This important strength of RM is also one of its key weaknesses. Events which have already taken place are not relevant to the risk processes, since there is no uncertainty associated with them.

EVM is also deterministic, as it produces a single forecast of future cost and schedule outcomes based on past performance and progress. Risk techniques such as Monte Carlo analysis are stochastic, or probabilistic, forecasts as they take into account probability distributions of unknown values for key variables [25].

Hillson noted that the EVM performance measurement baseline is typically seen as an S-shaped curve beginning at zero and increasing over the planned project duration to the budget at completion (BAC) [26].

He suggested that undertaking a full risk assessment (using a stochastic approach) at or soon after project inception would result in the recognition of both best and worst case project outcomes, plus all other possible outcomes between those extremes. Those can be shown as a set of three related S-curves representing the best case, most likely case, and worst case scenarios. This is shown in Figure 2.7 below.

Although these are typically referred to as curves the lines representing these three sets of outcomes would not usually be symmetrical and smooth lines as shown in the figure. It would be possible to calculate the data points on each of these three curves as the risk simulation software can produce a range of possible results for regular intervals on the time scale.

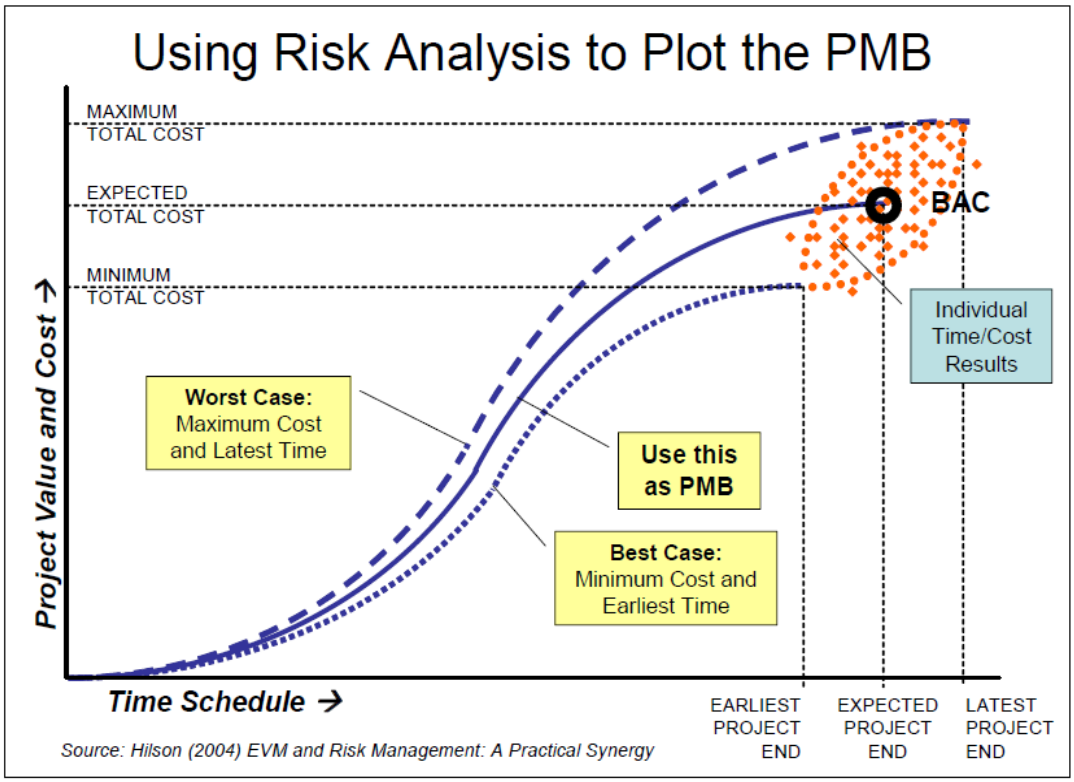


Figure 2.7: Using Risk Analysis to Plot the PMB [26].

Hillson further proposed that EVM and PRM could be combined during the project execution, through an EAC formula that would include not only the CPI (or a performance efficiency factor based on both CPI and SPI) but also the known risks and unknown uncertainty on the remainder of the project.

The result would be a collection of individual time/cost results that would cluster as shown in Figure 2.8 below.

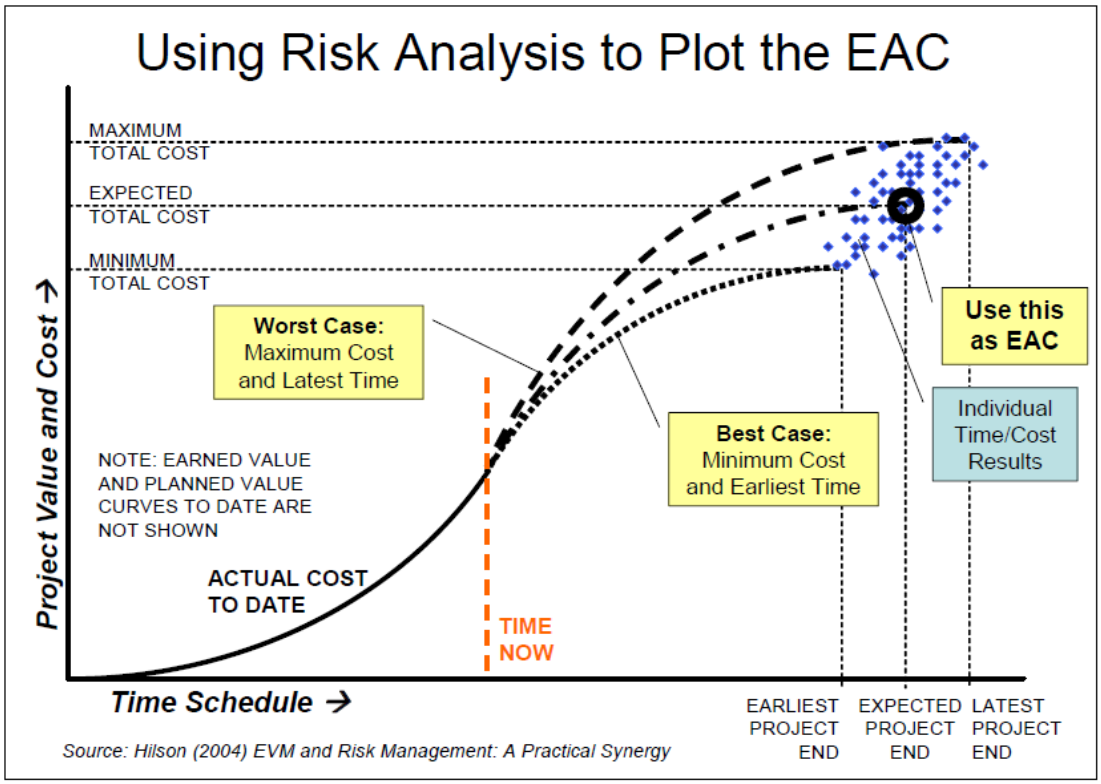


Figure 6: Using Risk Analysis to Plot the EAC [26].

The worst case results would indicate the maximum total cost and latest project end date; the best case results would indicate the minimum total cost and earliest project end date. The central point on the line joining those two extremes represents the estimated total cost, also known as the Estimate at Completion (EAC).

Hillson's combined PRM-EVM approach represents a valuable contribution to project performance evaluation, and certainly an area of research that deserves greater attention.

Combining risk management with EVM has its merits, but certainly does not simplify the evaluation process.

For example, although it is possible to plot a time-phased budget, known as the Performance Management Baseline (PMB), on a chart as shown in Figure 2.7 Using Risk Analysis to Plot the PMB, it would be very demanding to plot the expected future actual costs as shown in Figure 2.8 Using Risk Analysis to Plot the EAC. That is because the expected dates and budget amounts for future work packages are contained in the project plan, but the expected dates and actual costs for future work are not known. Risk techniques (such as Monte Carlo analysis) should be able to generate the required data to plot the Actual Cost line, but doing so would be rather challenging for many practitioners.

Meetings

Team meetings in which the project manager can perform risk reviews and risk audits.

• Risk reviews Risk reviews are hold regularly to discuss the effectiveness of planned risk responses that have been implemented on the project and may result in the identification of new risks, secondary risks created by risk response plans, and risks that are no longer applicable.

Closing of risks allows the team to focus on managing the risks th.it are still open. The closing of a risk will likely result in the associated risk reserve being returned to the company.

• Risk audits

These audits can be performed during meetings to assess the overall process of risk management on the project.

The auditing process is documented in the risk management plan.

Outputs of Monitor Risks

As with the previous risk management processes, updates to the risk report and other project documents are a result of Monitor Risks, along with additional outputs listed here.

Work Performance Information

This is the analysis of the work performance data gathered as part of project control. Examples include results of risk reviews and audits of how well risk processes are working for the project, performance measurements on schedule progress, comparisons of planned versus actual risk data, determinations of which risks can be closed or are likely to close in the near future, and variance analyses comparing the planned versus actual time and cost of implemented risk response. This information may be added as updates to that risk register, other project documents, and the project management plan or it could be the basis of change requests.

Risk Register Updates

The Monitor Risks process will add the following to the risk register:

• Outcomes of risk reassessment and risk audits

• Results of implemented risk responses

• Updates to previous parts of risk management, including the identification of new risks

• Closing of risks that arc no longer applicable

• Details of what happened when risks occurred

• Lessons learned

Change Requests

The Monitor Risks process will uncover needed project changes, including changes to the cost and schedule baselines due to overall and individual project risks.

Project Management Plan Updates

This process can result in updates to any component of the project management plan, including the schedule, cost, quality, and procurement management plans, as well as the resource management plan and the scope, schedule, and cost baselines for the project. These changes generally reflect approved preventive or corrective actions or changes to the plans.

Organizational Process Assets Updates

The Monitor Risks process may include the creation or enhancement of risk templates, such as the risk register, checklists, and risk report, as well as updates to risk management processes and procedures. 1he project's risk breakdown structure and other data may be added to organizational process assets as historical records for future projects.

2.5 Impact of apply risk management on time and cost performance:

Risk management does not really take additional time; rather, it saves huge amounts of time on projects.

Then you have done risk management, your project will go smoother and faster, with significantly fewer complications because avoidable problems were solved before they happened. You now have time to spend implementing reward systems, updating organizational process assets, creating lessons learned, preventing problems, assisting, coaching, and completing all the other work you might have thought you did not have time for.

CHAPTER III

Methodology and data collection

CHAPTER III

Methodology and data collection

3.1 Introduction

This chapter illustrates the procedures of the survey that aims to identify the most important risk factors that are expected to affect the construction project Time and Cost Performance in Khartoum state. A questionnaire survey was conducted among three main parties in construction industry; Client, Consultant and Contractor to identify the probable risk factors that have the greatest impact on the construction project time and cost Performance. Such questionnaire survey is based on the risk factors that were previously identified in the previous literature review.

3.2 industry survey

The questionnaire design took into consideration the objective of study as stated in section 1.3 with the aim to answer the research questions. Great effort and brainstorming went into designing the questionnaire. Meeting with member of the industry were conducted to identify the right questions required and to represent them clear an unambiguous format. Special care also went into phrasing the questions in language that is easily understood by respondents. In anticipation that many respondents may not by fluent English reader and speakers, an Arabic version of questionnaire was developed. The same effort was put into the Arabic version to present a clear and easy to understand format.

3.2.1 Design questionnaire:

The questionnaire is a method that includes a set of questions or sentences so that it can collect information about the problem of the study and examine its hypotheses. It is formulated in clear terms and easy words.

The questionnaire process requires the following main steps:

1. Determine the subject of the study in general as well as the sub-topics

2. Formulate a set of questions about each subtopic.

3. Conducting a pilot test on the questionnaire by presenting it to the experienced people to know their opinions on the questionnaire paragraphs and their suitability for use.

4. After the initial answers, the questionnaire will be modified in the light of the notes and printed in final form

3.2.2 Contents of the questionnaire

The questionnaire as shown in appendix 1 is divided into four section.

- The First section includes " instructions " to respondents defining the key terms in the study and providing respondents with instructions on completing the questionnaire and contains general information about the respondents such address, company size, type industry characteristics such as size, experience, etc.
- The second section addresses "The practice of apply risk management in Sudanese construction project". This section includes information about Sudanese construction Company whither they apply plans for risk management or not.

- The third section includes risk factors which have impact in cost and time performance on construction project, this list was developed from the literature review, and to evaluate the impact of this risk factor on cost and time performance must determine the probability and the impact of each risk.
  Responses in this section are given on a 5-point scale starting with (1) to indicate for very low (probability and impact) and ending with (5) to indicate for very high (probability and impact).
- The fourth section this section includes responses plan strategies during the planning phase and executing (construction) phase.

3.2.3 Population and Sample.

- Three restriction were imposed on the selection process of respondents:
- Restricted to contractors and consultant, restricted to building projects (Administrative, Commercial, Residential, Hospital), restricted to Khartoum State. With these restrictions in mind, the researcher targeted Populations (Owner, Contractor and Consultant) as presented in the Contractor Union classification and Council of Organization of Consultant.
- This listing includes (70) Contractors and (60) Consultants in Khartoum. The size of the sample required from each population was determined on the basis of statistical principles for this type of exploratory research. For such research, sample size was determined as follows (27), (28):

$$n_o = \frac{p*q}{v^2} \quad \text{..... (1)}$$

$$n = \left[\frac{n_o}{\left(1+\frac{n_o}{N}\right)}\right] \quad \text{..... (2)}$$

Where

n_o: First estimate of sample size, P: Population of characteristic being measured in the target population, q: Complement of "p" or 1-p, V: The maximum standard error allowed, N: The Population size, n: The sample size.

To maximize n, p is set at 0.5. The target population N are 70 and 60 for Contractor and Consultant respectively. To account for more error V is set at 10% or 0.1. Substituting in Equations 1 and 2 above, minimum required sample is calculated to be 19 and 18 for Contractor and Consultant respectively. This means that the minimum sample size for each population is 19 and 18. The respondents were grouped into three major groups namely Owner, Contractor and Consultant the returns from the three groups are tabulated in table (3.1) below which shows the response rate.

Out of 120 targeted responses, only 92 (76.7%) of them completed and returned the questionnaire.

Table (3.1) Questionnaire distribution and return rate.

Participant category	Questionnaires sent (sample size)	Response	Response rate (%)
Contractors	60	50	54.3
Consultants	50	35	38.1
Owners	10	7	7.6
Total	120	92	100

3.3.4 Pilot study

A pilot study could help to refine data collection plans with respect to both content of the data and procedure to be followed [28]. Thus, piloting the questionnaire with small representative sample ensure the effectiveness of a questionnaire [29]. In this case, a judgment sample of 20 respondents with a good spread of respondents, characteristics was chosen for the preliminary testing of the questionnaire. Questionnaires were administered to contractors, consultants, owners contacted in person. Nevertheless, only 15 valid responses were received from respondents constituting 75% response which was considered adequate for validation. Based on the feedback, minor corrections were made to improve the format, layout, questions and overall content of the questionnaire. Through this process, the questionnaire was validated and provided the authors with improvement opportunity prior to main survey.

3.3 Data analysis

The analysis of data was carried out with the help of statistical package for social sciences (SPSS) version 21.0. Data were carefully analyzed statistically using reliability test, frequencies and factor analysis, importance index, correlation coefficient, descriptive statistics.

3.3.1 Importance Index

Calculate the importance index of each risk factors by the following equations:

Importance Index = (Wi*Xi)/N ……. (3)

$$\text{Importance Index} = \left[\frac{5\times X5+4\times X4+3\times X3+2\times X2+ \times X1}{N}\right] \quad \text{.....} \quad (4)$$

Where:

Wi the weight is assigned to the it option of factor; Xi is the number of respondents who selected the option of factor; and N is he total number of respondents.

3.3.2 Risk matrix and scoring

In the third section to evaluate risk factors which have impact in cost and time performance we used risk matrix and scoring for each risks according to their importance Index and weight of (probability and Impact scale). Such as figure 3.1.

Score = probability weight X Impact weight ……..(5)

probability weight		Score = probability X Impact				
		Very Low	Low	Medium	High	Very High
0.9	Very High	0.045	0.09	0.18	0.36	0.72
0.7	High	0.035	0.07	0.14	0.28	0.56
0.5	Medium	0.025	0.05	0.1	0.2	0.4
0.3	Low	0.015	0.03	0.06	0.12	0.24
0.1	Very Low	0.005	0.01	0.02	0.04	0.08
		0.05	0.1	0.2	0.4	0.8
	Impacts weight					

Figure 3.1 risk scoring matrix

Scale of importance index for (Probability/ Impact)

Importance index Rating	Interpretation
Im ≤ 1	Very Low
1< Im ≤ 2	Low
2< Im ≤ 3	Medium
3< Im ≤ 4	High
4< Im≤ 5	Very high

Tolerance scale

Description		Color	Score
High	Severe and likely to happen		≥ 0.24
Medium	Moderate risk; impact is no so severe		0.24 > Score >0.05
Low	Low risk of occurrence, low project impact if it does occur		≤ 0.05

3.3.3 Reliability

[30] Reckon that Reliability is a measure of the degree to which a research instrument yields consistent results or data after repeated trials. Reliability in research is influenced by random errors. As random error increases, Reliability decreases. [31] Provided a commonly accepted rule of thumb for describing internal consistency Cronbach's alpha is as follows:

Table (3.2) Cronbach's consistency alpha [31]

Cronbach's coefficient alpha	Internal consistency remarks
$\alpha \geq 0.9$	Excellent
$0.7 \leq \alpha < 0.9$	Good
$0.6 \leq \alpha < 0.7$	Acceptable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

Reliability test was carried out to determine whether questionnaire was capable of yielding similar scores if the respondents have used it twice. The test was conducted using (SPSS) version 21.0. The most determined Cronbach's alpha coefficient values for questionnaire were $0.7 \leq \alpha < 0.9$ as shown in table 3.3.

These values indicate that questionnaire items from a scale that has reasonable internal consistency reliability. Impliedly, the survey instrument used was good reliable and Acceptable and that an agreement exists between construction industry participants.

Table (3.3) Cronbach's consistency alpha of Questionnaire section

Questionnaire section		Number of item	Cronbach's alpha
General information		8	
Sector 2		10	0.873
Sector 3	division 1	13	0.781
	division 2	5	0.791
	division 3	3	0.843
	division 4	4	0.927
	division 5	5	0.839
	division 6	7	0.897
Sector 4	division 1	8	0.822
	division 2	5	0.780

CHAPTER IV

Results analysis and discussion

CHAPTER IV

Result analysis and discussion

4.1 Introduction

This study examine how were the parties involved in any construction project deal with the concept of risk during the construction phase and to determine and ranking the risk factors in construction industry, strategies used to deal with risk and the techniques adopted in analyzing these risk. After distribution and collection processes the returned questionnaires and the valid ones were 92 questionnaires out of 120 which represented 78% that have been analyzed. The analysis and illustration the results of the data which was collected from the questionnaires, was done by using SPSS software program.

4.2 Questionnaire Analysis and Discussion

This section will include an in depth analysis for the questionnaire. This will be conducted in the same order of the questions as appearing in the questionnaire form.

4.2.1 Sample Configuration (General Questions):

(1) Participants Scientific Qualification:

Table 4.1 Scientific qualification

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	diploma	7	7.6	7.6	7.6
	Bachelor	62	67.4	67.4	75.0
	Master	19	20.7	20.7	95.7
	PHD	3	3.3	3.3	98.9
	Other	1	1.1	1.1	100.0
	Total	92	100.0	100.0	

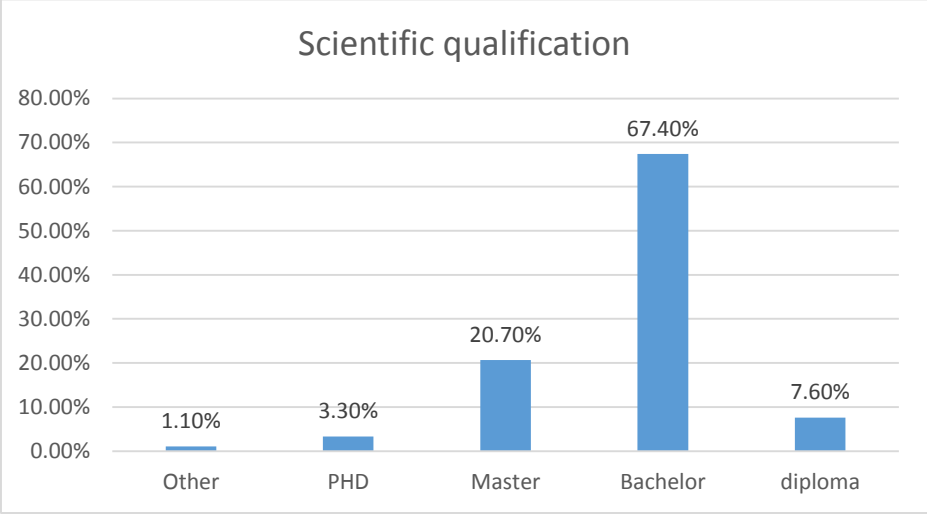


Figure 4.1 Scientific qualification

The academic qualifications of the overall participants were as presented in table (4.1) and figure (4.1). The highest percentages of participants 67.40% have bachelor degree while 20.70% earned master degree, a diploma 77.60% PhD and 1.10% other. This gives indication that the sample covers participants with

a wide range of qualification. from figure (4.1) and table (4.1) show that (2/3) of participants have bachelor degree but they have been working at least 5 years which imply a good experience to give a reasonable consent. As shown in table (4.5) and figure (4.5).

(2) Participants Category of Work Area:

Table 4.2 Category of work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Owner	7	7.6	7.6	7.6
	contractor	50	54.3	54.3	61.9
	consultant	35	38.1	38.1	100
	Total	92	100.0	100.0	

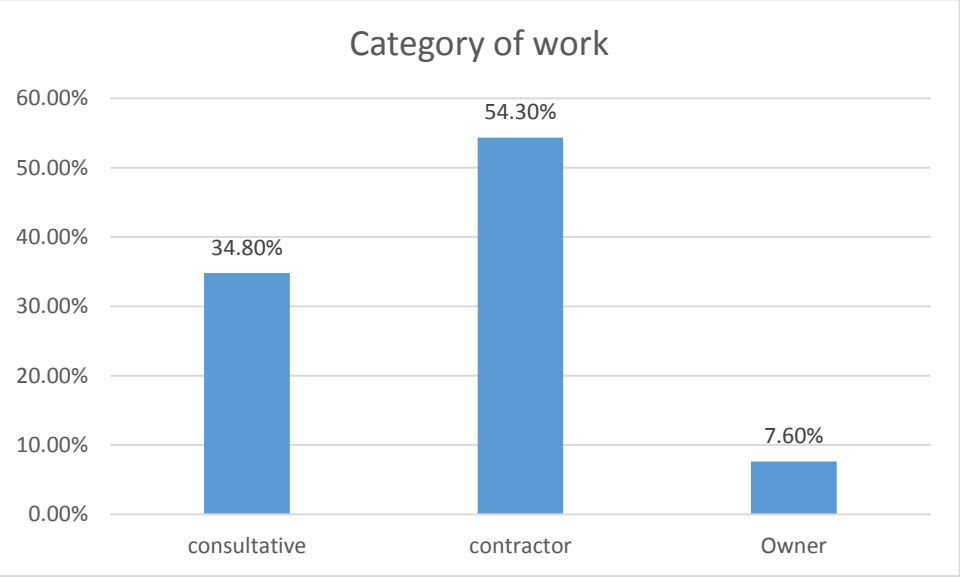


Figure 4.2 Category of work

The configuration of the participants was as presented in table (4.2) and figure (4.2), 54.30%were of the respondents were working as contractors, 7.60% were owners, 34.80% were working as consultants and 3.30% were other.

(3) Participants' type of business:

Table 4.3Type of business

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Public	77	83.7	83.7	83.7
	Private	15	16.3	16.3	100.0
	Total	92	100.0	100.0	

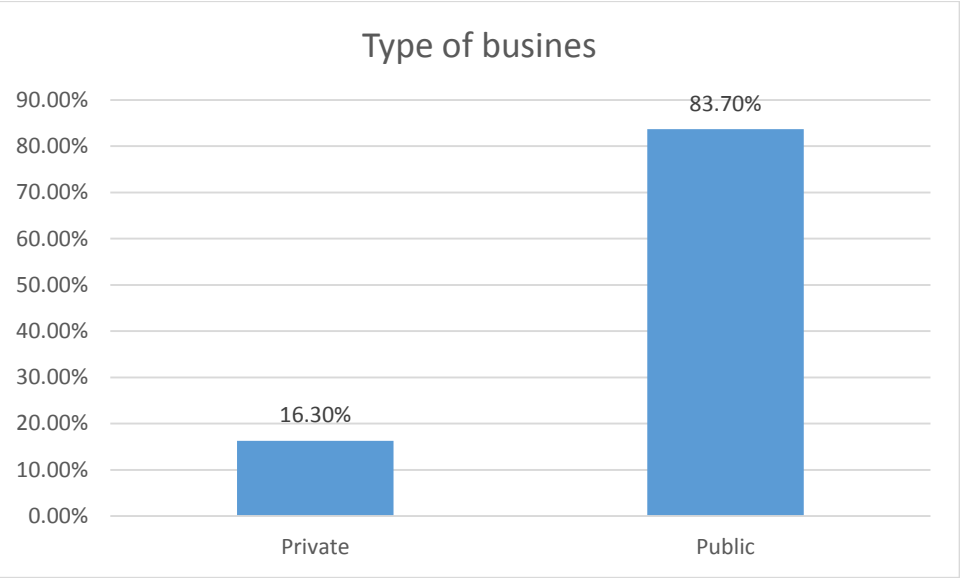


Figure 4.3Type of business

Regarding the work area, the results showed that: 83.70 % classify themselves as public sector organizations, while 16.30% were private sector organizations as shown in table (4.3) and figure (4.3).

(4) Participants Specialization:

Table 4.4 Specified field

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Civil	61	66.3	66.3	66.3
	architect	21	22.8	22.8	89.1
	other	5	5.4	5.4	94.6
	Electricity	5	5.4	5.4	100.0
	Total	92	100.0	100.0	

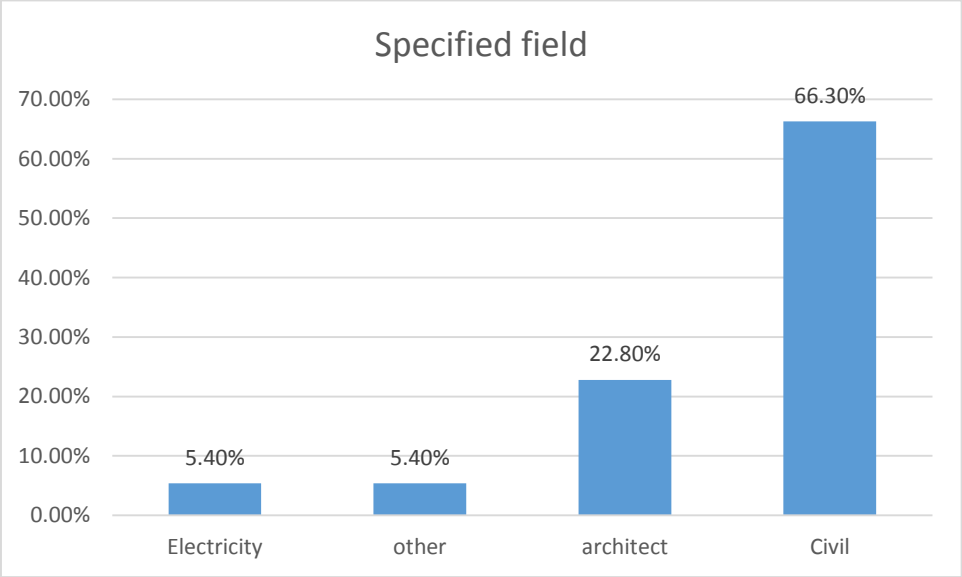


Figure 4.4 Specified field

When asked participants to specify their area of specialization, 66.30% were recorded as civil engineers, 22.80% were architects, 5.40% were electrical engineers and 5.40% were other. As shown in table (4.4) and figure (4.4).

(5) Participants Experience

Table 4.5 Years of experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 5 years	25	27.2	27.2	27.2
	5 - 10 years	23	25.0	25.0	52.2
	11 - 15 years	25	27.2	27.2	79.3
	16 - 20 years	3	3.3	3.3	82.6
	More than 20 years	16	17.4	17.4	100.0
	Total	92	100.0	100.0	

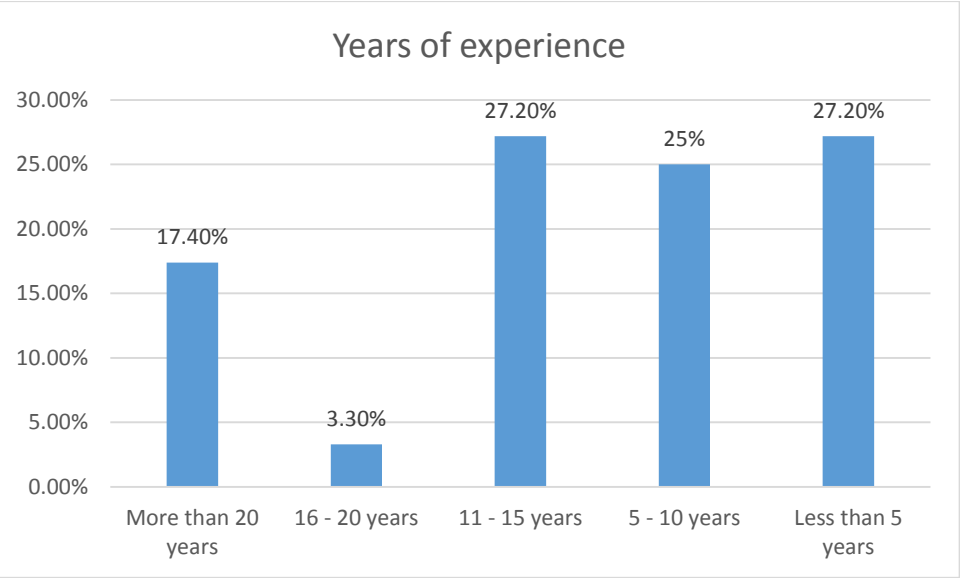


Figure 4.5 Years of experience

To evaluate the respondents experience, 27.20% admitted to be working in the field less than 5 years, 25% were working for (5 – 10) years, 27.20% for (11-15), 3.30% for (16-20) years and 17.40% for more than 20 years. This confirms that (2/3) of participants have been working for more than 5 years which imply a good experience to give a reasonable consent. As shown in table (4.5) and figure (4.5).

(6) Years of experience in risk management:

Table 4.6 Years of experience in risk management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Nill	26	28.3	28.3	28.3
	less than 5 years	34	37.0	37.0	65.2
	5-10 years	21	22.8	22.8	88.0
	11-15 years	2	2.2	2.2	90.2
	16-20 years	3	3.3	3.3	93.5
	more than 20 years	6	6.5	6.5	100.0
	Total	92	100.0	100.0	

Figure 4.6 Years of experience in risk management

From table (4.6) and figure (4.6) we note that the Experience in risk management of most of the individual's study are(Less than 5 years) with percentage (37%) and (1/3) of respondents have no Experience in risk management, this indicates no experience enough for risk management in Sudanese construction project.

(7) The number of annual executing projects

Table 4.7 The number of annual executing projects

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	less than 5	28	30.4	30.4	30.4
	5-10.	39	42.4	42.4	72.8
	11-15.	13	14.1	14.1	87.0
	16-20.	3	3.3	3.3	90.2
	more than 20	9	9.8	9.8	100.0
	Total	92	100.0	100.0	

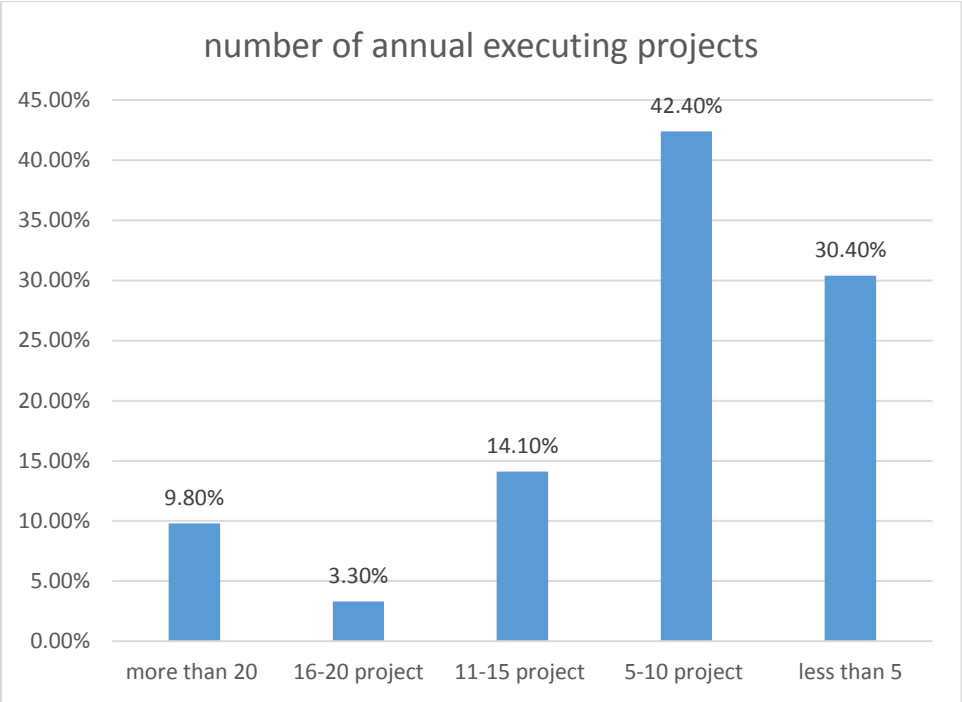


Figure 4.7 The number of annual executing projects

From table (4.7) and figure (4.7) we note that number of annual executive projects of most of the individual's study are(5-10 project) with percentage (42.40%), less than 5 project with percentage (30.40%), (11-15 project) with percentage (14.10%), (16-20 project) with percentage (3.30%) and more than 20 project with percentage (9.80%).

(8) Type of executing projects:

Table 4.8 Type of executing projects

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Residential building projects	35	38.0	38.0	38.0
	Infrastructure projects	39	42.4	42.4	80.4
	Non Residential building projects	18	19.6	19.6	100.0
	Total	92	100.0	100.0	

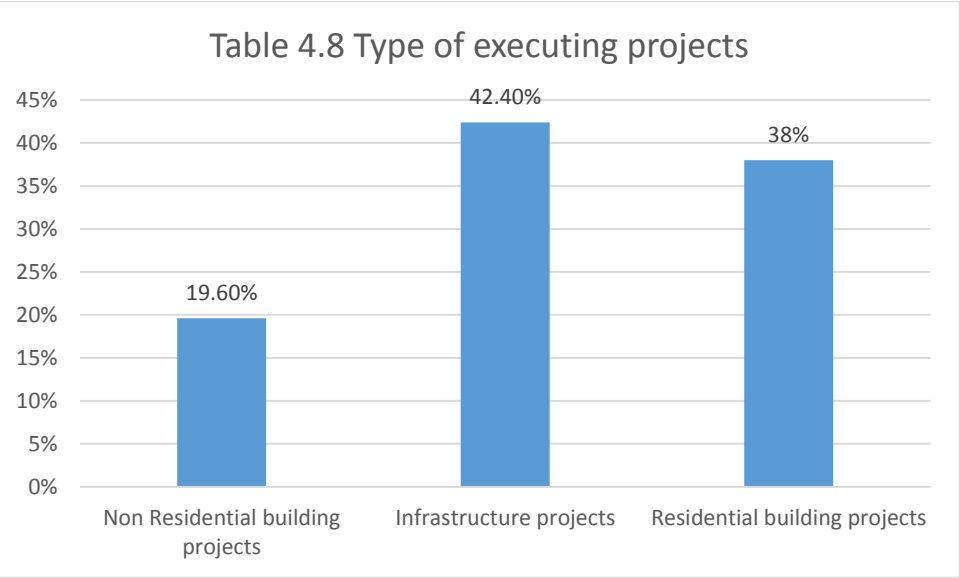


Figure 4.8 Type of executing projects

From table (4.8) and figure (4.8) we note that the type of work of most of the individual's study are (Infrastructure projects) with percentage (42.40%), this indicates the most of attention to development in the field of Infrastructure projects more than others.

4.3 The practice of apply risk management in Sudanese construction project.

Table 4.9 Reliability Statistics of the tool study for Sector two:

NO	Questions	Cronbach's Alpha if Item Deleted
Q1	Sudanese construction companies are applying risk management in their projects.	0.861
Q2	There is risk management plan.	0.850
Q3	Identify and define of risks which may face project.	0.855

Q4	There is risk responses plan.	0.850
Q5	The responsible person is identified to remedy the specific risk.	0.858
Q6	There are specialized sections on costs and cash flow accounts in construction companies.	0.873
Q7	Contract parties have enough knowledge about type of contracts and their consequences.	0.879
Q8	The total project cost is estimated include cost of reserves Contingency.	0.860
Q9	The total project duration is estimated include schedule reserves for risk.	0.858
Q10	There is analysis for cash flow paths during execution of projects.	0.858

Table 4.10 Reliability Statistics for Sector two

valitidy by squared islands	Cronbach's Alpha	N of Items
0.934	.873	10

Reliability (Internal Consistency):

Table 4.10 above shows Cronbach's alpha is 0.873, which does indicate a questionable level of internal consistency for this sample of The practice of apply risk management in Sudanese construction project. However, this could reasonably be considered 'good' as it is fairly close to the range where alpha is considered $0.7 \leq \alpha < 0.9$ Appendix 1 provides further test details.

Table (4.11) Q1 Sudanese construction companies are applying risk management in their projects?

		Frequency	Percent	Valid Percent	Cumulative Percent	Importance index
Valid	Strongly Agree	5	5.4	5.4	100.0	
	Agree	4	4.3	4.3	94.6	
	Sometimes	37	40.2	40.2	90.2	
	Disagree	17	18.5	18.5	50.0	
	Strongly Disagree	29	31.5	31.5	31.5	
	Total	92	100.0	100.0		3.65

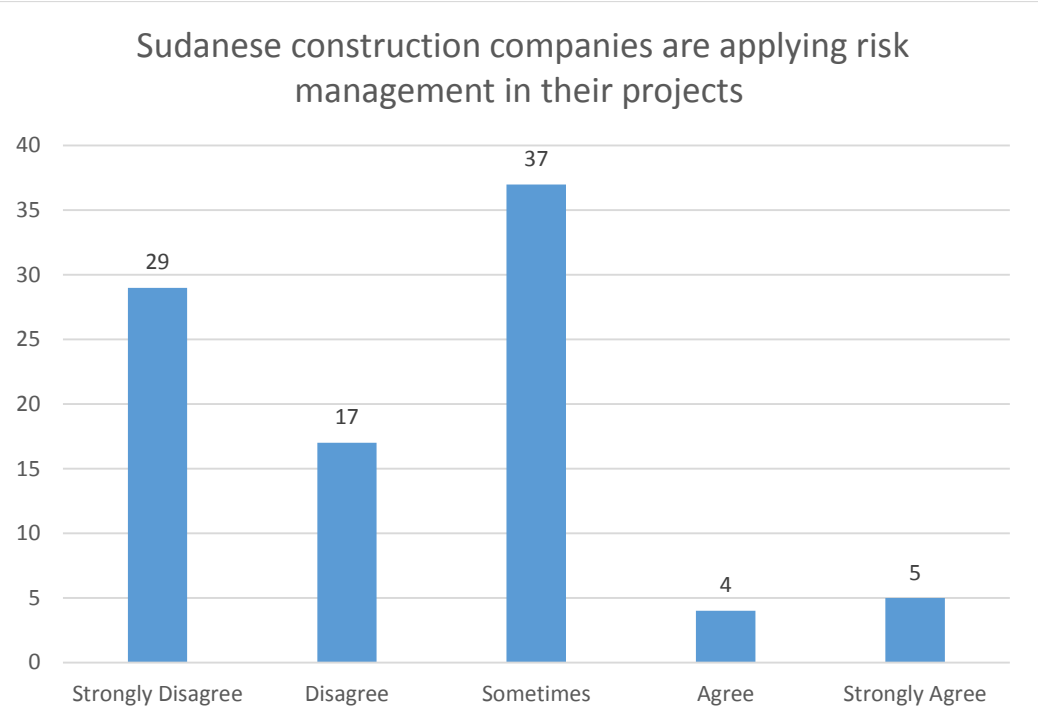


Figure 4.9 Sudanese construction companies are applying risk management in their projects?

The above table 4.11 and figure 4.9 present if the Sudanese construction companies are applying risk management in their projects, the results were as follow: 5(5.4%) of the respondents were Strongly Agree, 4(4.30%) of the respondents Agree, 37(40.2%) of the respondents Sometimes, 17(18.5%) of the respondents Disagree and 29(31.5%) of the respondents Strongly Disagree. From The above table 4.11 and figure 4.9 more than half of respondents (55.5%) with important index (3.65) were respond that the Sudanese construction companies are not applying risk management in their projects, and this indicate there is lack of knowledge and experience of risk management.

Table (4.12) Q2 There is risk management plan.

		Frequency	Percent	Valid Percent	Cumulative Percent	Importance index
Valid	Strongly Agree	5	5.4	5.4	100.0	
	Agree	8	8.7	8.7	94.6	
	Sometimes	28	30.4	30.4	85.9	
	Disagree	34	37.0	37.0	55.4	
	Strongly Disagree	17	18.5	18.5	18.5	
	Total	92	100.0	100.0		3.55

Figure 4.10 There is risk management plan

The above table 4.12 and figure 4.10 present if the Sudanese construction companies they have risk management plan in their projects, the results were as follow: 5(5.4%) of the respondents were Strongly Agree, 8(8.7%) of the respondents Agree, 28(30.4%) of the respondents Sometimes, 34(37%) of the respondents Disagree and 17(18.5%) of the respondents Strongly Disagree. 50% of respondents with important index (3.55) were respond there is not risk management plan in their projects, and this indicate there is lack of standards to manage the risks.

Table (4.13) Q3 Identify and define of risks which may face project.

		Frequency	Percent	Valid Percent	Cumulative Percent	Importance index
Valid	Strongly Agree	7	7.6	7.6	7.6	
	Agree	20	21.7	21.7	29.3	
	Sometimes	40	43.5	43.5	72.8	
	Disagree	20	21.7	21.7	94.6	
	Strongly Disagree	5	5.4	5.4	100.0	
	Total	92	100.0	100.0		3

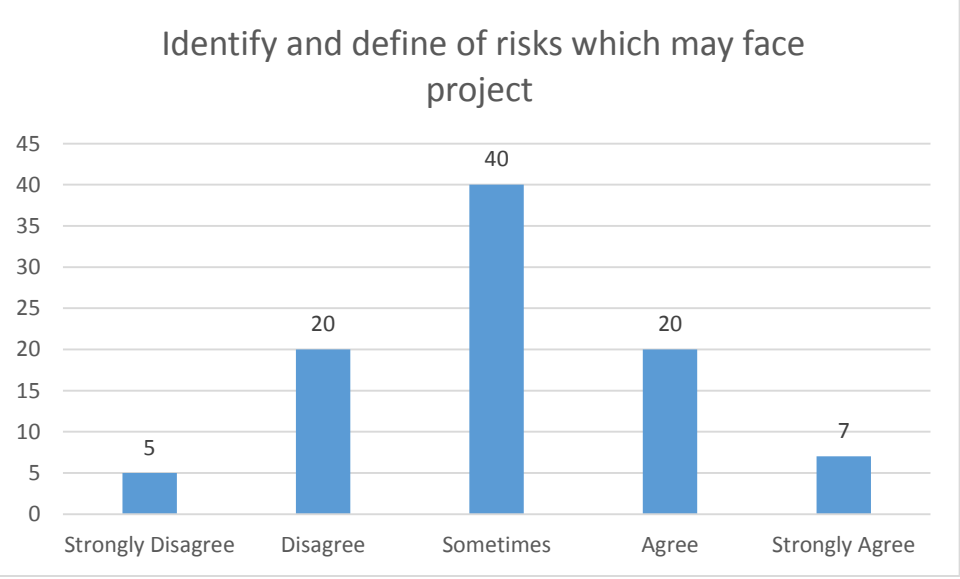


Figure 4.11 Identify and define of risks which may face project.

The above table 4.13 and figure 4.11 present Identify and define of risks which may face project, the results were as follow: 7(7.6%) of the respondents were

Strongly Agree, 20(21.7%) of the respondents Agree, 40(43.5%) of the respondents Sometimes, 20(21.7%) of the respondents Disagree and 5(5.4%) of the respondents Strongly Disagree. with importance index (3).

Table (4.14) Q4 There is risk responses plan

		Frequency	Percent	Valid Percent	Cumulative Percent	Importance index
Valid	Strongly Agree	6	6.5	6.5	6.5	
	Agree	4	4.3	4.3	100.0	
	Sometimes	24	26.1	26.1	75.0	
	Disagree	19	20.7	20.7	95.7	
	Strongly Disagree	39	42.4	42.4	48.9	
	Total	92	100.0	100.0		3.90

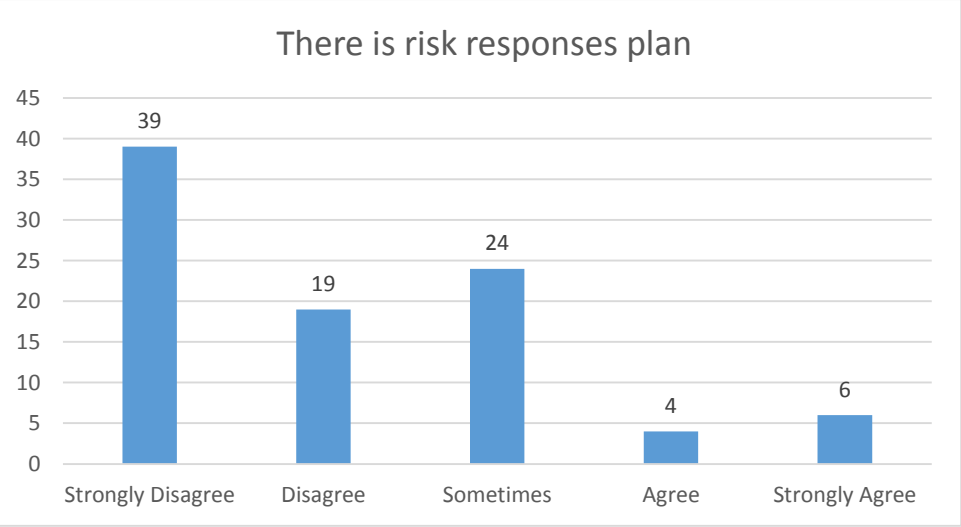


Figure 4.12 There is risk responses plan

The above table 4.14 and figure 4.12 present Identify and define of risks which may face project, the results were as follow: 6(6.5%) of the respondents were Strongly Agree, 4(4.3%) of the respondents Agree, 24(26.1%) of the respondents Sometimes, 19(20.7%) of the respondents Disagree and 39(42.4%) of the respondents Strongly Disagree. with importance index (3.90).

Table (4. 15) Q5 The responsible person is identified to remedy the specific risk.

		Frequency	Percent	Valid Percent	Cumulative Percent	Importance index
Valid	Strongly Agree	5	5.4	5.4	5.4	
	Agree	16	17.4	17.4	22.8	
	Sometimes	38	41.3	41.3	64.1	
	Disagree	28	30.4	30.4	94.6	
	Strongly Disagree	5	5.4	5.4	100.0	
	Total	92	100.0	100.0		3.15

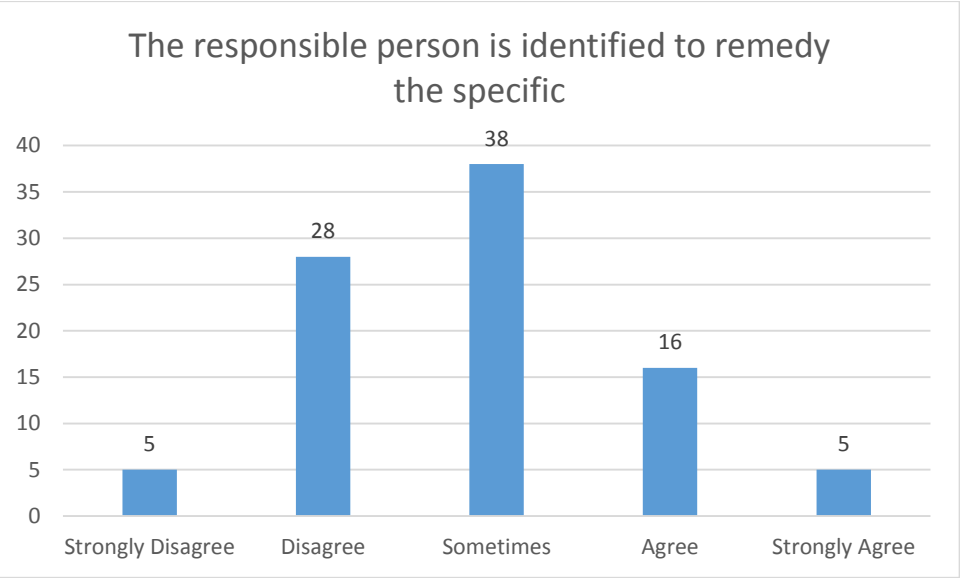


Figure 4.13The responsible person is identified to remedy the specific risk.

The above table 4.15 and figure 4.13 present the responsible person is identified to remedy the specific risk, the results were as follow: 5(5.4%) of the respondents were Strongly Agree, 16(17.4%) of the respondents Agree, 38(41.4%) of the respondents Sometimes, 28(30.4%) of the respondents Disagree and 5(5.4%) of the respondents Strongly Disagree. with importance index (3.15).

Table (4.16) Q6 There is specialized sections on costs and cash flow accounts in construction companies.

		Frequency	Percent	Valid Percent	Cumulative Percent	importance index
Valid	Strongly Agree	1	1.1	1.1	1.1	
	Agree	7	7.6	7.6	8.7	
	Sometimes	21	22.8	22.8	31.5	
	Disagree	47	51.1	51.1	82.6	
	Strongly Disagree	16	17.4	17.4	100.0	
	Total	92	100.0	100.0		3.75

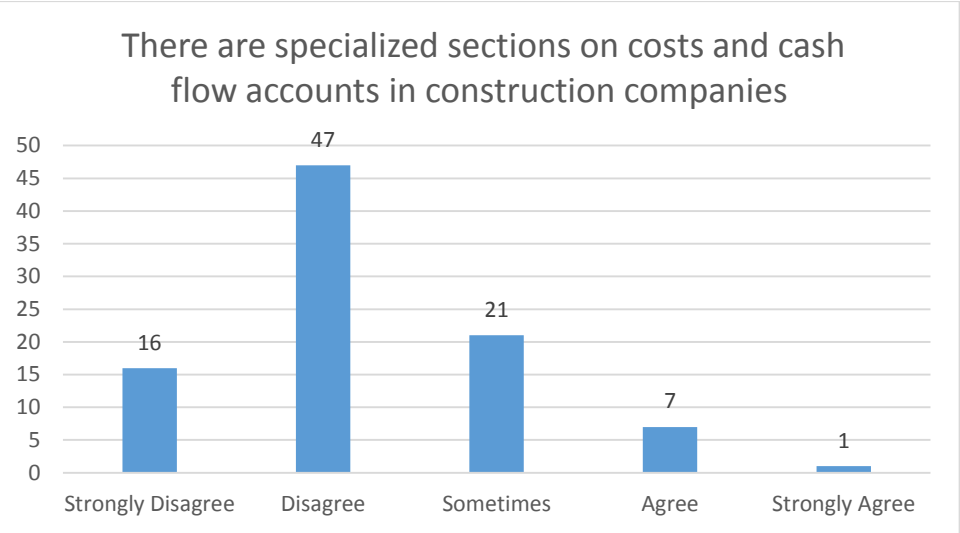


Figure 4.14 There is specialized sections on costs and cash flow accounts in construction companies.

The above table 4.16 and figure 4.14 present There are specialized sections on costs and cash flow accounts in construction companies, the results were as follow: 1(1.2%) of the respondents were Strongly Agree, 7(7.6%) of the respondents Agree, 21(22.8%) of the respondents Sometimes, 47(51.1%) of the respondents Disagree and 16(17.4%) of the respondents Strongly Disagree. with importance index (3.75)

Table (4.17) Q7 Contract parties have enough knowledge about type of contracts and their consequences.

		Frequency	Percent	Valid Percent	Cumulative Percent	Importance index
Valid	Strongly Agree	2	2.2	2.2	2.2	
	Agree	10	10.9	10.9	13.0	
	Sometimes	27	29.3	29.3	42.4	
	Disagree	43	46.7	46.7	89.1	
	Strongly Disagree	10	10.9	10.9	100.0	
	Total	92	100.0	100.0		3.55

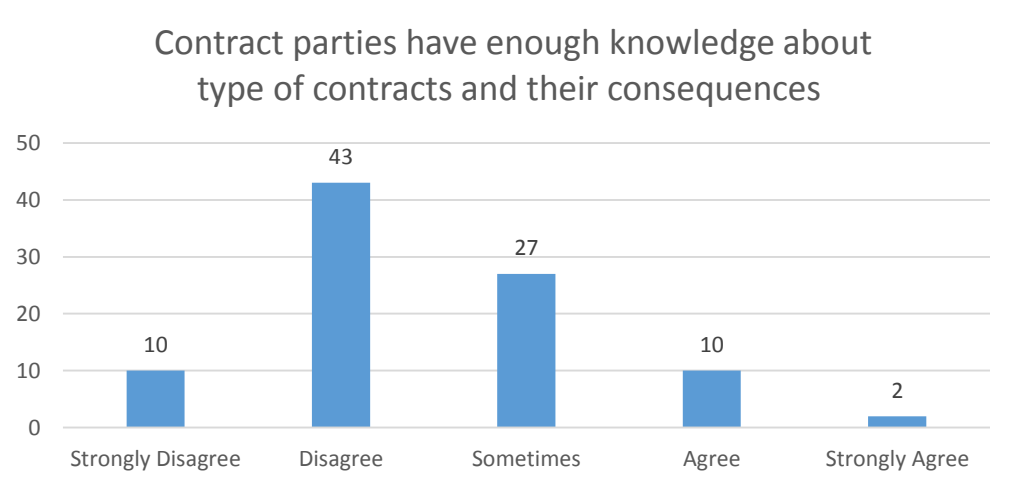


Figure 4.15 Contract parties have enough knowledge about type of contracts and their consequences.

The above table 4.17 and figure 4.15 Contract parties have enough knowledge about type of contracts and their consequences, the results were as follow:

2(2.2%) of the respondents were Strongly Agree, 10(10.9%) of the respondents Agree, 27(29.3%) of the respondents Sometimes, 43(46.7%) of the respondents Disagree and 10(10.9%) of the respondents Strongly Disagree. with importance index (3.55).

Table (4.18) Q8 The total project cost is estimated include cost of reserves Contingency.

		Frequency	Percent	Valid Percent	Cumulative Percent	Importance index
Valid	Strongly Agree	4	4.3	4.3	4.3	
	Agree	27	29.3	29.3	33.7	
	Sometimes	28	30.4	30.4	64.1	
	Disagree	27	29.3	29.3	93.5	
	Strongly Disagree	6	6.5	6.5	100.0	
	Total	92	100.0	100.0		3.05

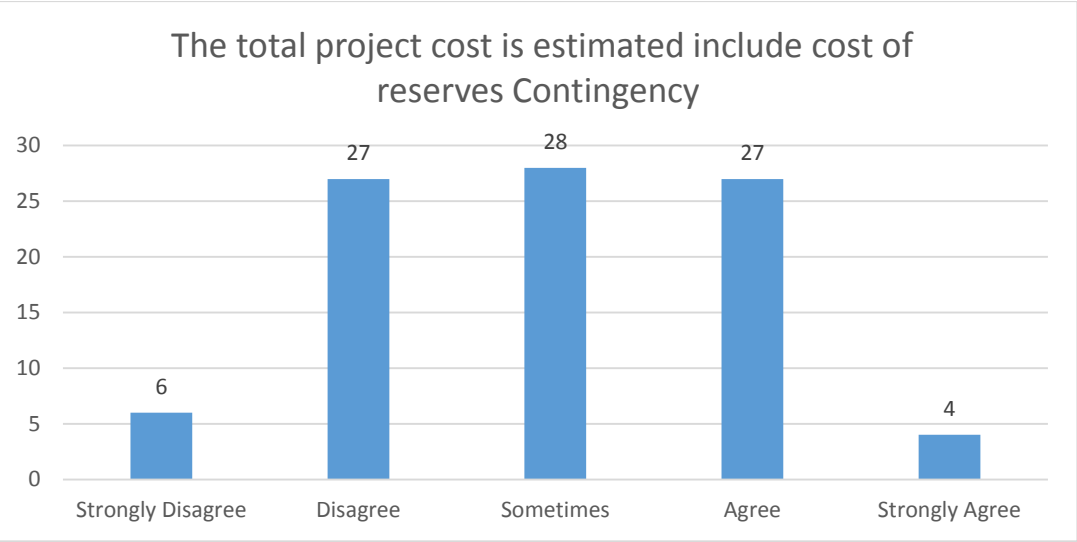


Figure 4.16 the total project cost is estimated include cost of reserves Contingency.

The above table 4.18 and figure 4.16 the total project cost is estimated include cost of reserves Contingency, the results were as follow: 4(4.4%) of the respondents were Strongly Agree, 27(29.3%) of the respondents Agree, 28(30.4%) of the respondents Sometimes, 27(29.3%) of the respondents Disagree and 6(6.5%) of the respondents Strongly Disagree. with importance index (3.05).

Table (4.19) Q9The total project duration is estimated include schedule reserves for risk.

		Frequency	Percent	Valid Percent	Cumulative Percent	Importance index
Valid	Strongly Agree	7	7.6	7.6	7.6	
	Agree	25	27.2	27.2	34.8	
	Sometimes	27	29.3	29.3	64.1	
	Disagree	27	29.3	29.3	93.5	
	Strongly Disagree	6	6.5	6.5	100.0	
	Total	92	100.0	100.0		3

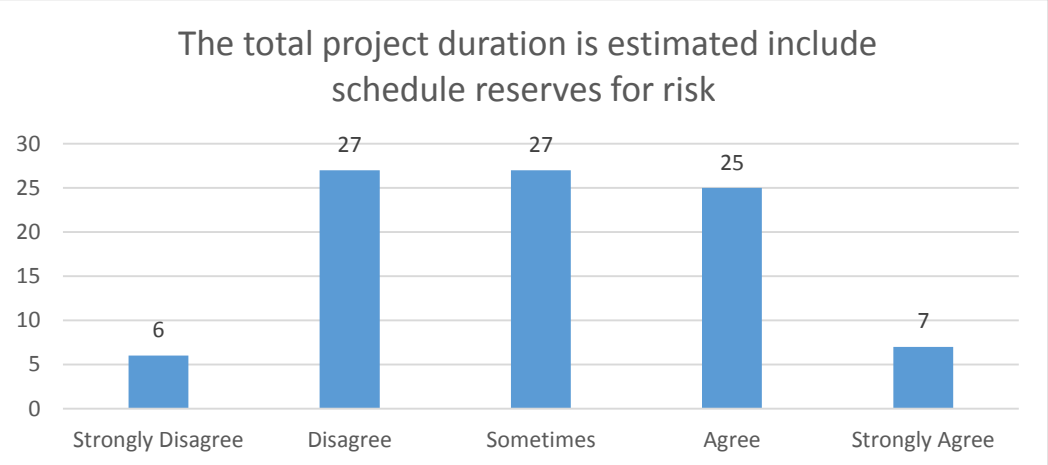


Figure 4.17 the total project duration is estimated include schedule reserves for risk.

The above table 4.19 and figure 4.17 the total project duration is estimated include schedule reserves for risk, the results were as follow: 7(7.6%) of the respondents were Strongly Agree, 25(27.2%) of the respondents Agree, 27(29.3%) of the respondents Sometimes, 27(29.3%) of the respondents Disagree and 6(6.5%) of the respondents Strongly Disagree. with importance index (3.05).

Table (4.20) Q10 There is analysis for cash flow paths during execution of projects.

		Frequency	Percent	Valid Percent	Cumulative Percent	Importance index
Valid	Strongly Agree	2	2.2	2.2	2.2	
	Agree	10	10.9	10.9	13.0	
	Sometimes	33	35.9	35.9	48.9	
	Disagree	40	43.5	43.5	92.4	
	Strongly Disagree	7	7.6	7.6	100.0	
	Total	92	100.0	100.0		3.45

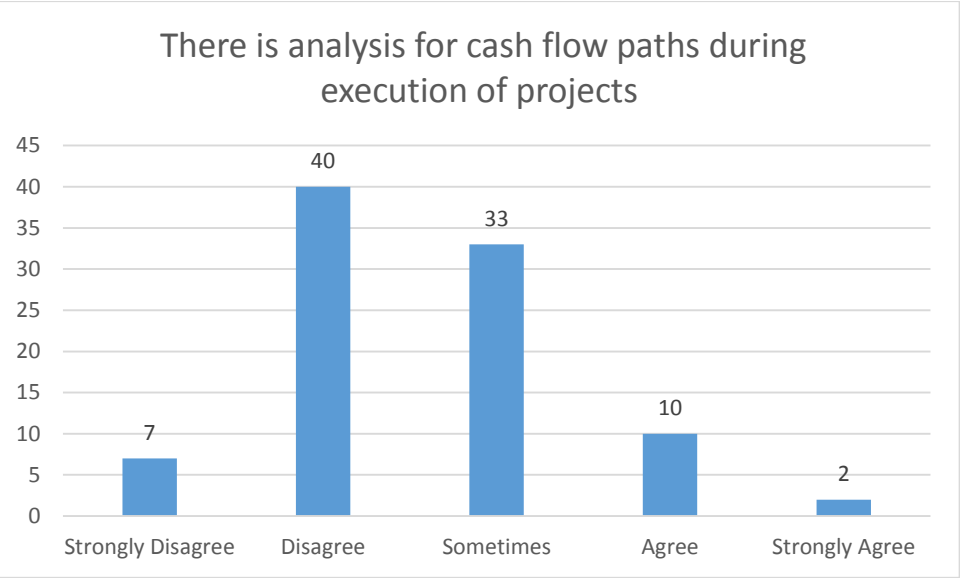


Figure 4.18 There is analysis for cash flow paths during execution of projects.

The above table 4.20 and figure 4.18 There is analysis for cash flow paths during execution of projects, the results were as follow: 2(2.2%) of the respondents were Strongly Agree, 10(10.9%) of the respondents Agree, 33(35.9%) of the respondents Sometimes, 40(43.5%) of the respondents Disagree and 7(7.6%) of the respondents Strongly Disagree. with importance index (3.45).

4.4 Risk factors which have effects on time and cost performance in construction projects in khartoum state.

4.4.1 Probability, impact and Importance Index of Risk factors related to contractors:

Evaluation the impact of contractor's risk factors on time performance:

Table 4.21 Probability of contractor's risk factors, Cronbach's Alpha and Importance Index

ID	Risk factors	Probability level					Cronbach's Alpha if Item Deleted	Importance Index
		1	2	3	4	5		
R1	Decrease in productivity of workers	8	12	17	22	33	0.607	3.65
R2	lack on main resource of contractor	25	13	20	14	20	0.739	2.90
R3	Bad understanding for contract items.	30	25	20	12	5	0.658	2.32
R4	Shortage of contractors' experience and technical skills	27	22	16	15	12	0.749	2.60
R5	Financial failure of the contractor	11	27	21	12	21	0.839	3.05
R6	Financial failure of supplier /subcontractor	9	30	25	11	17	0.607	2.97
R7	Shortage of subcontractors' experience and technical skills	45	30	5	5	7	0.539	1.90
R8	Technology changes	36	33	15	5	3	0.658	1.98
R9	The scope of work for the contractor is not well defined	11	29	22	12	18	0.749	2.97

R10	Ambiguous planning due to project complexity	4	33	30	10	15	0.839	2.99
R11	Poor resource management	14	31	24	13	10	0.707	2.72
R12	Occurrence of accidents due to poor safety procedure	2	3	23	29	35	0.639	4.00
R13	Non-compliance with building codes and regulations	40	33	15	3	1	0.558	1.83

Table 4.22 Reliability Statistics test of contractor's Probability risk factors

Cronbach's Alpha[a]	Cronbach's Alpha Based on Standardized Items	N of Items
0.781	0.610	13

Reliability (Internal Consistency):

Table 4.22 above shows Cronbach's alpha is 0.781, which does indicate a questionable level of internal consistency for this sample of Probability of contractor's risk factors. However, this could reasonably be considered 'good' as it is fairly close to the range where alpha is considered $0.7 \leq \alpha < 0.9$ Appendix 1 provides further test details.

The risk factors on bellow tables were rank according to their Importance Index (of probability / Impact) from highest to lowest.

Table 4.23 ranking of contractor's risk factors probabilities (on time)

ID	Importance Index	probability scale
Risk Factors related to contractors		
R12	4.00	High
R1	3.65	High
R5	3.05	High
R10	2.99	Medium
R6	2.97	Medium
R9	2.97	Medium
R2	2.90	Medium

R11	2.72	Medium
R4	2.60	Medium
R3	2.32	Medium
R8	1.98	Low
R7	1.90	Low
R13	1.83	Low

Table 4.24 ranking of contractor's risk factors impacts (on time)

ID	Importance Index	Impact scale
Risk Factors related to contractors		
R1	4.08	Very High
R2	4.08	Very High
R4	4.08	Very High
R5	4.08	Very High
R10	4.08	Very High
R8	4.05	Very High
R3	3.05	High
R9	3.05	High

R6	2.97	Medium
R7	1.90	Low
R11	1.90	Low
R13	1.66	Low
R12	1.64	Low

Probabilities	Impacts				
	Very Low	Low	Medium	High	Very High
Very High					
High		R12			R1,R5
Medium		R11	R6	R9,R3	R10,R2,R4
Low		R7,R13			R8
Very Low					

Figure 4.19 risk matrix to evaluate the impact of contractor's risk factors on time performance

- The results in figure (4.19) show that R1(Decrease in productivity of workers), R5(Financial failure of the contractor), R10(Ambiguous planning due to project complexity), R2 (lack on main resource of contractor), R4(Shortage of contractors' experience and technical skills) and R8(Technology changes) are requires the most attention ,further

analysis, including quantification, and aggressive risk management (an immediate response).

- The results in figure (4.19) show that R9 (The scope of work for the contractor is not well defined), R3 (Bad understanding for contract items), R6 (Financial failure of supplier /subcontractor) and R12 (Occurrence of accidents due to poor safety procedure) are requires a good amount of attention, should be put on the watch list
- The results in figure (4.19) show that R7 (Shortage of subcontractors' experience and technical skills), R11 (Poor resource management) and R13(Non-compliance with building codes and regulations) are requires less attention to be paid, should be put on the watch list.

Evaluation the impact of contractor's risk factors on cost performance:

The risk factors on bellow tables were rank according to their Importance Index (of probability / Impact) from highest to lowest.

Table 4.25 ranking of contractor's risk factors probabilities (on cost)

ID	Importance Index	probability scale
Risk Factors related to contractors		
R12	4.00	High
R1	3.65	High
R5	3.05	High

R10	2.99	Medium
R6	2.97	Medium
R9	2.97	Medium
R2	2.90	Medium
R11	2.72	Medium
R4	2.60	Medium
R3	2.32	Medium
R8	1.98	Low
R7	1.90	Low
R13	1.83	Low

Table 4.26 ranking of contractor's risk factors impacts (on cost)

ID	Importance Index	Impact scale
Risk Factors related to contractors		
R11	4.20	Very High
R9	4.08	Very High
R1	3.88	High
R3	3.34	High

R5	3.11	High
R2	3.00	Medium
R8	3.00	Medium
R6	2.90	Medium
R10	2.89	Medium
R4	2.57	Medium
R7	1.91	Low
R12	1.83	Low
R13	1.82	Low

Probabilities	Impacts				
	Very Low	Low	Medium	High	Very High
Very High					
High		R12		R1,R5	
Medium			R10,R6,R2,R4	R3	R9,R11
Low		R7,R13	R8		
Very Low					

Figure 4.20 risk matrix to evaluate the impact of contractor's risk factors on cost performance

- The results in figure (4.20) show that R1 (Decrease in productivity of workers), R5 (Financial failure of the contractor), R9 (The scope of work

for the contractor is not well defined), R11 (Poor resource management) are requires the most attention, further analysis, including quantification, and aggressive risk management (an immediate response).

- The results in figure (4.20) show that, R3 (Bad understanding for contract items), R10 (Ambiguous planning due to project complexity), R6 (Financial failure of supplier /subcontractor), R2 (lack on main resource of contractor), R4(Shortage of contractors' experience and technical skills) and R8(Technology changes) and R12 (Occurrence of accidents due to poor safety procedure) are requires a good amount of attention, should be put on the watch list.
- The results in figure (4.20) show that R7 (Shortage of subcontractors' experience and technical skills), and R13 (Non-compliance with building codes and regulations) are requires less attention to be paid, should be put on the watch list.

4.4.2 Probability, impact and Importance Index of Factors related to consultant:

Evaluation the impact of consultant's risk factors on time performance:

Table (4.27) Probability of consultant's risk factors and Cronbach's Alpha

ID	Risk factors	Probability level						Importance Index
		1	2	3	4	5		

							Cronbach's Alpha if Item Deleted	
R14	Shortage of consultants' experience and technical skills	2	9	16	18	47	0.658	4.08
R15	Delay from consultant to approve executed works	30	17	24	13	8	0.818	2.48
R16	poor communication between involved parties	29	18	19	17	9	0.687	2.55
R17	Materials not conforming to specifications	40	33	15	2	2	0.821	1.84
R18	Unethical practices of consultant	39	34	16	2	1	0.709	1.83

Table (4.28) Reliability Statistics of consultant's Probability risk factor

Cronbach's Alpha[a]	Cronbach's Alpha Based on Standardized Items[a]	No of Items
0.791.	0.627	5

Reliability (Internal Consistency):

Table 4.28above shows Cronbach's alpha is 0.791, which does indicate a questionable level of internal consistency for this sample of Probability of consultant's risk factors. However, this could reasonably be considered 'good' as it is fairly close to the range where alpha is considered $0.7 \leq \alpha < 0.9$ Appendix 1 provides further test details.

The risk factors on bellow tables were rank according to their Importance Index (of probability / Impact) from highest to lowest.

Table (4.29) ranking of consultant's risk factors probabilities (on time)

Risk factors related to consultant		
ID	Importance Index	probability scale
R14	4.08	Very High
R15	2.48	Medium
R16	2.55	Medium
R17	1.84	Low
R18	1.83	Low

Table (4.30) ranking of consultant's risk factors (on time) impacts

Risk factors related to consultant		
ID	Importance Index	Impact scale
R16	2.49	Medium
R15	2.46	Medium
R17	1.78	Low
R14	1.72	Low
R18	1.72	Low

Probabilities	Impacts				
	Very Low	Low	Medium	High	Very High
Very High		R14			
High					
Medium			R15,R16		
Low		R17,R18			
Very Low					

Figure 4.21 risk matrix to evaluate the impact of consultant's risk factors on time performance

- The results in figure (4.21) show that, R15 (Delay from consultant to approve executed works), R16 (poor communication between involved parties), R14 (Shortage of consultants' experience and technical skills) are requires a good amount of attention, should be put on the watch list.
- The results in figure (4.21) show that R17 (Materials not conforming to specifications) and R18 (Unethical practices of consultant) are requires less attention to be paid, should be put on the watch list.

Evaluation the impact of consultant's risk factors on cost performance:

The risk factors on bellow tables were rank according to their Importance Index (of probability / Impact) from highest to lowest.

Table (4.31) ranking of consultant's risk factors probabilities (on cost)

Risk factors related to consultant		
ID	Importance Index	probability scale
R14	4.08	Very High
R15	2.48	Medium
R16	2.55	Medium
R17	1.84	Low
R18	1.83	Low

Table (4.32) ranking of consultant's risk factors impacts (on cost)

Risk factors related to consultant		
ID	Importance Index	Impact scale
R17	3.95	High
R16	1.88	Low
R15	1.87	Low
R14	1.83	Low
R18	1.83	Low

Probabilities					Impacts
	Very Low	Low	Medium	High	Very High
Very High		R14			
High					
Medium		R15,R16			
Low		R18		R17	
Very Low					

Figure 4.22 risk matrix to evaluate the impact of consultant's risk factors on cost performance

- The results in figure (4.22) show that R14 (Shortage of consultants' experience and technical skills) and R17 (Materials not conforming to specifications) are requires a good amount of attention, should be put on the watch list.
- The results in figure (4.22) show that R15 (Delay from consultant to approve executed works), R16 (poor communication between involved parties) and R18 (Unethical practices of consultant) are requires less attention to be paid, should be put on the watch list.

4.4.3 Probability, impact and Importance Index of Factors related to designer:

Evaluation the impact of designer's risk factors on time performance:

Table (4.33) Probability of designer's risk factors and Cronbach's Alpha

ID	Risk factors	Probability level					Cronbach's Alpha if Item Deleted	Importance Index
		1	2	3	4	5		
R19	Design mistake	14	31	26	13	8	0.641	2.67
R20	Design complexity	40	25	24	1	2	0.801	1.91
R21	Lack / shortage of design	2	9	16	19	46	0.716	4.07

Table (4.34) Reliability Statistics of designer's risk factors

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items[a]	No of Items
0.843	0.712	3

Reliability (Internal Consistency):

Table 4.34 above shows Cronbach's alpha is 0.843, which does indicate a questionable level of internal consistency for this sample of Probability of designer's risk factors. However, this could reasonably be considered 'good' as it is fairly close to the range where alpha is considered $0.7 \leq \alpha < 0.9$ Appendix 3 provides further test details.

The risk factors on bellow tables were rank according to their Importance Index (of probability / Impact) from highest to lowest.

Table (4.35) ranking of designer's risk factors probabilities (on time)

Risk factors related to designer		
ID	Importance Index	probability scale
R21	4.07	Very High
R19	2.67	Medium
R20	1.91	Low

Table (4.36) ranking of designer's risk factors impacts (on time)

Risk factors related to designer		
ID	Importance Index	Impact scale
R20	4.10	Very High
R19	2.68	Medium
R21	2.45	Low

Probabilities	Impacts				
	Very Low	Low	Medium	High	Very High
Very High		R21			
High					
Medium			R19		
Low					R20
Very Low					

Figure 4.23 risk matrix to evaluate the impact of designer's risk factors on time performance

- The results in figure (4.23) show that R20 (Complex of design) is requires the most attention, further analysis, including quantification, and aggressive risk management (an immediate response).

- The results in figure (4.23) show that, R19 (Design mistake) and (Lack / shortage of design) are requires a good amount of attention, should be put on the watch list

Evaluation the impact of designer's risk factors on cost performance:

The risk factors on bellow tables were rank according to their Importance Index (of probability / Impact) from highest to lowest

Table (4.37) ranking of designer's risk factors probabilities (on cost)

Risk factors related to designer		
ID	Importance Index	probability scale
R21	4.07	Very High
R19	2.67	Medium
R20	1.91	Low

Table (4.38) ranking of designer's risk factors impacts (on cost)

Risk factors related to designer		
ID	Importance Index	Impact scale
R19	2.67	Medium
R20	2.14	Medium

R21	2.00	Medium

Probabilities	Impacts				
	Very Low	Low	Medium	High	Very High
Very High			R21		
High					
Medium			R19		
Low			R20		
Very Low					

Figure 4.24 risk matrix to evaluate the impact of designer's risk factors on cost performance

- The results in figure (4.24) show that, R19 (Design mistake), R20 (Complex of design) and R21 (Lack / shortage of design) are requires a good amount of attention, should be put on the watch list.

4.4.4 Probability, impact and Importance Index of Factors related to client:

Evaluation the impact of client's risk factors on time performance:

Table (4.39) Probability of client's risk factors and Cronbach's Alpha

ID	Risk factors	Probability level					Cronbach's Alpha if Item Deleted	Importance Index
		1	2	3	4	5		
R22	Delay in payment from client	12	27	21	11	21	0.640	3.02

R23	lack in financial resource of client	40	21	20	4	7	0.772	2.10
R24	client required are not clarified	3	9	15	18	47	0.871	4.05
R25	Change of Scope by Owner	40	35	14	2	1	0.640	1.79

Table (4.40) Reliability Statistics of Probability for client's risk factors

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
0.927	0.760	4

Reliability (Internal Consistency):

Table 4.28above shows Cronbach's alpha is 0.927, which does indicate a questionable level of internal consistency for this sample of Probability of client's risk factors. However, this could reasonably be considered 'Excellent' as it is fairly close to the range where alpha is considered $\alpha \geq 0.9$Appendix 3 provides further test details.

The risk factors on bellow tables were rank according to their Importance Index (of probability / Impact) from highest to lowest.

Table (4.41) ranking of client's risk factors probabilities (on time)

Risk factors related to client		
ID	Importance Index	probability scale
R24	4.05	Very High
R22	3.02	High
R23	2.10	Medium
R25	1.79	Low

Table (4.42) ranking of client's risk factors Impact (on time)

Risk factors related to client		
ID	Importance Index	Impact scale
R22	4.10	Very High
R25	4.07	Very High
R23	3.05	High

R24	3.04	High

Probabilities	Impacts				
	Very Low	Low	Medium	High	Very High
Very High				R24	R22
High					
Medium				R23	
Low					R25
Very Low					

Figure 4.25 risk matrix to evaluate the impact of client's risk factors on time performance

- The results in figure (4.25) show that R22 (Delay in payment from client), R24 (client required are not clarified) and R25 (Change of Scope by Owner) are requires the most attention, further analysis, including quantification, and aggressive risk management (an immediate response).
- The results in figure (4.25) show that, R23 (lack in financial resource of client) is requires a good amount of attention, should be put on the watch list.

Evaluation the impact of client's risk factors on cost performance:

The risk factors on bellow tables were rank according to their Importance Index (of probability / Impact) from highest to lowest.

Table (4.43) ranking of client's probabilities risk factors (on cost)

Risk factors related to client		
ID	Importance Index	probability scale
R24	4.05	Very High
R22	3.02	High
R23	2.10	Medium
R25	1.79	Low

Table (4.44) ranking of client's risk factors impacts (on cost)

Risk factors related to client		
ID	Importance Index	Impact scale
R25	4.04	Very High
R24	3.59	High
R22	1.86	Low
R23	1.79	Low

Probabilities	Impacts

	Very Low	Low	Medium	High	Very High
Very High				R24	
High		R22			
Medium		R23			
Low					R25
Very Low					

Figure 4.26 risk matrix to evaluate the impact of client's risk factors on cost performance

- The results in figure (4.26) show that R24 (client required are not clarified) and R25 (Change of Scope by Owner) are requires the most attention, further analysis, including quantification, and aggressive risk management (an immediate response).
- The results in figure (4.26) show that, R22 (Delay in payment from client), is requires a good amount of attention, should be put on the watch list.
- The results in figure (4.26) show that R23 (lack in financial resource of client) is requires less attention to be paid, should be put on the watch list.

4.4.5 Probability, impact and Importance Index of Contractual risk Factors:

Evaluation the impact of Contractual risk factors on time performance:

Table (4.45) Probability of Contractual risk factors and Cronbach's Alpha

ID	Risk factors	Probability level					Cronbach's Alpha if Item Deleted	Importance Index
		1	2	3	4	5		
R26	Errors in project documents (invoices)	41	26	11	5	9	0.871	2.08
R27	Different meanings of specifications	43	20	18	4	7	0.873	2.04
R28	Not completing information at the tender stage	10	25	21	11	25	0.790	3.17
R29	Delayed disputes resolutions	11	27	21	11	22	0.737	3.07
R30	Delayed disputes resolutions	39	26	11	6	10	0.601	2.15
R31	Payment receiving are not regular	14	31	24	13	10	0.681	2.72

Table (4.46) Reliability Statistics of Probability of Contractual risk factors

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.839	0.705	6

Reliability (Internal Consistency):

Table 4.46 above shows Cronbach's alpha is 0.839, which does indicate a questionable level of internal consistency for this sample of Probability Contractual risk factors. However, this could reasonably be considered 'good' as it is fairly close to the range where alpha is considered $0.7 \leq \alpha < 0.9$ Appendix 3 provides further test details.

The risk factors on bellow tables were rank according to their Importance Index (of probability / Impact) from highest to lowest.

Table (4.47) ranking of Contractual risk factors probabilities (on time)

Contractual risk factors		
R28	3.17	High
R29	3.07	High

R31	2.72	Medium
R30	2.15	Medium
R26	2.08	Medium
R27	2.04	Medium

Table (4.48) ranking of Contractual risk factors impacts (on time)

Contractual risk factors		
R28	3.17	High
R30	3.05	High
R26	3.04	High
R29	2.72	Medium
R31	2.72	Medium
R27	2.04	Medium

Probabilities	Impacts				
	Very Low	Low	Medium	High	Very High
Very High					
High			R29	R28	
Medium			R31,R27	R30,R26	
Low					

Figure 4.27 risk matrix to evaluate the impact of Contractual risk factors on time performance

- The results in figure (4.27) show that R28 (Not completing information at the tender stage) is requires the most attention, further analysis, including quantification, and aggressive risk management (an immediate response).
- The results in figure (4.27) show that R30 (Delayed disputes resolutions), R26 (Errors in project documents (invoices)), R31 (Payment receiving are not regular), R27 (Different meanings of specifications) and R29 (Delayed disputes resolutions) requires a good amount of attention, should be put on the watch list.

Evaluation the impact of Contractual risk factors on cost performance:

The risk factors on bellow tables were rank according to their Importance Index (of probability / Impact) from highest to lowest.

Table (4.49) ranking of Contractual risk factors probabilities (on cost)

Contractual risk factors		
ID	Importance Index	probability scale
R28	3.17	High
R29	3.07	High

R31	2.72	Medium
R30	2.15	Medium

Table (4.50) ranking of Contractual risk factors impacts (on cost)

Contractual risk factors		
ID	Importance Index	Impact scale
R28	3.17	High
R31	2.72	Medium
R30	2.15	Medium
R26	2.08	Medium

Probabilities	Impacts				
	Very Low	Low	Medium	High	Very High
Very High					
High		R29		R28	
Medium			R31,R30,R26.R27		
Low					
Very Low					

Figure 4.28 risk matrix to evaluate the impact of Contractual risk factors on cost performance

- The results in figure (4.28) show that R28 (Not completing information at the tender stage) is requires the most attention, further analysis, including quantification, and aggressive risk management (an immediate response).
- The results in figure (4.28) show that R30 (Delayed disputes resolutions), R26 (Errors in project documents (invoices)), R31 (Payment receiving are not regular), R27 (Different meanings of specifications) and R29 (Delayed disputes resolutions) requires a good amount of attention, should be put on the watch list.

4.4.6 Probability, impact and Importance Index of External risk Factors:

Evaluation the impact of External risk factors on time performance:

Table (4.51) Probability of External risk factors and Cronbach's Alpha

ID	Risk factors	Probability level					Cronbach's Alpha if Item Deleted	Importance Index
		1	2	3	4	5		
R32	New government regulations and legislation	41	35	14	1	1	0.587	1.76
R33	Non availability of construction manual and procedure for construction project in Sudan	40	33	15	2	2	0.562	1.84
R34	Financial inflation	1	8	13	21	49	0.741	4.18
R35	Exchange rate fluctuation	1	6	17	22	46	0.806	4.15
R36	Security instability (e.g. demonstrations)	11	27	21	11	22	0.654	3.07
R37	Force Majeure	40	33	15	3	1	0.871	1.83
R38	Bad weather	10	27	21	11	23	0.708	3.11

Table (4.52) Reliability Statistics

Probability of External risk factors

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.897	0.805	7

Reliability (Internal Consistency):

Table 4.52 above shows Cronbach's alpha is 0.897, which does indicate a questionable level of internal consistency for this sample of Probability of External risk factors. However, this could reasonably be considered 'good' as it is fairly close to the range where alpha is considered $0.7 \leq \alpha < 0.9$ Appendix 3 provides further test details.

The risk factors on bellow tables were rank according to their Importance Index (of probability / Impact) from highest to lowest.

Table (4.53) ranking of External risk factors probabilities (on time)

External risk factors		
ID	Importance Index	probability scale
R34	4.18	Very High
R35	4.15	Very High
R38	3.11	High
R36	3.07	High
R33	1.84	Low
R37	1.83	Low
R32	1.76	Low

Table (4.54) ranking of External risk factors impacts (on time)

External risk factors		
ID	Importance Index	Impact scale
R34	4.22	Very High
R35	4.15	Very High

R36	2.72	Medium
R38	2.50	Medium
R37	1.83	Low
R33	1.77	Low
R32	1.72	Low

Probabilities	Impacts				
	Very Low	Low	Medium	High	Very High
Very High					R34,R35
High			R38,R36		
Medium					
Low		R33,R37,R32			
Very Low					

Figure 4.29 risk matrix to evaluate the impact of External risk factors on time performance

- The results in figure (4.29) show that R34 (Financial inflation) and R35 (Exchange rate fluctuation) are requires the most attention, further

analysis, including quantification, and aggressive risk management (an immediate response).

- The results in figure (4.29) show that, R38 (Bad weather) and R36 (Security instability (e.g. demonstrations)) are requires a good amount of attention, should be put on the watch list.
- The results in figure (4.29) show that R33 (Non availability of construction manual and procedure for construction project in Sudan), R37 (Force major) and R32 (New government regulations and legislation) are requires less attention to be paid, should be put on the watch list.

Evaluation the impact of External risk factors on cost performance:

The risk factors on bellow tables were rank according to their Importance Index (of probability / Impact) from highest to lowest.

Table (4.55) ranking of External risk factors probabilities (on cost)

External risk factors		
ID	Importance Index	probability scale
R34	4.18	Very High
R35	4.15	Very High
R38	3.11	High

R36	3.07	High
R33	1.84	Low
R37	1.83	Low
R32	1.76	Low

Table (4.56) ranking of External risk factors impacts (on cost)

External risk factors		
ID	Importance Index	Impact scale
R34	4.17	Very High
R35	4.14	Very High
R37	4.11	Very High
R38	2.15	Medium
R33	1.84	Low
R36	1.79	Low
R32	1.78	Low

Probabilities	Impacts				
	Very Low	Low	Medium	High	Very High
Very High					R34,R35
High		R36	R38		
Medium					
Low		R33,R32			R37
Very Low					

Figure 4.30 risk matrix to evaluate the impact of External risk factors on time performance

- The results in figure (4.30) show that R34 (Financial inflation), R35 (Exchange rate fluctuation) and R37 (Force major) are requires the most attention, further analysis, including quantification, and aggressive risk management (an immediate response).
- The results in figure (4.30) show that, R38 (Bad weather) and R36 (Security instability (e.g. demonstrations)) are requires a good amount of attention, should be put on the watch list.
- The results in figure (4.30) show that R33 (Non availability of construction manual and procedure for construction project in Sudan), and R32 (New government regulations and legislation) are requires less attention to be paid, should be put on the watch list.

4.5 Risk Responses strategies which were applied in construction projects in khartoum state.

4.5.1 Importance Index of Preventive action:

Table (4.57) Preventive action

Strategy No	Phrase	Strongly Agree	Agree	Sometimes	Disagree	Strongly Disagree	Importance index
	Preventive action						
Strategy 1	Utilize quantitative or qualitative risk analysis techniques for accurate time estimate	7	10	17	33	25	2.36
		7.61%	10.8%	18.48%	35.8%	27.17%	
Strategy 2	Depend on subjective judgment on produce a proper program	35	24	18	10	5	3.80
		38.0%	26.0%	19.57%	10.8%	5.43%	
Strategy 3	Make cost reserve to meet the expected risks (identified in the risk register) and the unexpected.	2	5	19	26	40	1.95
		2.17%	5.43%	20.65%	28.2%	43.48%	
Strategy 4	Consciously adjust for bias risk premium to time estimation	6	15	25	33	13	2.65
		6.52%	16.3%	27.17%	35.8%	14.13%	
Strategy 5	Transfer or share risk to/ with other parties	12	25	32	19	4	3.24
		13.0%	27.1%	34.78%	20.6%	4.35%	
Strategy 6	Refer to previous and ongoing similar	16	28	36	8	4	3.48
		17.3%	30.4%	39.13%	8.70%	4.35%	

	projects for accurate program						
Strategy 7	Produce a proper schedule by getting updated project information	5	21	44	19	3	3.07
		5.43%	22.8%	47.83%	20.65%	3.26%	
Strategy 8	Expert systems (including software packages, decision support systems, computer-based analysis techniques such as @Risk	4	11	18	39	20	2.35
		4.35%	11.96%	19.57%	42.39%	21.74%	

Table (4.58) Reliability Statistics

Preventive action

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.822	0.677	8

Table 4.58 above shows Cronbach's alpha is 0.822, which does indicate a questionable level of internal consistency for this sample of Preventive action. However, this could reasonably be considered 'good' as it is fairly close to the range where alpha is considered $0.7 \leq \alpha < 0.9$ Appendix 3 provides further test details.

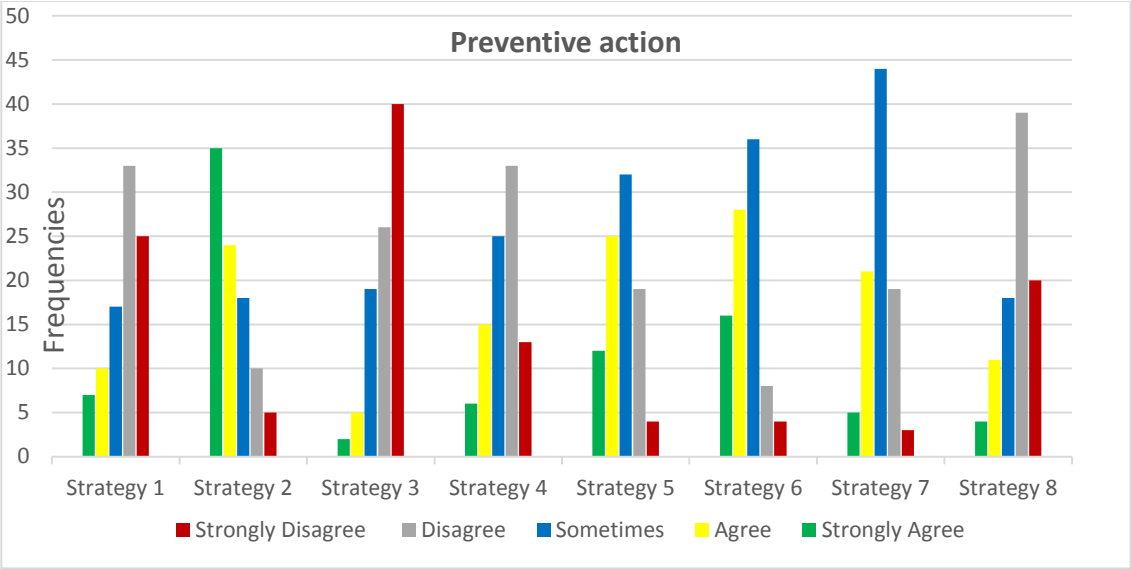


Figure 4.31 Preventive action

The above table 4.58 and figure 4.31 present Preventive actions, the results were as follow:

- Strategy1 (Utilize quantitative or qualitative risk analysis techniques for accurate time estimate) 7(7.61%) of the respondents were Strongly Agree, 10(10.8%) of the respondents Agree, 17(18.48%) of the respondents Sometimes, 33(35%) of the respondents Disagree and 25(27.17%) of the respondents Strongly Disagree.

- Strategy2 (Depend on subjective judgment on produce a proper program) 35(38%) of the respondents were Strongly Agree, 24(26%) of the respondents Agree, 18(19.57%) of the respondents Sometimes, 10(10.8%) of the respondents Disagree and 5(5.43%) of the respondents Strongly Disagree.

- Strategy3 (Make cost reserve to meet the expected risks (identified in the risk register) and the unexpected) 2(2.17%) of the respondents were Strongly Agree, 5(5.43%) of the respondents Agree, 19(20.56%) of the respondents Sometimes, 26(28.2%) of the respondents Disagree and 40(43.48%) of the respondents Strongly Disagree.

- Strategy4 (Consciously adjust for bias risk premium to time estimation) 6(6.52%) of the respondents were Strongly Agree, 15(16.30%) of the respondents Agree, 25(27.17%) of the respondents Sometimes, 33(35.80%) of the respondents Disagree and 13(14.13%) of the respondents Strongly Disagree.

- Strategy5 (Transfer or share risk to/ with other parties) 12(13%) of the respondents were Strongly Agree, 25(27.1%) of the respondents Agree, 32(34.78%) of the respondents Sometimes, 19(20.60%) of the respondents Disagree and 4(4.35%) of the respondents Strongly Disagree.

- Strategy6 (Refer to previous and ongoing similar projects for accurate program) 16(17.3%) of the respondents were Strongly Agree, 28(30.40%) of the respondents Agree, 36(39.13%) of the respondents Sometimes, 8(8.70%) of the respondents Disagree and 4(4.35%) of the respondents Strongly Disagree.

- Strategy7 (Produce a proper schedule by getting updated project information) 5(5.43%) of the respondents were Strongly Agree, 21(22.80%) of the respondents Agree, 44(47.83%) of the respondents Sometimes, 19(20.56%) of the respondents Disagree and 3(3.26%) of the respondents Strongly Disagree.

- Strategy8 (Expert systems including software packages, decision support systems, computer-based analysis techniques such as @Risk) 4(4.35%) of the respondents were Strongly Agree, 11(11.96%) of the respondents Agree, 18(19.57%) of the respondents Sometimes, 39(42.39%) of the respondents Disagree and 20(21.74%) of the respondents Strongly Disagree.

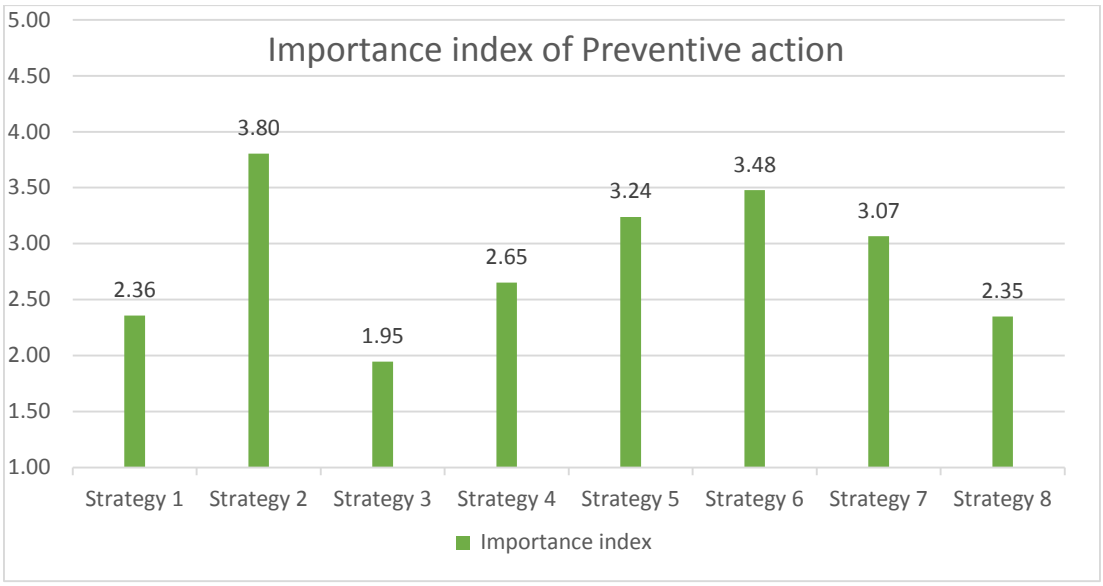


Figure 4.32 Importance index Preventive actions

According to the survey result in (figure 4.32) respondents show the most used Preventive method is usually depending on subjective judgment on produce a proper program is most effective risk Preventive Actions with importance index (3.80). Judgment or subjective probability uses the experience gained from similar projects undertaken in the past by the decision maker to decide on the likelihood of risk exposure and the outcomes. Judgment and experience gained from previous contracts may become the most valuable information source for the use when there limited time for preparing the project program. Construction, however, is subjected to a dynamic environment, that is why risk managers must constantly strive to improve their estimates. Even with the near perfect estimates, decision making about risk is difficult task. Thus depending only on experience subjective judgment may not be enough, and updated project information should be obtained and applied.

Refer to previous and ongoing similar projects for accurate program with importance index (3.48) was recommended by the practitioners to be an

effective Preventive method. Consequently, Transfer or share risk to/ with other parties and Produce a proper schedule by getting updated project information to be effective risk preventive method with importance index (3.24) and (3.07) consequently. Yet, this result was expected since taking into consideration such as risk premiums would increase the price bid and would consequently decrease the probability of gaining the bid due to highly competitive Sudan construction market.

Utilize quantitative or qualitative risk analysis techniques for accurate time estimate, make cost reserve to meet the expected risks (identified in the risk register) and the unexpected, Expert systems including software packages, decision support systems, computer-based analysis techniques such as @Risk and Consciously adjust for bias risk premium to time estimation were not applicable well to be an effective Preventive method for reducing the effects of risk on construction project. These result reflected insufficient knowledge and experience of analysis techniques and difficulty of apply them.

4.4.2 Importance Index of Mitigative actions:

Table (4.59) Mitigative actions

Strategy No	Phrase	Strongly Agree	Agree	Sometimes	Disagree	Strongly Disagree	Importance index
	Mitigative actions						
Strategy 1	Increase manpower and/or equipment	4	8	38	26	16	2.54
		4.35%	8.70%	41.30%	28.26%	17.39%	
Strategy 2	Increase the working hours	3	9	40	23	15	2.52
		3.26%	9.78%	43.48%	25.00%	16.30%	
Strategy 3	Change the sequence of work by overlapping activities	28	34	22	6	2	3.87
		30.43%	36.96%	23.91%	6.52%	2.17%	
Strategy 4	Coordinate closely with subcontractors	27	30	21	9	5	3.71
		29.35%	32.61%	22.83%	9.78%	5.43%	
Strategy 5	Close supervision to subordinates for minimizing abortive work	25	33	28	4	2	3.82
		27.17%	35.87%	30.43%	4.35%	2.17%	

Table (4.60) Reliability Statistics of Mitigative actions

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.780	0.609	5

Table 4.60 above shows Cronbach's alpha is 0.780, which does indicate a questionable level of internal consistency for this sample of Mitigative actions. However, this could reasonably be considered 'good' as it is fairly close to the range where alpha is considered $0.7 \leq \alpha < 0.9$ Appendix 3 provides further test details.

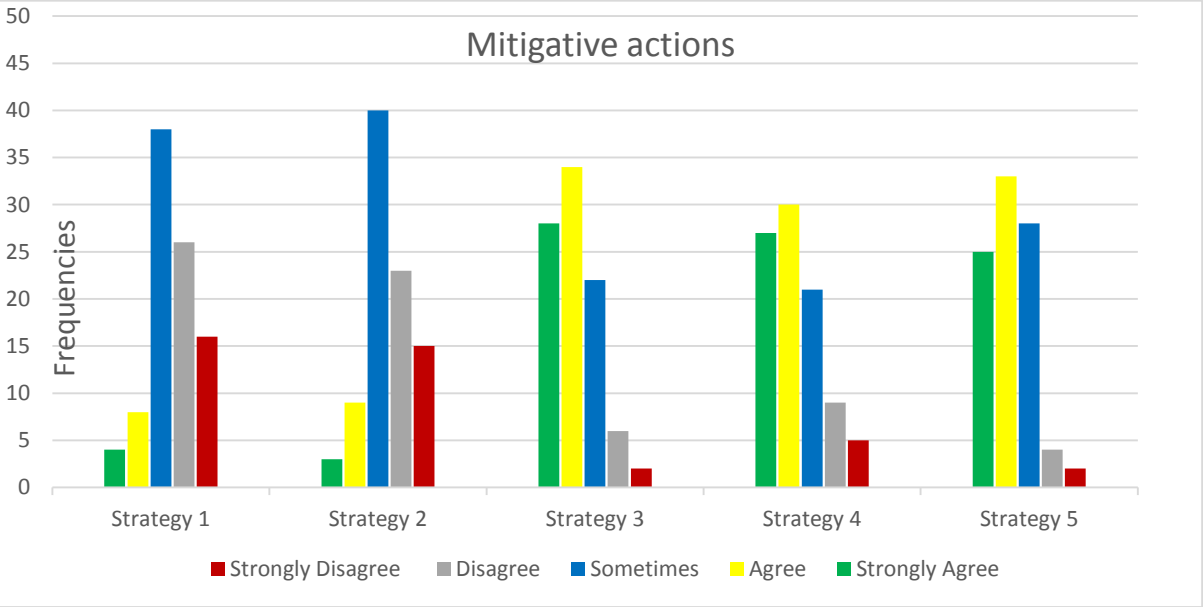


Figure 4.33 Mitigative actions

The above table 4.10 and figure 4.33 present Mitigative actions, the results were as follow:

- Strategy1 (Increase manpower and/or equipment) 4(4.35%) of the respondents were Strongly Agree, 8(8.70%) of the respondents Agree,

38(41.30%) of the respondents Sometimes, 26(28.26%) of the respondents Disagree and 16(17.39%) of the respondents Strongly Disagree.

- Strategy2 (Increase the working hours) 3(3.20%) of the respondents were Strongly Agree, 9(9.78%) of the respondents Agree, 40(43.48%) of the respondents Sometimes, 23(25%) of the respondents Disagree and 15(16.30%) of the respondents Strongly Disagree.

- Strategy3 (Change the sequence of work by overlapping activities) 28(30.43%) of the respondents were Strongly Agree, 34(36.96%) of the respondents Agree, 22(23.91%) of the respondents Sometimes, 6(6.52%) of the respondents Disagree and 2(2.17%) of the respondents Strongly Disagree.

- Strategy4 (Coordinate closely with subcontractors) 27(29.35%) of the respondents were Strongly Agree, 30(32.61%) of the respondents Agree, 21(22.83%) of the respondents Sometimes, 9(9.78%) of the respondents Disagree and 5(5.43%) of the respondents Strongly Disagree.

- Strategy5 (Close supervision to subordinates for minimizing abortive work) 25(27.17%) of the respondents were Strongly Agree, 33(35.87%) of the respondents Agree, 28(30.43%) of the respondents Sometimes,

4(4.35%) of the respondents Disagree and 2(2.17%) of the respondents Strongly Disagree.

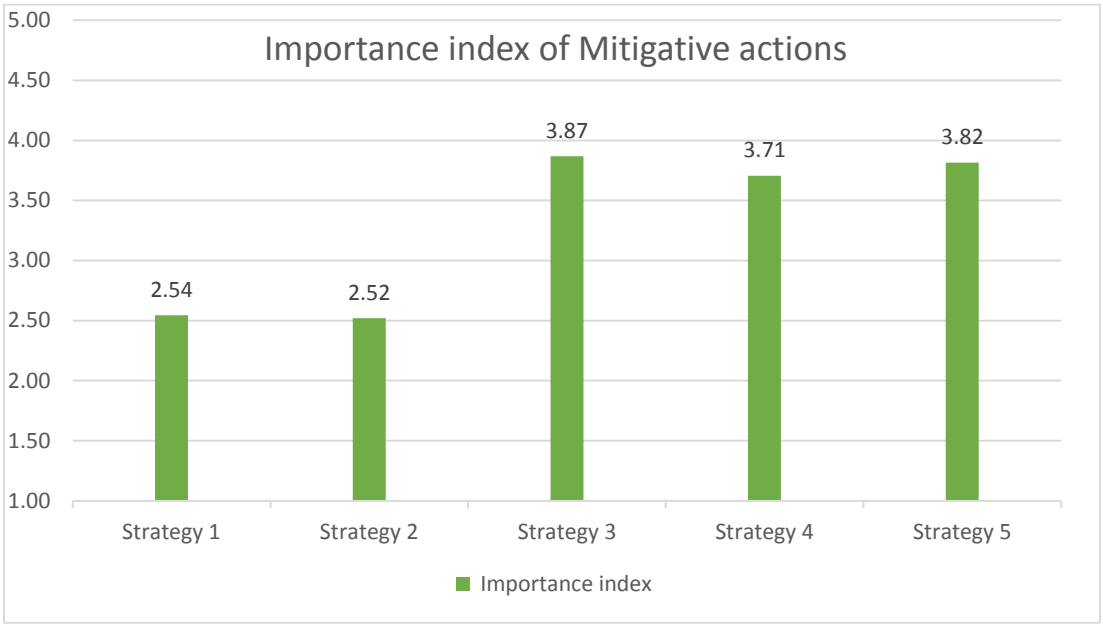


Figure (4.34) relative importance index of Mitigative actions

According to the survey result in (figure 4.34) respondents show the most used of five mitigative methods were Change the sequence of work by overlapping activities, Close supervision to subordinates for minimizing abortive work and Coordinate closely with subcontractors consequently, the number above the column is relative importance index for each method.

And at the last using of mitigative methods were Increase manpower and/or equipment and Increase the working hours.

CHAPTER V

Conclusions and Recommendations

CHAPTER V

5.1 Introduction

This chapter was carried out to know how risk management is practiced in Sudanese construction project. Furthermore, identify risk factors and evaluate their impact on (time and cost) performance and known Risk Responses strategies which were apply in construction project on Khartoum state. These objective were brought out and some action that may improve risk management is practiced were recommended.

5.2 Conclusions

1. From research result more than half of respondents (55.5%) with important index (3.65) were respond that the Sudanese construction companies are not applying risk management in their projects, and this indicate there is lack of knowledge and experience of risk management. Project risk management is a very complex and layered task, which has a significant impact on the success of project goals. It is based on knowledge and experience and communication and mutual understanding among stakeholders. Managing risk is a difficult task that is avoided or performed with a minimal effort by individuals, and this often results in delays and losses.
2. 50% of respondents with important index (3.55) were respond there is not risk management plan in their projects, and this indicate there is lack of standards to manage the risks. An initial step towards quality risk management involves adopting a traditional approach and the use of standards, such as PMBoK and ISO 31000, which provide a stable

framework and precise steps such that managers can gain the experience and knowledge necessary to progress towards the application of the holistic approach.

3. Risk management in both construction business and construction projects should be part of the organizational culture. This would allow its development and implementation and to become a standard for planning and implementation of projects. Important part of this is to generate an effective management of knowledge to have a system, which can keep the lessons learned so that they can be spread and reused in future projects. Having the proper channels of communication between project parties for risk management is also imperative as well as training on this topic.
4. From research result more than half of respondents (57.6%) were respond that Contract parties have not enough knowledge about type of contracts and their consequences. risk analysis and management are important part of the decision-making process in construction industry. To management the risk effectively and efficiently, the contractor, consultant and client must understand risk responsibilities, risk event conditions, risk preference, and risk management capabilities.
5. Contractors are more willing to adopt the risk management concept especially the identification process of risk management as a first step.
6. Most of consulting firms and construction companies in Sudan have no idea about the concept of risk management as managing tool; (2/3) of respondents are not using (Expert systems including software packages, decision support systems, computer-based analysis techniques such as @Risk) which are helpful in monitoring and controlling of projects.
7. Risk management does not really take additional time; rather, it saves huge amounts of time and money on projects.

8. About the research Hypothesis: (1) Risk factors are prevalent on all construction projects in Khartoum state -Sudan., we identified about 38 risk factors and respondents were apply the rate of probabilities occurrence of this factors with average important index (2.72) which does indicate a (Medium) probabilities occurrence for all factors and (42%) of this risk factors have (High and Very High) probabilities occurrence , (2) Risk factors affect cost and time performance of construction project dramatically. respondents were applying the rate of the impact on time and cost for this factors with average important index (2.89, 2.68 respectively) which does indicate a (Medium) impact for all factors and (48%) of this risk factors have (High) impact on time performance, and (34%) of this risk factors have (Very High) impact on cost performance, (3) The affect of risk factors can be under control if a proper risk management strategies are applying. We can reduce the impact or probabilities of threats (negative risks) and increase the impact or probabilities of opportunity (positive risks) through effective management strategies and effective risk responses strategies which are concluded from this research survey or recommended.
9. From research result the most risk factors which have highest effect on time performance in construction project.

- **Factors related to contractors**

Decrease in productivity of workers, Financial failure of the contractor, Ambiguous planning due to project complexity, lack on main resource of contractor, Shortage of contractors' experience and technical skills and Technology changes.

- **Factors related to consultant**

Delay from consultant to approve executed works, poor communication between involved parties and Shortage of consultants' experience and technical skills.

- **Factors related to designer**

Complex of design.

- **Factors related to client**

Delay in payment from client, client required are not clarified and Change of Scope by Owner.

- **Contractual risk Factors**

Not completing information at the tender stage.

- **External risk Factors**

Financial inflation and Exchange rate fluctuation.

10. And the most risk factors which have highest effect on cost performance in construction projects are

- **Factors related to contractors**

Decrease in productivity of workers, Financial failure of the contractor, the scope of work for the contractor is not well defined and Poor resource management.

- **Factors related to consultant**

Shortage of consultants' experience and technical skills and Materials not conforming to specifications.

- **Factors related to client**

Client required are not clarified and Change of Scope by Owner.

- **Contractual risk Factors**

Not completing information at the tender stage.

- **External risk Factors**

Financial inflation, Exchange rate fluctuation and Force major.

11. From research result the most preventive actions which were implemented in Sudanese construction projects are: Depend on subjective judgment on produce a proper program and Refer to previous and ongoing similar projects for accurate program.
12. And the most Mitigative actions were: Change the sequence of work by overlapping activities, Coordinate closely with subcontractors and Close supervision to subordinates for minimizing abortive work

5.3 Recommendations:

5.3.1 Recommendations from study:

1. Contracting companies should compute and consider risk by adding cost reserves contingence to quotation and schedule reserves to time estimation. This trend has to be supported by organizations like Sudanese Contractors Union, and other organizations concerned about the construction industry.
2. Expert techniques are available such as @Risk system, which integrates with time schedules and spread sheets software, should be learned and applied obtain adequate risk estimation.
3. There is an essential need for more standardization and effective forms of contract, which address issues of clarity, fairness, roles and

responsibilities of risks, dispute resolution and payment – this could be done by adopting a standard form of contracts e.g. "FIDIC".

4. Contracting firms should compute and consider risk by adding the risk factors before quotation and time estimation.
5. The design process is most important phase in the construction process, so it should have more focus by clients.
6. Documentation work should be applied widely in the industry. In addition, contractors and clients are requested to keep computerized historical data of finished project. this may help in rights reservation and to be an information source for future comparison.
7. Assign responsibility for risk mitigation activities, and monitor progress through a formal tracking system e.g. "Email".

5.3.2 Future recommendations

1. Study the effect of the previously identified risk factors into construction project cash flow. This will be through the development of a probabilistic model for cash flow prediction.
2. Study the impact of the previously identified risk factors into cost and time performance on construction project but this will be through the quantitative evaluation (case study) by use Expert systems (including software packages, decision support systems, computer-based analysis techniques such as @Risk).

References

[1] Iqbal S, Choudhry R M, Holschemacher K, Ali A and Tamošaitienė J 2015 Risk management in construction projects, *Technol. Econ. Dev. Eco.* **21** 65-78

[2] Crnković D and Vukomanović M 2016 Comparison of trends in risk management theory and practices within the construction industry, *e-GFOS* **7**(13) 1-11

[3] Taroun A 2014Towards a better modelling and assessment of construction risk: Insights from aliterature review, *Int.J .Proj. Manag.* **32** 101-15

[4] PMI 2017 *A Guide to The Project Management Body of Knowledge (PMBOK guide)* (Newtown Square: Project Management Institute)

[5] Taylan O, Bafail A O, Abdulaal R M and Kabli M R 2014 Construction projects selection and risk assessment by fuzzy AHP and fuzzy TOPSIS methodologies, *Appl. Soft Comput.* **17**

105-16

[6] Tesfaye E, Berhan E and Kitaw D 2016 A Comprehensive Literature Review on Construction Project Risk Analysis, *Int. J. Risk Contingency Manag* **5** 1-15

[7] El-Sayegh S M and Mansour M H 2015 Risk assessment and allocation in highway construction projects in the UAE, *J. Manage. Eng.* **31**(6) 04015004

[8] Serpella A F, Ferrada X, Howard R and Rubio L 2014 Risk management in construction projects: a knowledge-based approach *Procedia - Social and Behavioral Sciences* vol 119 (United Kingdom: Elsevier) pp 653-62

[9] Jarkas A M and Haupt T C 2015 Major construction risk factors considered by general contractors in Qatar, *J. Eng. Des. Tech.* **13** 165-94

[10] Ebrahimnejad S, Mousavi S M and Seyrafianpour H 2010 Risk identification and assessment for build–operate–transfer projects: A fuzzy multi attribute decision making model, *Expertsyst. Appl.* **37** 575-86

[11] Tadayon M, Jaafar M and Nasri E 2012 An assessment of risk identification in large construction projects in Iran, *J. Constr. Dev. Countr.* **17** 57-69

[12] El-Sayegh S M 2014 Project risk management practices in the UAE construction industry, *Int.J. Pro. Org. Manag.* **6** 121-37

[13] Radujković M., Basics of Project Management, lecture from Managing construction projects; Faculty of Civil Engineering, Zagreb

[14] Zavadskas, E. K.; Turskis, Z.; Tamošaitienė, J. 2010a. Risk assessment of construction projects, *Journal of Civil Engineering and Management* 16(1): 33–46. http://dx.doi.org/10.3846/jcem.2010.03

[15] Wang, S., Dulaimi, M. & Aguria, Y. (2004). Risk management framework for construction projects in developing countries. Construction Management and Economics, 22(3), 237-252.

[16] Yu, Z. (2002). Integrated risk management under deregulation. Power Engineering Society Summer Meeting, IEEE, 3, 1251-1255.

[17] Baloi, P. & Price, A. (2003). Modelling global risk factors affecting construction cost performance. *Int. J.* of Project Management, 21(4), 261–269.

[18] Hillson, D. (2011). *Dealing with business uncertainty*. Unloaded from: http://www.risk-doctor.com/briefings.

[19] Olsson, R. (2007). In search of opportunity management: Is the risk management process enough? *Int. J.* of Project Management, 25(8),745-752.

[20] Del Caño A., & De la Cruz, M. P. (2002). Integrated methodology for project risk *Int. J.* of Construction Engineering and Management ASCE 128(6):473-485.

[21] Anderson, S. (2009). *Risk Identification and Assessment*. PMI Virtual Library.

[22] Perera, J. & Holsomback, J. (2005). An integrated risk management tool and process, Aerospace Conference, 2005 IEEE, vol., no., pp.129-136, 5-12 March.

[23] Alali, B. and Pinto, A. (2009). Project, systems and risk management processes interactions. Management of Engineering & Technology.

[24] Rita Mulcahy's, Ninth Edition (2018).

[25] Schuyler, J. (2001). Risk and Decision Analysis in Projects (2nd ed.). Newtown Square, PA, USA: Project Management Institute.

[26] Hillson, D. (2004a, October 2004). *Earned Value Management and Risk Management: A Practical Synergy.* Paper presented at the PMI Global Congress North America, Anaheim, CA, USA.

[27] Yin, R. K., 2009, Case Study Research: Design and Methods. 4th ed.

London: SAGE Publications.

[28] Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., and Hoagwood, K., 2015, Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. Administration and Policy in Mental Health, 42(5), 533-44.

[29] Kombo, D. K., and Tromp, D. L. A., 2006, Proposals and Thesis Writing: An Introduction. Nairobi: Pauline's Publications Africa.

[30] Alinaitwe, H., Nyamutale W., and Tindiwensi, D., 2014, Design Phase

Constructability Improvement Strategies for Highway Projects in Uganda. Journal of Construction in Developing Countries, 19(1), 127-140.

[31] George D & P Marllery. (2003). SPSS for Windows Step by Step: A Simple Guide and Reference.

Appendix 1

بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of graduate Studies – Civil Engineering

EVALUATING THE IMPACT OF RISK MANAGRMENT ON TIME AND COST PERFORMANCE IN CONSTRUCTION PROJECT ON KHARTOUM STATE

- The aim of this study is to know how risk management is practiced in Sudanese construction project, identify risk factors and evaluate their impact on (time and cost) performance and known Risk Responses strategies which were apply in construction project on Khartoum state.
- Thank you for filling out this questionnaire to contribute to the achievement of the objectives of this study in the hope that the benefit to all.
- The information to be used will be used for scientific research purposes only.

For any queries, please do not hesitate to contact on tell: 0123987172

- **Sector 1 (General Questions):**

1. Name (optional)……..

2. The name of the company (optional)…….....

1. Scientific qualification								
diploma		Bachelor		Master	PHD		Other (specify)	
2. Category of work								
Owner		contractor		consultative		Other (specify)		
3. Type of business								
Private sector		Gov. sector		Other (specify)				
4.Specified field								
Civil		architect		Other (specify)				
5. Years of experience								
Less than 5		5-10		11-15		16-20		More than 20
6. Years of experience in risk management								
Less than 5		5-10		11-15		16-20		More than 20
7. The number of annual executive projects								
Less than 5		5-10		11-15		16-20		More than 20
8.Type of executive projects								
Residential building projects		Infrastructure projects		Non Residential building projects				

Sector 2 The practice of apply risk management in Sudanese construction project.

Please indicate (√) the answer that represents your point of view accurately

NO	Phrase	Strongly Agree	Agree	Some times	Disagree	Strongly Disagree
1	Sudanese construction companies are applying risk management in their projects.					
2	There is risk management plan.					
3	Identify and define of risks which may face project.					
4	There is risk responses plan.					
5	The responsible person is identified to remedy the specific risk.					
6	There are specialized sections on costs and cash flow accounts in construction companies.					
7	Contract parties have enough knowledge about type of contracts and their consequences.					
8	The total project cost is estimated include cost of					

	reserves Contingency.					
9	The total project duration is estimated include schedule reserves for risk.					
10	There is analysis for cash flow paths during execution of projects.					

Sector 3

Risk factors which have effects on time and cost performance in construction projects in khartoum state.

Please indicate (√) the answer that represents your point of view accurately

The bellow table can help you to determine the probabilities and impacts for risk factors.

Risk probability or Impact level	Risk probability or Impact scale
Very high	5
High	4
Medium	3
Low	2
Very Low	1

NO	Risk factors	Time Performance										Cost Performance									
		Risk probability					Risk impact					Risk probability					Risk impact				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	Factors related to contractors																				
1.1	Decrease in productivity of workers																				
1.2	lack on main resource of contractor																				
1.3	Bad understanding for contract items.																				
1.4	Shortage of contractors' experience and technical skills																				
1.5	Financial failure of the contractor																				
1.6	Financial failure of supplier /subcontractor																				
1.7	Shortage of subcontractors' experience and technical skills																				

1.8	Technology changes																				
1.9	The scope of work for the contractor is not well defined																				
1.10	Ambiguous planning due to project complexity																				
1.11	Poor resource management																				
1.12	Occurrence of accidents due to poor safety procedure																				
1.13	Non-compliance with building codes and regulations																				
2	Factors related to consultant																				
2.1	Shortage of consultants' experience and technical skills																				
2.2	Delay from consultant to approve executed works																				
2.3	poor communication between involved parties																				
2.4	Materials not conforming to specifications																				
2.5	Unethical practices of consultant																				
3	Factors related to designer																				
3.1	Design mistake																				
3.2	Design complexity																				
3.3	Lack / shortage of design																				

4	Factors related to client																				
4.1	Delay in payment from client																				
4.2	lack in financial resource of client																				
4.3	client required are not clarified																				
4.4	Change of Scope by Owner																				
5	Contractual factors																				
5.1	Errors in project documents (invoices)																				
5.2	Different meanings of specifications																				
5.3	Not completing information at the tender stage																				
5.4	Delayed disputes resolutions																				
5.5	Payment receiving are not regular																				
	External factors																				
6.1	New government regulations and legislation																				
6.2	Non availability of construction manual and procedure for construction project in Sudan																				
6.3	Financial inflation																				
6.4	Exchange rate fluctuation																				

6.5	Security instability (e.g. demonstrations)																				
6.6	Force Majeure																				
6.7	Bad weather																				

Sector 4: (Risk Responses strategies)

The below table contents some of Risk Responses strategies which were apply in construction project on Khartoum state. Please indicate (√) the answer that represents your point of view accurately

NO	Phrase	Strongly Agree	Agree	Some times	Disagree	Strongly Disagree
1	**Preventive action**					
1.1	Utilize quantitative or qualitative risk analysis techniques for accurate time estimate					
1.2	Depend on subjective judgment on produce a proper program					
1.3	Make cost reserve to meet the expected risks (identified in the risk register) and the unexpected.					
1.4	Consciously adjust for bias risk premium to time estimation					
1.5	Transfer or share risk to/ with other parties					
1.6	Refer to previous and ongoing similar projects for accurate program					
1.7	Produce a proper schedule by getting					

	updated project information					
1.8	Expert systems (including software packages, decision support systems, computer-based analysis techniques such as @Risk					
2	**Mitigative actions**					
2.1	Increase manpower and/or equipment					
2.2	Increase the working hours					
2.3	Change the sequence of work by overlapping activities					
2.4	Coordinate closely with subcontractors					
2.5	Close supervision to subordinates for minimizing abortive work					

Appendix 2

بسم الله الرحمن الرحيم

جامعة السودان للعلوم والتكنولوجيا

كلية الدراسات العليا _ الهندسة المدنية

استبيان حول تقويم اثر ادارة المخاطر علي اداء (التكلفة و الزمن) في مشاريع التشييد داخل ولاية الخرطوم

- تهدف الدراسة الي معرفة واقع ممارسة ادارة المخاطر في مشاريع التشييد في السودان و تحديد عوامل المخاطر واثرها علي اداء (التكلفة والزمن) ، ومعرفة طرق الاستجابة لهذة المخاطر في مشاريع التشييد بولاية الخرطوم ، **وذلك للحصول على درجة الماجستير في الهندسة المدنية (هندسة التشييد).**
- تكرمكم بملء هذا الاستبيان يسهم في تحقيق اهداف هذه الدراسة آملين في أن تعم الفائدة للجميع.
- هذة الدراسة تحت الاشراف الاكاديمي لجامعة السودان للعلوم والتكنولوجيا كلية الدراسات العليا _ الهندسة المدنية.
- المعلومات التي سترد ستستخدم لاغراض البحث العلمي فقط.

مع خالص شكري ،،،

لأي استفسار او إبداء أي ملاحظة أرجو الاتصال علي الجوال (0123987172).

القطاع الاول (اسئلة عامة

1- الاسم (اختياري): .....

2- اسم المؤسسة او الشركة (اختياري): .....

ضع علامة (√) امام الاجابة المختارة :

1- المؤهل العلمي								
دبلوم		بكالريوس		ماجتسير		دكتوراه		أخري (حدد)
2- طبيعة العمل								
مالك		مقاول		إستشاري		أخري (حدد)		
3- نوع العمل								
قطاع خاص		قطاع عام		أخري (حدد)				
4- التخصص								
مدني		معماري		أخري (حدد)				
5-سنوات الخبرة العملية								
أقل من 5		10-5		15-11		20-16		أكثر من 20
6- سنوات الخبرة في ادارة المخاطر								
أقل من 5		10-5		15-11		20-16		أكثر من 20
7- عدد المشاريع التي تقومون بتنفيذها سنويا								
أقل من 5		10-5		15-11		20-16		أكثر من 20
8- انوع المشاريع المنفذة								
مشاريع مباني سكنية		مشاريع بنية تحتية		مشاريع مباني غير سكنية				

القطاع الثاني :

واقع ممارسة ادارة المخاطر في مشاريع التشييد في السودان

فضلا أشر بعلامة (√) علي الإجابة التي تمثل وجهة تظرك بدقة

الرقم	العـــــــــبارة	اوافق بشدة	اوافق	أحيانا	لا اوافق	لا أوافق بشدة
1	توجد إدارة للمخاطر في شركات التشييد السودانية					
2	هنالك خطة ممنهجة لإدارة المخاطر					
3	يتم تحديد وتصنيف المخاطر التي يمكن تواجه المشروع					
4	هنالك خطة لتدارك المخاطر					
5	يتم تحديد الجهة المسؤولة لتدارك الخطر المحدد					
6	توجد أقسام متخصصة بالتكاليف و حسابات التدفقات النقدية بشركات التشييد					
7	أطراف العقد لديهم المعرفة الكافية بأنواع العقود و مقتضياتها					
8	يتم التنبؤ بتكلفة المشروع الكلية متضمنة تكلفة المخاطر المتوقعة					
9	يتم التنبؤ بالفترة الزمنية الكلية للمشروع متضمنة الفترة المتوقع لتدارك المخاطر					
10	يتم تحليل مسار التدفقات النقدية أثناء تنفيذ المشاريع					

القطاع الثالث(عوامل المخاطر) :

في تقديرك ماهي عوامل المخاطر التي تؤثر في اداء التكاليف والزمن لمشاريع التشييد بولاية الخرطوم (فضلا أشر بعلامة (√) علي الإجابة التي تمثل وجهة تظرك بدقة)

فضلا استعن بالجداول ادناه لتحديد احتمالية الحدوث و قوة التأثير ، علما بأن الرقم 1 يمثل اقل احتمالية حدوث واقل درجة تأثير ، وأن الرقم 5 يمثل اعلي احتمالية حدوث واعلي درجة تأثير

Risk probability or Impact level	Risk probability or Impact scale
Very high	5
High	4
Medium	3
Low	2
Very Low	1

الرقم	العـــــــــــوامل	تأثيرها علي اداء الزمن										تأثيرها علي اداء التكلفة									
		احتمالية حدوث الخطر Risk probability					قوة التأثير Risk impact					احتمالية حدوث الخطر Risk probability					قوة التأثير Risk impact				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	عـــــــــــوامل لها علاقة المقاول																				
1-1	انخفاض القدرة الانتاجية للعمال																				
1-2	نقص الموارد الرئيسية لدي المقاول																				
1-3	سوء فهم بنود العقد																				
1-4	نقص الخبرة و المهارات التقنية لدي المقاول																				
1-5	نقص الموارد المالية لدي المقاول																				

1-6	نقص الموارد المالية لدي المورد / المقاول من الباطن																				
1-7	نقص الخبرة و المهارات التقنية لدي المورد/ المقاول من الباطن																				

1-8	تغييرات التكنولوجيا																				
1-9	نطاق العمل للمقاول غير محددة بشكل جيد																				
1-10	عدم وضوح التخطيط بسبب تعقيد المشروع																				
1-11	ادارة الموارد سوء																				
1-12	وقوع الحوادث بسبب قلة احتياطات الامن																				
1-13	عدم الإلتزام بالقوانين و اللوائح الخاصة بالبناء																				
2	عــــــــــوامل لها علاقة بالإستشاري																				

2-1	نقص الخبرة و المهارات التقنية لدي الإستشاري																				
2-2	تأخيير الاستشاري لاستلام الاعمال المنجزة																				
2-3	ضعف التواصل بين المشاركيين في المشروع																				
2-4	عدم مطابقة المواد للمواصفات																				
2-5	الممارسات الغير أخلاقية للإستشاري																				
3	عوامل لها علاقة بالمصمم																				
3-1	أخطاء التصميم																				
3-2	تعقيد التصاميم																				
3-3	ضعف / عدم إكتمال التصاميم																				
4	عوامـــــــــل لها علاقة بالمـــــــــالك																				
4-1	التأخر في تدفق الدفعات النقدية من قبل صاحب العمل																				

4-2	نقص الموارد المالية لصاحب العمل																				
4-3	عدم وضوح رغبات صاحب العمل																				
4-4	التغيير في مجال العمل بواسطة صاحب العمل																				
5	عــــــــوامل تعــــــــاقدية																				
5-1	أخطاء في وثائق المشروع (فواتير الكميات)																				
5-2	المعاني المختلفة للمواصفات																				
5-3	عدم إكتمال المعلومات في مرحلة العطاء																				
5-4	التأخير في فض المنازعات																				
5-5	تذبذب إستلام الدفعات النقدية																				
5-6	مدي السماحية في مدة العقد																				

6	عـــــوامل خـــــــــــــارجية																				
6-1	و التشريعات الحكومية الجديدة اللوائح																				
6-2	عدم توفر دليل البناء وإجراءات مشروع البناء في السودان.																				
6-3	معدل التضحم																				
6-4	التغيير في أسعار العملات																				
6-5	عدم الاستقرار الامني (المظاهرات مثلا)																				
6-6	الكوارث الطبيعية (قوي قاهرة)																				
6-7	سؤ الأحوال الجوية																				

القطاع الرابع (وسائل تدارك آثارالمخاطر) :

1-الجدول الموضح أدناه يحتوي بعض الوسائل لتدارك آثار المخاطر ، فضلا أشر بعلامة (√) علي الإجابة التي تمثل وجهة نظرك بدقة.

الرقم	طرق تدارك آثار المخاطر	اوافق بشدة	اوافق	أحيانا	لا اوافق	لا أوافق بشدة
1	مرحلة ما قبل التنفيذ					
1-1	استخدام طرق تحليل المخاطر الكمية او الوصفية لتوقع التكلفة والمدة الزمنية بشكل دقيق .					
1-2	الاعتماد علي الخبرة العملية في عمل برنامج عمل قابل للتنفيذ .					
1-3	عمل احتياضي من تكلفة المشروع لمواجهة المخاطر المتوقعة (المحددة في سجل المخاطر) والغير متوقع حدوثها.					
1-4	إضافة احتياطي زمني للمدة كاحتياطي لمخاطر الجدول الزمني .					
1-5	نقل المخاطر وتقسيمها مع اطراف المشروع .					
1-6	الرجوع الي المشاريع المشابهة المنفذة او الجاري تنفيذها والحصول علي المعلومات لانتاج برنامج عمل دقيق .					
1-7	عمل جدول زمني قابل للتحديث بالحصول لي كل المعلومات المحدثة عن المشروع .					
1-8	استخدام الانظمة الحديثة (برامج كمبيوتر متكاملة مثل برنامج برايمافيرا لتحليل المخاطر)					
2	اثناء مرحلة التنفيذ					
2-1	زيادة العمالة و/ او الآلات					
2-2	زيادة ساعات العمل					
2-3	تغيير تتابع عمليات التنفيذ او التداخل بينها .					
2-4	التنسيق التام مع مقاولي الباطن .					
2-5	الاشراف الدقيق علي الاعمال لتلاشي رفض الاعمال واعادة التنفيذ .					

Appendix 3

The second sector of questionnaire

Reliability Statistics of the tool study:

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation person	Cronbach's Alpha if Item Deleted
Q1	28.0543	36.316	0.592	0.861
Q2	27.9348	35.468	0.716	0.850
Q3	27.4348	36.732	0.669	0.855
Q4	27.6522	35.966	0.722	0.850
Q5	27.2609	37.514	0.622	0.858
Q6	26.6304	40.411	0.407	0.873
Q7	26.8587	41.068	0.325	0.879
Q8	27.3478	37.196	0.601	0.860
Q9	27.3913	36.417	0.629	0.858
Q10	26.9565	38.064	0.639	0.858

Reliability Statistics

valitidy by squared islands	Cronbach's Alpha	N of Items
0.934	0.873	10

The third sector of questionnaire

Factors related to contractors

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
R1	216.0000	115.667	0.771	0.607
R2	218.6154	194.090	0.820	0.739
R3	211.6923	289.731	0.358	0.658
R4	206.4615	779.603	0.877	0.749
R5	211.0000	1128.333	0.964	0.839
R6	216.0000	115.667	0.771	0.607
R7	218.6154	194.090	0.820	0.539
R8	211.6923	289.731	0.358	0.658
R9	206.4615	779.603	0.877	0.749
R10	211.0000	1128.333	0.964	0.839
R11	216.0000	115.667	0.771	0.707
R12	218.6154	194.090	0.820	0.639
R13	211.6923	289.731	0.358	0.558

Table 4.22 Reliability Statistics

Cronbach's Alpha[a]	Cronbach's Alpha Based on Standardized Items	N of Items
0.781	0.610	13

Factors related to consultant

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
R14	78.6000	15.300	0.254	0.658
R15	81.6000	12.300	0.547	0.818
R16	74.0000	13.500	0.354	0.687
R17	69.8000	18.700	0.542	0.821
R18	64.0000	23.500	0.597	0.709

Table 4.28 Reliability Statistics

Cronbach's Alpha[a]	Cronbach's Alpha Based on Standardized Items[a]	N of Items
0.791.	0.627	5

Factors related to designer

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
R21	29.6667	30.333	0.889	0.716
R20	40.6667	35.333	0.877	0.801
R19	33.0000	52.000	0.360	0.641

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items[a]	N of Items
0.843	0.712	3

Factors related to client:

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
R22	49.2500	56.250	0.356	0.640
R23	59.5000	148.333	0.427	0.772
R24	50.7500	374.250	0.355	0.871
R25	45.2500	756.250	0.448	0.640

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
0.927	0.760	4

Contractual factors:

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
R26	101.8333	79.767	0.321	0.871
R27	107.3333	17.067	0.412	0.873
R28	98.0000	36.400	0.254	0.790
R29	89.8333	8.567	0.265	0.737
R30	89.3333	25.267	0.423	0.601
R31	92.0000	24.000	0.247	0.681

Reliability Statistics

Cronbach's Alpha[a]	Cronbach's Alpha Based on Standardized Items[a]	N of Items
0.839	0.705	6

.

External risk Factors:

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
R32	118.2857	493.905	0.324	0.587
R33	128.7143	135.905	0.365	0.562
R34	122.2857	65.238	0.410	0.741
R35	114.7143	200.905	0.487	0.806
R36	118.2857	441.571	0.359	0.654
R37	109.7143	22.571	0.549	0.871
R38	121.1429	75.810	0.258	0.708

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.897	0.805	7

The fourth sector of questionnaire

Preventive action:

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
R1	23.50000	9.364	0.552	0.610
R2	23.75000	10.932	0.549	0.629
R3	23.08333	11.720	0.353	0.665
R4	23.08333	11.174	0.296	0.679
R5	23.16667	8.152	0.841	0.518
R6	22.41667	13.538	0.267	0.743
R7	22.50000	10.091	0.595	0.608
R8	23.41667	12.811	0.430	0.735

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.822	0.677	8

Mitigative actions:

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
R1	14.7500	4.386	0.421	0.795
R2	14.5833	4.083	0.540	0.887
R3	15.2500	4.386	0.267	0.601
R4	15.1667	3.970	0.211	0.802
R5	14.5833	4.265	0.392	0.818

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.780	0.609	5