Sudan University of Science and Technology
College of Graduate Studies

Risk Management in Construction Projects in Sudan

إدارة المخاطر في مشاريع التشييد بالسودان

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master in Civil Engineering
(Construction Engineering)

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Dedication

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

A special feelings of gratitude to my loving sisters and brothers, whose believe in the richness of learning and word of words of encouragement. They also have supported me unlimitedly all the way since the beginning of my studies.

To my wife and children, I say, I appreciate the patience and support. There were times when you needed a husband and a father respectively, whom you missed for he was so engrossed in this academic journey whose destination we now celebrate.

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Abstract

Construction is a risky industry compared to many other industries where it requires proper application of business practices and plays a major role in the economy via its significant share in the Sudanese Growth Domestic Product (GDP). The main objective of this research is to gain understanding of some risk factors that could be applied in managing construction projects in Sudan. The study aims also to investigate the effectiveness of risk preventive and mitigative methods. Moreover, the usage of risk analysis techniques is addressed.

The research objectives have been achieved through a comparative study of closed-ended questionnaires and a case study in Khartoum State – Omdurman locality. The results obtained from the data analysis where interpreted and discussed thoroughly. The output that were directed to respondents concluded that the most important risk factors are: poor/ defective supply of materials, natural disasters, awarding the design to unqualified designers, shortage of human resources/ machinery and material resources, instability of currency exchange, delays in resolving disputes, gaps between the implementation and the specifications and poor resource management. The results show that there are many risk factors contractors and owners could not allocate them on the party that should bear these factors' consequences. The research results show that the respondents suffer from lack of innovative methods to prevent or mitigate risks.

The results of this study recommended that there is an essential need for more standardization and effective forms of contract, which address issues of clarity, fairness, roles and responsibilities, allocation of risks, dispute resolution and payment should be adopted for all the projects in Sudan instead of the consequential disorder that was a result of applying different types of contracts. Owners and contractors are advised to identify the possible risk factors that could confront their projects and to allocate them contractually. The recommendations of this research are useful for the policy makers to establish legislations towards the welfare of the industry.

المستخلص

تعتبر صناعة التشييد من المجالات المحفوفة بالمخاطر مقارنة مع العديد من الصناعات الأخرى، حيث تتطلب تطبيق الممارسات التجارية بشكل صحيح، وتلعب دوراً رئيسياً في الإقتصاد من خلال مساهمتها الكبيرة في الناتج القومي الإجمالي. الهدف الرئيسي من هذا البحث هو فهم بعض عوامل الخطر التي يمكن تطبيقها في إدارة مشاريع التشييد في السودان. وتهدف الدراسة أيضاً إلى التحقق من فعالية أساليب الوقاية المستخدمة للتعامل مع المخاطر سواء بمنع وقوع هذه المخاطر أو بالتقليل من تبعاتها. وعلاوة على ذلك، تناول البحث إستخدام تقنيات تحليل المخاطر.

وقد تم تحقيق أهداف البحث من خلال دراسة مقارنة للإستبيانات المغلقة ودراسة حالة في ولاية الخرطوم – محلية أم درمان. النتائج التي تم الحصول عليها من تحليل البيانات حيث تم تفسيرها ومناقشتها بدقة. وخلصت النواتج الموجهة إلى المشاركين إلى أن أهم عوامل الخطر هي: وقوع الحوادث بسبب قلة إحتياطات الأمان، الأخطاء في التصميم، فشل المقاول مالياً، ضعف/ نقص إمدادات المواد والكوارث الطبيعية، ومنح التصميم للمصممين غير المؤهلين، ونقص الموارد البشرية/ الآلات والموارد المادية، وعدم إستقرار صرف العملات، والتأخير في حل النزاعات، والثغرات بين التنفيذ والمواصفات، وضعف إدارة الموارد. وتظهر النتائج أن هناك العديد من عوامل الخطر التي لا يمكن للمقاولين وأصحاب العمل تخصيصها على الطرف الذي يجب أن يتحمل نتائج هذه العوامل. وأظهرت نتائج البحث أن المقاولين وأصحاب مشاريع التشييد يعانون من عدم وجود طرق مبتكرة لمنع أو تخفيف المخاطر.

وأوصت نتائج هذه الدراسة أن شركات المقاولات والهيئات المالكة مدعوة لتعريف عوامل المخاطرة وتسمية الطرف الذي سيتحملها تعاقدياً. إن توصيات هذا البحث مفيدة لصانعي السياسات لوضع تشريعات من أجل رفاه الصناعة.

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Chapter One

INTRODUCTION

Introduction

1.1 Background

Significant changes in global economy have resulted in increased business chances for engineering and construction companies throughout the world. In recent years; it had been recognized that the construction industry in Sudan is increased in the size of many of its projects and also the technological complexity of such projects is increased. Currently, more companies are positioning to extend their operations in universal construction market. However, while realizing the project in the universal field, the construction companies should give necessary importance to risk management concept which simply covers risk identification, analysis and response development stages. The reason to take risk management concept into the account is that construction industry is subject to more risk and uncertainty than many other industries due to requirement of multitude of people with different skills and interests, the co-ordination of a wide range of interrelated activities and sensibility of construction projects to political, economic, social and environmental conditions.

In recent years, intensive research and development has been done in the area of project risk management; it is widely recognized as one of the most critical procedures and capability areas in the field of project management. Voetsch, Cioffi, and Anbari found a statistically significant relationship between management support for risk management processes and a reported project success. However, shortcomings and improvement opportunities in this field have been identified. Some of the shortcomings are related to the ever increasing complexity of projects. Subcontracting is expanding since many companies are focusing simply on their core businesses, which results in more complex project networks and greater numbers of project participants.

Every construction project passes through phases, each of which has a purpose, duration and scope of work. Breaking the project down into phases is an important part of every construction process. The project must start from some kind of definition of need, after which follow design, contracting, construction and project completion (Huges, 2000). Risk and uncertainty are inherent in all the phases through which the construction project passes, from Demonstrating the Need do Operation and Maintenance. Risk can be managed, minimised, shared, transferred or accepted. Risks do not appear only in major projects, although size may be a cause of risk, complexity, construction speed, site and many other factors that affect time, cost and quality to a greater or lesser degree cannot be overlooked. All the participants in the deciding process should observe risks and their effects on all key points of decision-making before and during project realisation.

The construction industry generally has a bad reputation for its work. The industry has a reputation for time and cost overruns (Raftery, 1997). This bad reputation is due to many reasons; one of them is that the construction industry is one of riskiest of all business types (Clough and Sears, 1994). There are many types of risks in the construction contracts; they are:

- Physical works
- Delay and disputes
- Direction and supervision
- Damage and injury to persons and property
- External factors
- Payment
- Law and arbitration

1.2 Research Objectives

The research objectives are:

- To introduce the risk management in building projects phases.
- To define the risk management process in construction projects.
- To investigate how the risk management concept is acceptable for the Sudanese companies and to what extent.
- To identify key risk variables and their effects on the projects.

1.3 Research Problem

A construction industry became one of the top resources which contribute highly to the growth domestic product (GDP) for the most countries, but Sudan like many other developing countries, struggle several problems; economics, politics and some other crises. These problems often lead to the failure of projects, particularly construction projects, that because of difficulty of managing very well to achieve the desired objectives of the project.

This study focusing on how the Sudanese construction industries can implement; risk management to benefit from its advantages to overcome and solve all problems and obstacles that hinder the project's success in Sudan.

1.4 Research Questions

- What are the methods and tools for risk management in construction projects?
- How are these methods and tools used?
- What are the results from previous research done in the field of risk management in construction processes?
- What are the obstacles and drivers for risk management in construction projects?

1.5 Purpose of the study

Risk management became an essential mission of the management missions. Taking into account that the construction industry is considered one of the riskiest industries, unfortunately, few researchers have participated in this topic addressing the construction industry in the local market. The purpose of this master thesis is to evaluate how the risk management process is used in the construction industry and how the practitioners are managing risks in everyday situations and to analyze risk factors affecting the construction industry in Khartoum sector.

1.6 Research hypothesis

This study includes a number of hypotheses related to the direct aim of the study that will identify to describe and understand the problem research topic, which are:

- Supporting the effective use of resources.
- Quick grasp of new opportunities.
- Enhance other project management processes.

Know the factors affect the level of cost control lead to success cost control of the project.

1.7 Research Methodology

The qualitative method will be used in the study for the 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 results. The questionnaire survey will be used and also the interviews (if necessary) for the collection of qualitative data.

1.8 Research Limitations

1. Due to time limitation, this research is concerned with building projects only and will not take into account that other categories of construction industry like heavy engineering construction (tunnels, bridges, dams, etc.), industrial projects (factories and workshops), and infrastructure projects (sewage and water supply).
2. Only residential construction projects be addressed by the study.
3. Risk key-variables and the affected processes of projects by these variables will form the core of the study.
4. This research is bounded to one type of construction projects, which is Residential Projects.

1.9 Research Structure

Chapter One: outlines the background, research objectives, problem statement, research questions, research importance, hypotheses, methodology, and research limitations.

Chapter Two: is the theoretical framework and the state-of-the-art for the area on which this thesis focuses. This chapter gives the theoretical foundation for the thesis

Chapter Three: is the guideline the description of the method used to realize the aim of the study. This chapter aims to explain to the reader how the study has been realized to ensure its validity and reliability.

Chapter Four: contains the analyses, results and discussion of the collected data. And test the results by applying them to a case study. This chapter aims to present the collected data as objectively and completely as possible for each of the research questions.

Chapter Five: contains the discussion and conclusions of the study. It also discusses the strengths and weaknesses of the study, as well as the researcher's view of how the results should be used, together with suggestions for further research.

- References
- Appendices

Chapter Two

LITERATURE REVIEW

Literature Review

2.1 Preamble

This chapter establishes the scope of this study by examining literatures relating to risk management. It also identifies the suitable theoretical viewpoint to be applied on this study.

In order to identify the concepts of the research title and how these concepts can be applied, the literature review process begins by looking into various journals and books by often cited authors in this knowledge area like Shahid IQBAL, Nerija Banaitiene, Nigel J. Smith and David Hillson and others in order to understand deeply the underlying meaning of risk management as well as to be aware of where and how far the research has gone. Thereafter, a wider view is used to look into how risk is managed in different industries, the subjective elements embedded in risk management and the impact of different project types on ways risk is managed. Lastly, the review is directed towards risk management in construction projects where detailed studies is performed to identify the modest value add that this study can contribute to the field of research, thus, form the basis for this study.

The search of literatures begins through academic databases. The approach of the search was based on the use of keywords such as “risks”, “risk management”, “risk assessment”, “project management”. From the initial books and journals that found, the search went through the individual reference list to more expand. There are many of citation and recency of the literature are acceptance criterions that were applied to select the respective literatures for this chapter.

This chapter contains the following sub-categories:

- Definition of risk
- Types of construction projects
- Construction project life cycle
- Risk and its types in construction projects
- History of risks management in construction projects
- Benefits of risk management in construction projects

- Risk management process

2.2 Definition of risk

The findings of this search resulted in a number of definitions of risk:

Project risk is an uncertain event or condition that, if it happens, has a positive or a negative effect on project objectives. There are two primary components of risk for any given event, which are the probability of occurrence of that event and the impact of the occurring event. Therefore, if either of these two components increases, it will lead to the increase of the risk. - *M.Sc. research (Rasha Faroug, 2002).*

The term “risk” does not have a single unanimous definition. Based on the Oxford English Dictionary risk is “the possibility that something unpleasant will happen” and its origin refers to the Italian words “risco”, “riscare” and “richiare” from the 17th century (Hay-Gibson, 2009, cited in Lemieux, 2010). In the other hand Althaus states that the term risk has an origin in Portuguese with the meaning of “to dare” (Althaus, 2005; Hay-Gibson, 2009; Lemieux, 2010). Risk can be theoretically described as any potential deviation from the predefined target with its defined specifications. It is normally linked to terms such as uncertainty, the unknown, and unpredictability. Basically all efforts and movements of people contain risks and uncertainties. Daily life is fraught with dynamic situations involving unknown factors which can have pleasant or unpleasant, and mostly unforeseen and unpredictable consequences (Mulcahy, 2003).
- *Amir Hassan Mohebbi, Ngadhnjim Bislimi*

Risk can be defined in different ways:

- (Rescher 1983) has defined it as an uncertain situation with potential unwilling consequences.
- “Risk is most commonly conceived as reflecting variation in the distribution of possible outcomes, their likelihoods, and their subjective values” (March & Shapira, 1987).
- In accordance with (Williams et al., 1998) Risk is defined as the possible variation in results and can be either positive or negative (upside or downside risk).
- Risk is “the likelihood that it will actually cause harm” (Jeynes, 2002)

- Based on ISO/IEC Guide 73 (BSI, 2002) risk is defined as "the combination of the probability of an event and its consequences". "In some situations, risk arises from the possibility of deviation from the expected outcome or event" but it "is generally used only when there is at least the possibility of negative consequences."
- Joint Technical Committee OB-007 (Standards Australia/Standards New Zealand, 2009) defines risk as the "effect of uncertainty on objectives" while "An effect is a deviation from the expected - positive and/or negative. Objectives can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process). Risk is often characterized by reference to potential events and consequences or a combination of these. Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated likelihood of occurrence."
- "The quantitative engineering definition of the risk is: Risk = (probability of an accident) x (losses per accident)" (Agrawal, 2009) Considering the definitions above, a wide variety of risk descriptions can be found based on the circumstances and applications. These definitions reveal two important aspects of the risk in general; uncertainty and consequences. Therefore, the occurrence probability of the risk and the severity of the effects are considered as two major parameters of defining the risk.

  All in all, risk is interpreted as a type of unknown event with unpleasant effects, although it can be a pleasant happening with positive consequences which would normally be considered as an opportunity. Risk analysis focuses on both pleasant and unpleasant aspects of the risk.

Risk and uncertainty are the two most often used concepts in the literature covering RM field. Although these terms are closely related, a number of authors differentiate between them (Samson, 2009). Also practitioners working with risk have difficulty in defining and distinguishing between these two. Often definitions of risk or uncertainty are tailored for the use of a particular project. To make it more systematized, a literature research was done. The findings of this search resulted in a number of definitions of risk.

These have been compiled and are presented in Table 2.1. All risk definitions complied in this table describe risk as a situation where lack of some aspect can cause a threat to the project. Lack of information and knowledge are those factors which are most commonly mentioned by all the authors as leading reasons for a failure. The description provided by (Cleden, 2009) will best fit the purpose of this thesis; it concerns how risk is defined as a gap in knowledge which, if not handled correctly, will constitute a threat to the project. - *M.Sc. research (Ewelina Gajewska, Mikaela Ropel, 2011).*

Table 2.1 Definitions of risk

Author	Risk definition
Winch (2002)	A stage where there is a lack of information, but by looking at past experience, it is easier to predict the future. Events where the outcome is known and expected.
Cleden (2009)	Risk is the statement of what may arise from that lack of knowledge. Risks are gaps in knowledge which we think constitute a threat to the project.
Smith et al., (2006)	Risks occur where there is some knowledge about the event.
Cooper et al., (2005)	Risk is exposure to the consequences of uncertainty.
Webb (2003)	Risk is a situation in which he possesses some objectives information about what the outcome might be. Risk exposure can be valued either positively or negatively.
Darnall and Preston (2010)	Risk is a possibility of loss or injury.

2.3 Types of construction projects (Haitham et al., 2013)

There are different types of construction projects according to (Grace F. M. 2010):

a. Residential: This type of construction projects includes different types of buildings such as houses, townhouses, apartments, and subdivisions. The process to design the houses is done, in general, by the architects and engineers and the builders (or may hire subcontractors) do structural, electrical, mechanical and other specialty work in the construction process of these houses. Local building authority regulations and codes must be applied in these buildings. The market of this type of building is highly competitive and high risks as well as high rewards.

b. Building: The most popular type of construction project is the Building construction. It can be defined as - is the process of adding structure to real property‖ (Grace F. M., 2010). The building projects in the most cases are adding a new room and making small renovations. Most new building construction projects are building sheltered enclosures in order to house people, equipment or machinery. Installation of utilities and equipment is included.

c. Institutional and Commercial: A great variety of institutional and commercial building are available in this industry with different types and sizes such as schools, universities, hospitals, clinics, sports facilities, stadiums, large shopping centers and retail chain stores, light manufacturing plants and warehouses and skyscrapers for offices and hotels. The designs of such building must be done by specialty architects and engineers who are often hired for designing such buildings. Few competitors are competing in this market of these types of buildings because of the high capital needed in addition this type is sophisticated compared to residential construction projects.

d. Industrial: This type represents small percentage of the whole industrial construction. while it is a very important part of the industry. The owners of such projects are generally big, profit, industrial corporations and institutions

   such as manufacturing, power generation, medicine, petroleum, etc. highly specialized expertise processes in planning, cost estimating, design, and construction are required for these industries.

e. Specialized Industrial Construction: Very large scale projects represent this type of construction project and involve high degree of technological complexity such as nuclear power plants, chemical processing plants, steel mills and oil refineries.

f. Highway Construction: Highway construction - involves the construction, alteration, or repair of roads, highways, streets, alleys, runways, paths, parking areas, etc. (Grace F. M., 2010).

2.4 Construction project life cycle (PMBOK® Guide – Fifth Edition)

It is the series of phases that a project passes through from its initiation to its closure. The project life cycle serves to define the beginning and the end of a project. For example, the project life cycle will determine whether the feasibility study is treated as the first project phase or a separate standalone project. In addition, project life cycle definition can be used to link the project to ongoing operational organization. The life cycle provides the basic framework for managing the project, regardless of the specific work involved.

All projects can be mapped to the following generic life cycle structure (figure 2.1):

- Starting the project,
- Organizing and preparing,
- Carrying out the project work, and
- Closing the project.

This generic life cycle structure is often referred to when communicating with upper management or other entities less familiar with the details of the project. It should not be confused with the Project Management Process Groups, because the processes in a Process Group consist of activities that may be performed and recur within each phase of a project as well as for the project as a whole. The project life cycle is independent from the life cycle of the product produced by or modified by the project. However, the project should take the current life-cycle phase of the product into consideration. This high-level view can provide a common frame of reference for comparing projects-even if they are dissimilar in nature.

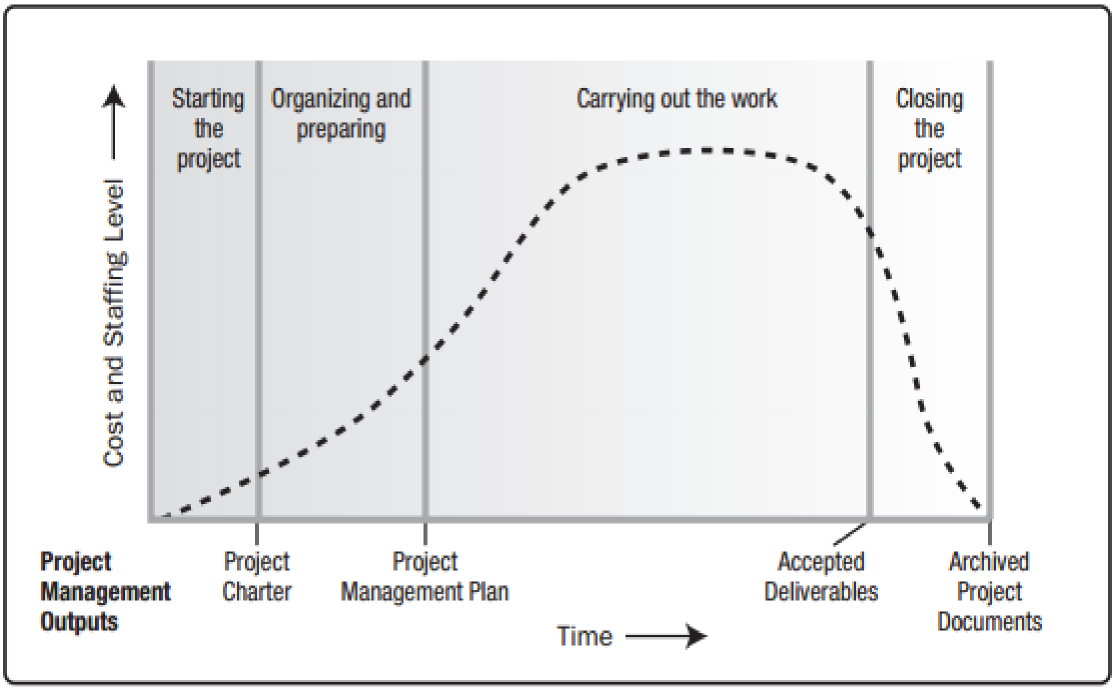

Figure 2.1 Typical cost and staffing levels across a generic project life cycle structure.

Source: PMBOK® Guide – Fifth Edition

The generic life cycle structure generally displays the following characteristics:

- Cost and staffing levels are low at the start, peak as the work is carried out, and drop rapidly as the project draws to a close. The typical cost and staffing curve above may not apply to all projects. A project may require significant expenditures to secure needed resources early in its life cycle, for instance, or be fully staffed from a point very early in its life cycle.

- Risk and uncertainty (as illustrated in Figure 2-2) are greatest at the start of the project. These factors decrease over the life of the project as decisions are reached and as deliverables are accepted.

- The ability to influence the final characteristics of the project's product, without significantly impacting cost, is highest at the start of the project and decreases as the project progresses towards completion. Figure 2-2 illustrates the idea that the cost of making changes and correcting errors typically increases substantially as the project approaches completion.

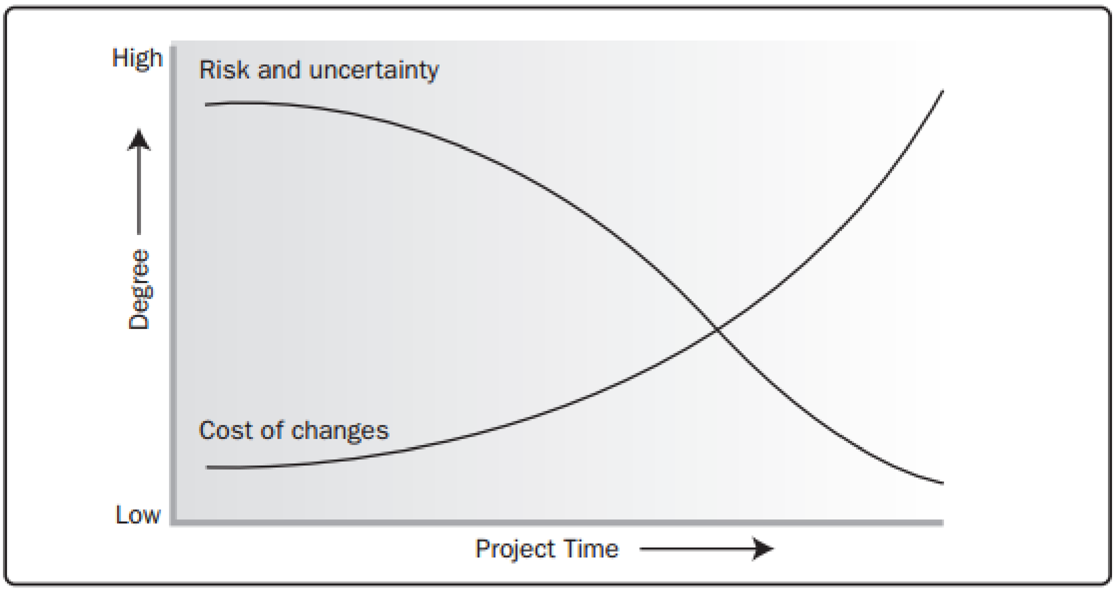

Figure 2.2 Impact of Variable Based on Project time

Source: PMBOK® Guide – Fifth Edition

2.5 Risk & its types in construction projects

Due to the nature of the construction sector, RM is a very important process here. It is most widely used in those projects which include high level of uncertainty. These types of risk investments are characterized by more formal planning, monitor and control processes. The easiest way to identify risk is to analyze and draw a conclusion from projects which failed in the past. To make sure that the project objectives are met, the portfolio of risks associated with all actors across the project life cycle (PLC) should be considered (Cleland and Gareis, 2006). In the early stages of the project where planning and contracting of work, together with the preliminary capital budget are being drawn risk management procedures should be initiated. In later stages, RM applied systemically, helps to control those critical elements which can negatively impact project performance. In other words, to keep track of previously identified threats, will result in early warnings to the project manager if any of the objectives, time, cost or quality, are not being met (Tummala and Burchett, 1999). There are a number of risks which can be identified in the construction industry and which can be faced in each construction project regardless of its size and scope. Changes in design and scope along with time frames for project completion are the most common risks for the construction sector. The further in the process, changes in scope or design are implemented, the more additional resources, time and cost, those changes require. Project completion ahead of time may be as troublesome as delays in a schedule. Too quick completion may be a result of insufficient planning or design problems which in fact shorten the completion time but on the other hand lead to a low quality of final product and increased overall cost. Being behind schedule generates greater costs for both investors and contractors due to non-compliance with contracted works (Gould and Joyce, 2002). And thus it is important to keep a balance in the concept of time-cost-quality tradeoff, which more widely is becoming an important issue for the construction sector (Zhang and Xing, 2010). Depending on the project scope, types of risks may differ among investments.

The construction industry is often considered as a risky business due to its complexity and strategic nature. It incurs a numerous project stakeholder, internal and external factors which will lead to massive risks. Unfortunately, the construction industry has a poor reputation in risk analysis when compared to other industries (Laryea, 2008). However, no construction project is risk free. Risk can be managed, minimized, shared, transferred, or accepted. It cannot be ignored (Latham 1994). Risk is a multi-facet concept according to (PMI, 2008) Project risk management is the processes concerned with identifying, analyzing, and responding to project risk.

In the context of construction industry, risk is the probability of the occurrence of a definite event or combination of events which occur during the whole process of construction. Construction involves many variables, and it is often difficult to determine cause and effect, dependence and correlations. Hence, those risks play a significant role in decision making and may affect the performance of a project (wiguna and scott, 2005). Risk is exposure to the consequences of uncertainty. As a result, subjective analytical methods that rely on historical information and the experiences of individuals and companies have been used to assess the impact of construction risk and uncertainty. Therefore, Risk assessment is a technique that aims to identify and estimate risks impacted upon by a project.

Patel Ankit Mahendra et al., 2013, categorized the types of risks as in the following table:

Table 2.2 Types of risks in construction projects.

1. Technical Risks: • Incomplete Design • Inadequate specification • Inadequate site investigation • Change in scope • Construction procedures • Insufficient resource availability	**2. Construction Risks:** • Labour productivity • Labour disputes • Site condition • Equipment failures • Design changes • Too high quality standard • New technology
3. Physical Risks: • Damage to structure • Damage to equipment • Labour injuries • Equipment and material fire and theft	**4. Organizational Risks:** • Contractual relations • Contractor's experience • Attitudes of participants • Inexperienced work force • Communication
5. Financial Risks: • Increased material cost • Low market demand • Exchange rate fluctuation • Payment delays • Improper estimation • Taxes	**6. Socio-political Risks** • Changes in laws and regulations • Pollution and safety rules • Bribery/Corruption • Language/Cultural barrier • Law and order • War and civil disorder • Requirement for permits and their approval
7. Environmental Risks:	

- Natural Disasters
- Weather Implications

2.6 History of Risks Management in Construction Projects

Risks management is taking knowledge, skills, tools, and techniques, applying those to project activities to satisfy the business need for which the project was undertaken.

- **The 1990's – Origin of Risk Analysis in Construction Industry**

During 1990s risk factor identification and assessment technique became a hot research topic. Many contractors developed a series of thumb rules to analyze and assess risks. As a result, many construction projects failed to achieve their time, cost and quality goals (Al- Bahar, 1988) The project risks and uncertainties in cost and time can be managed by a systematic approach during estimation stage in order to minimize their effects. This approach involves identifying risk sources, assessing their effects on a project and selecting ways to control them (Birnie and Yates, 1991). Accordingly, the sources of risk were classified based on controllable and uncontrollable factors which will lead to cost and time overrun in a project (Akincl, 1998). Based on this result, different risk assessment models have been formulated to analyze and assess project risks during the bidding stage of a construction project (Mustafa and Bahar, 1991). Similarly, few attempts were made by the researches like (Tah et al., 1993), (Wirba et al., 1996), (Dawood, 1998) in risk assessment by Probability- Impact assessment (P-I), Fuzzy Set Theory (FST) and Monte Carlo Simulation (MCS).

- **The New Millennium- Arrival of New Systematic Approaches**

Till 2000, only few attempts have made on the identification and assessment of risk factors of the construction projects. As a result, there was a lack of systematic approaches to identify and manage the risks in construction projects. (Chapman, 2001) grouped risks into four subsets: environment, industry, client and project. (Shen, 2001) classified them into six groups with the nature of the risks i.e. financial, legal, management, market, policy, and political. (Chen et al., 2004) proposed 15 risks affecting project cost and they were grouped under three heads: resource factors, management factors and parent factors. (Dikmen et al., 2007) used influence diagrams to define the factors which have influence on project cost. (Zeng et al., 2007) categorized risk factors as human, site, material and equipment factors. In the post 2000's many researchers made an attempt to propose the limitations and complexity of risk assessment tools such as Analytical hierarchy process (AHP), P-I, FST, MCS and decision support system.

- **The Post 2010's – Development of More Sophisticated Techniques**

There is a sharp increase in the number of risk identification and assessment papers published after 2010. More sophisticated models have been developed by various researchers for integrating the risk assessment in comprehensive decision making frame work. (Rezakhani 2012) classified the risk factors under three heads: External, Legal and internal. External risk was sub divided into two subsets: unpredictable/ uncontrollable, predictable/ uncontrollable and Internal risk was sub divided into two subsets: Non- technical / controllable, Technical / controllable. Further he suggested a hierarchy based risk break down structure and identified the key risk factors. (Goh et al., 2013) identified 19 risk factors in the life cycle of the project under four heads such as Planning stage, Design stage, Procurement stage, construction stage, Handling over stage. They discussed the use of work shop with an integrated approach which includes brain storming, checklist, probability impact matrices, subjective judgment, and risk register. Finally, they suggested that the risk management workshop will be useful for risk identification and analysis, as a means of managing risks. Many researchers have tried various approaches for representing the interdependencies between project risks and its complexity of the surrounding environment (Lazzerini and mkrtchyan, 2011). (Hwang et al., 2013) reported that risk management implementation is relatively low in small construction projects and this is due to lack of time and budget, low profit margin and not economical. The results indicated a positive correlation between RM implementation and improvement in project quality, cost and schedule performance of small projects.

2.7 Benefits of risk management in construction projects

Project risk management increases the likelihood of project success. It provides a holistic view of risks, challenges and potential problems and builds processes to help you monitor and manage them. This not only reduces the cost of your project, but gives you, as the project manager, a valuable tool to reduce risk associated with project investments and tactical project activities. Your confidence will increase knowing that your project will meet targeted goals and achieve expected outcomes.

Project risk management activities will give you clear visibility of your project risks and strengths and help you:

- Clarify and assess the accuracy and relevance of project scope;
- Validate and communicate project progress and risk;
- Evaluate and quantify project processes against benchmarks;
- Ensure project accountability and stakeholder management;
- Minimizing uncertainty on projects or during changes in company organization;
- Better decision-making – risk management either as a stand-alone projects or linked with a value management exercise (see value management fact sheet), can ensure that strategic decisions are well founded;
- Providing a hard focus on critical problems. For construction projects these will include risks associated with design, construction and maintenance/operation. Risk management techniques will complement a whole life costing approach (see whole life costing fact sheet);
- Better work planning – risk management enables you to balance high-risk projects with lower-risk projects.
- Clearer accountability – once risks are established, risk-minimization can be assigned to individuals within your team. Project risk management is preventive. Armed with proactive information about the project status, you will be in a better position to anticipate and prevent issues that lead to cost and schedule overruns. Preventing downstream defects and project delays will help you improve your project performance by:
- Identifying strengths and weaknesses of the project approach;
- Recommending effective project, process and technology controls; and
- Enabling effective project reporting and communication.

Project risk management will help you demonstrate measurable value, mange change and realize anticipated project benefits by:

- Measuring achievement of business case and strategy;
- Focusing on operational readiness; and
- Assessing change integration and organization acceptance.

2.8 Risk management process

2.7.1 PMBOK guide

For this approach, its explicit section for project risk management is enclosed in Chapter 11 of the PMI's PMBOK Guide (2004), where it is structured in a framework of inputs, processes and outputs. It deals with the process of managing responsibility and its relationship to the broad project management process restricted in the remnants of the PMBOK Guide. Figure 2-3 illustrates the risk management process by the PMBOK Guide. However, there is a lack of straight forward depiction of the risk management where (Cooper et al., 2005) remark that the approach is only obliged to many large complex technology projects in the operation sector. Also, it is supported without a clear link between the qualitative and quantitative risk analysis methods. In contrary, (Heldman 2005) argued that the PMI does provide a framework for project management processes and stresses that the framework merely acts as a guideline for organizations to expand their own processes and procedures.

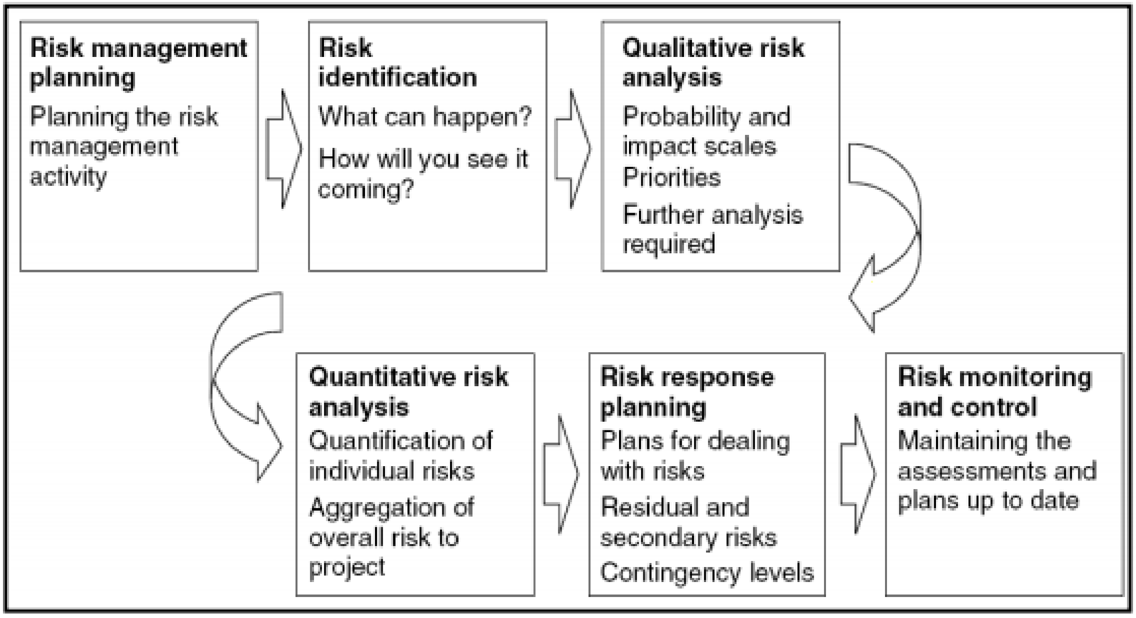

Figure 2.3 The PMBOK guide project risk management process

Source: (Cooper et al., 2005)

2.7.2 International Organization for Standardization, 14 - ISO 31000

Risk management is no longer special or optional: it is a necessary consideration each time we make a decision – whether to develop a relationship, start a project or hold an event. It is required for good quality outcomes. We must constructively align our activities and decision-making with objectives and outcomes that help us reach our strategic goals or successfully execute our operational plans. This is risk management. To manage risk, we apply the standard in the way described here. It takes into account the unique and special environments in which we work.

In many organizations, the management of risks with positive consequences is separate from the management of risks with negative consequences. ISO 31000:2009 is clear that the risk management process (shown in Figure 2.4 below) is the same for risks regardless of the nature of their consequences.

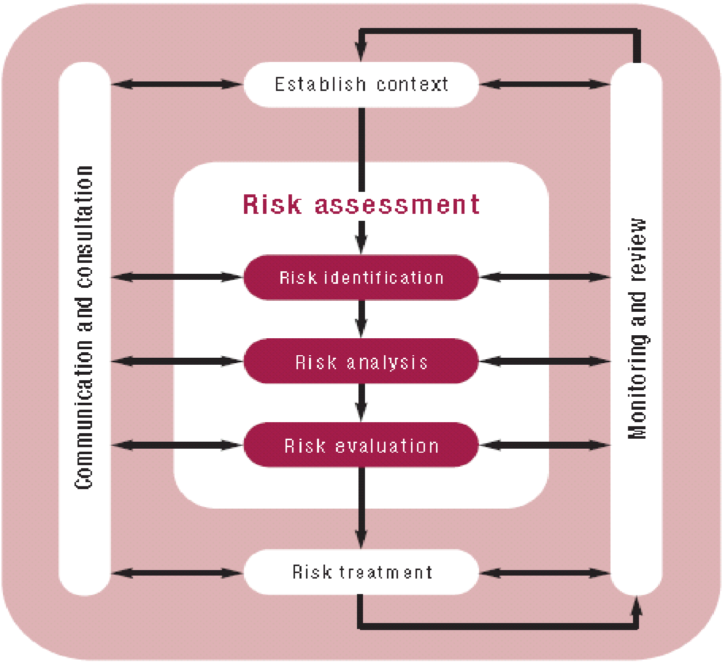

Figure 2.4 Risk management process (based on ISO 31000)

2.7.3 Patel Ankit Mahendra et al., 2013

Risk management is the process which consists of identification, assessment, response and control as shown in figure 2.5.

Figure 2.5 Risk Management Process

Source: Patel Ankit Mahendra et al., 2013

2.7.3.1 Risk Identification can be done by the following methods (Techniques):

- **Brainstorming:** This is one of the most popular techniques. Generally, it is used for idea generation, it is also very useful for risk identification. All relevant persons associated with project gather at one place. There is one facilitator who is briefing about various aspects with the participants and then after note down the factors. Before closing it the facilitator review the factors eliminate the unnecessary ones.

- **Delphi Technique:** This technique is similar to brainstorming but the participants in this do not know each other and they are not at the same place. They will identify the factors without consulting other participants. The facilitator like in brainstorming, sums up the identified factors.
- **Interview/ Expert Opinion:** Experts or personnel with sufficient experience in a project can be a great help in avoiding/solving similar problems over and over again. All the participants or the relevant persons in the project can be interviewed for the identification of factors affecting risk.
- **Past Experience:** Past experience from the same kind of project, the analogy can be formed for identification of the factors. When comparing the characteristics of projects will provide insight about the common factors.
- **Checklists:** These are simple but very useful predetermined lists of factors that are possible for the project. The check list which contains a list of the risks identified in projects undertaken in the past and the responses to those risks provides a head start in risk identification.

2.7.3.2 Risk Assessment can be done by the following methods:

- **Qualitative Method:**

Risk Priority Number:

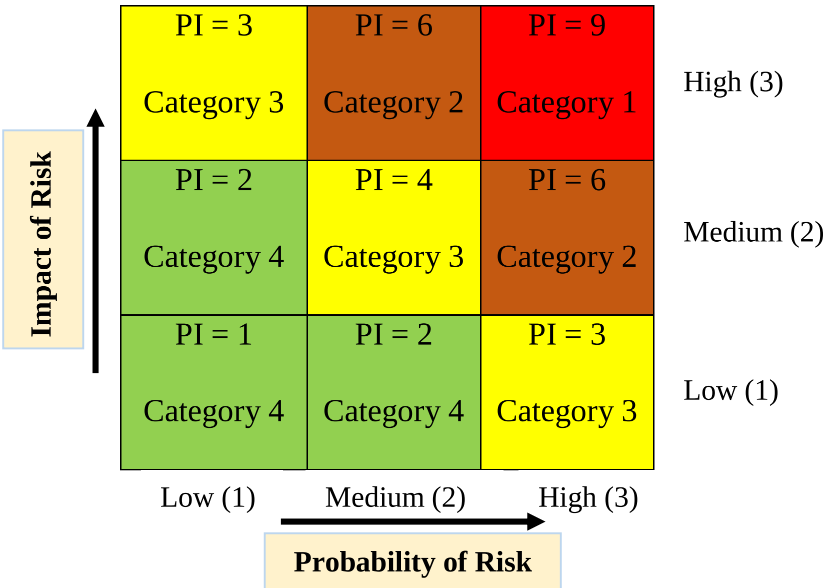

Figure 2.6. Risk Priority Number

There are 4 categories defined in the above diagram.

Category 1 - PI factor 9, which requires maximum attention

Category 2 - PI Factor 6, which requires a good amount of attention

Category 3 - PI Factor 3, which requires comparatively less attention to be paid

Category 4 - PI Factors of 1 and 2, requires less attention to be paid

- **Quantitative Methods:**
  - **Sensitivity Analysis:** This is carried out to identify the uncertain project components which will have maximum impact on the outcome of the project. After a risk model is made a sensitivity analysis is carried out to check the sensitivity of different elements of the model on project outcome. To do these the values of one variable at a time is changed and the impact of these changes is then seen on the project.
  - **Scenario Analysis:** Scenario analysis gives the impact of different scenario of the project or impact of different risk if that occurs simultaneously. A fair decision can be made after this analysis, the option which will give lesser loss or hazards that option can be opted.
  - **Probabilistic Analysis (Monte Carlo Simulation):** A project simulation is done using a model to show the potential impact of different level of uncertainties on project objectives. Monte Carlo Simulation is generally used for this analysis. It can quantify the effect of uncertainties and risks on project budget and schedule. It simulates the full system many times, each time randomly choosing a value for each factor from its probability distribution. It uses three-point estimate like most likely, worst case and best case duration for each task in time management.
  - **Decision Trees:** This analysis is carried out by decision tree diagram. Decision trees are very helpful to both formulate the problem and evaluate options. In this analysis there are graphical models used to represent a project and can clearly reflect the effects of each decision taken in the project.

2.7.3.3 Risk Response Planning.

It can be done by the following methods:

- **Risk Avoidance:** Risk can be warded off by removing the cause of the risk of executing the project in a different direction while still aiming to accomplish project objectives. Change project management plan to eliminate a threat, to isolate project objectives from the risk's impact, or to relax the project objective that is in jeopardy, such as extending schedule or reducing the scope.
- **Risk Transfer:** Transferring risk involves finding some other party who is willing to accept responsibility for its management, and who will bear the liability of the risk should it occur. Transferring a threat does not eliminate it; the threat still exists however it is owned and managed by another party. Transferring risk can be an effective way to deal with financial risk exposure. The aim is to ensure that the risk is owned and managed by the party best able to deal with it effectively.
- **Risk Mitigation/ Reduction:** Risk mitigation reduces the probability and/or impact of an adverse risk event to an acceptable threshold. Taking early action to reduce the probability and/or impact of a risk is often more effective than attempting to repair the damage after the risk has passed.
- **Risk Exploit:** This strategy seeks to eliminate the uncertainty associated with a particular upside risk by creating the opportunity definitely happens. Eliminate the uncertainty associated with a particular upside risk. An opportunity is defined as a risk event that if it occurs will have a positive effect on achievement of project objectives.
- **Risk Share:** Allocate risk ownership of an opportunity to another party who is best able to maximize its probability of occurrence and increase the potential benefits if it does happen. Transferring threats and sharing opportunities are similar in that a third party is used, those to whom the threats are transferred take on the liability and those to whom opportunities are allocated should also be allowed to share in the potential benefits.
- **Risk Enhance:** This response aims to alter the "size" of the positive risk. The opportunity is enhanced by increasing its probability and/or impact, thereby maximizing the benefits gained from the project. Seeking to facilitate or strengthen the cause of the opportunity, and proactively targeting and reinforcing its trigger conditions.

- **Risk Acceptance:** Ultimately it is not possible to eliminate all threats or take advantage of all opportunities – we can document them and at least provide awareness that these exist and have been identified, some term this ‘passive acceptance. This strategy is adopted when it is not possible or practical to respond to the risk by the other strategies, or a response is not justified by the grandness of the risk. When the project manager and the project team decide to accept a risk, they are agreeing to address the risk if and when it happens.
- **Contingency Plan:** This involves the use of a fallback plan if a risk occurs. Contingencies can also be in the form of sometime kept in reserve to deal with unknown risks or in the form of costs to deal with unknown risks.

2.7.3.4 Risk Control is the final step of the process:

After we have implemented response actions, we must track and record their effectiveness and any changes to the project risk profile. Did the response actions have a positive or negative effect on achieving project objectives? Responses taken in risks should also be documented for future reference and project plans.

2.7.4 Australian standards/ New Zealand standards AS/NZS 4360:2004:

The main elements of this process are:

- Commination and consultation: it is a continuous process throughout the risk management process. Communication and consultation with both external and internal stakeholders appropriately at stage of the risk management process;
- Establishing the context: internal, external and risk management context in which the rest of the process will take place is establishing. The risk evaluation criteria and definition of the analysis structure is established;
- Risk identification: the identification process should indicate where, when, why and how and occurrence of an event could delay, prevent, degrade or enhance the achievement of the objectives;

- Risk analysis: this comprise identification and evaluation of existing controls. It also includes determination and evaluation of likelihood, consequences and the level of risk. It is vital that range of potential consequences and how they could occur are taken into consideration;
- Risk evaluation: this consist of comparison of estimated risk levels against pre-established criteria. The balance between adverse outcomes and potential benefits is considered to enables decisions to be made about the nature and extent of treatment required and priorities;
- Risk treatment: it involves development and application of specific cost effective strategies and action plans to reduce potential adverse cost and increase potential benefits;
- Monitoring and review: the risk management process is an iteration process. It is therefore important to continuously monitor and review the effectiveness of all the steps in the whole risk management process. This is vital for continuous improvement and ensures changing circumstances do not alter priorities.

The whole risk management process as described in AS/NZS 4360:2004 is shown in figure 2.7 (Adopted from Williams et al., 2006).

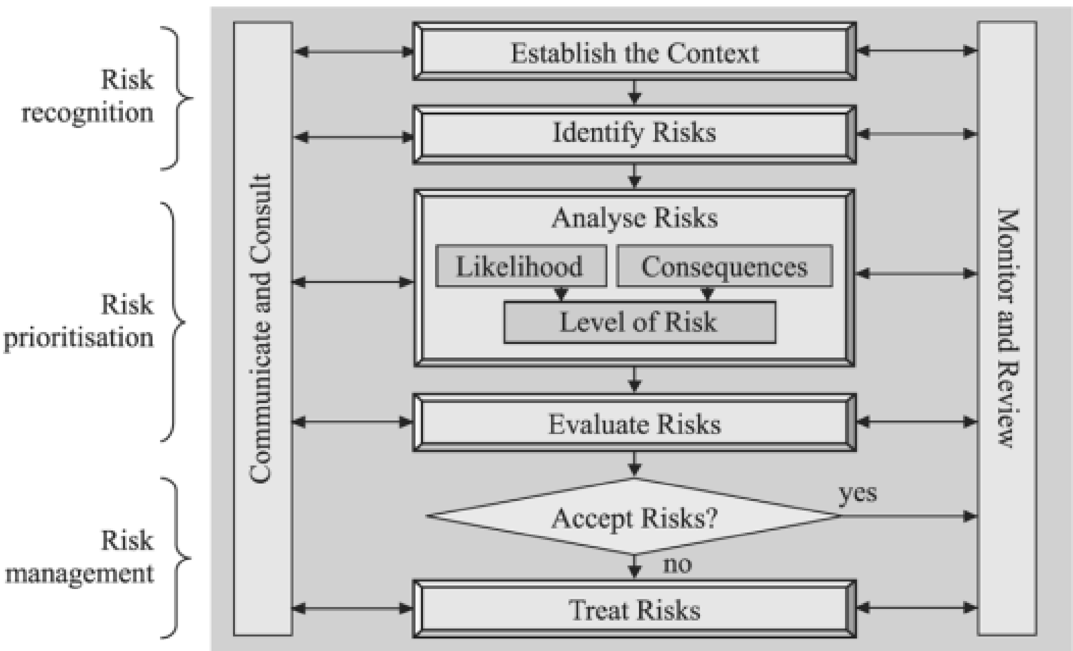

Figure 2.7 Risk management process – overview according to AS/NZS 4360:2004

Chapter Three

RESEARCH METHODOLOGY

Research Methodology

3.1 Preamble

The aim of this chapter is to describe the research methods and techniques employed in the study.

The previous chapter described in some detail the concepts and the practices of risk management in construction projects for full understanding of risk management concepts and practices. In this chapter, the information about research strategy is provided, a description of data collection procedure adopted for this research is described. It is also provides, research design, target population and sample size. It also discusses some of the practical problems encountered. A detailed methodology and tools used are described.

3.2 Research Strategy

Chambers English Dictionary defines research as (Fellows & Liu, 1997):

- a careful search
- investigation
- Systematic investigation towards increasing the sum of knowledge.

Research is diligent, systematic realization or investigation to validate old knowledge and generate new knowledge (Burns & Grove, 1987). Research does not occur in a vacuum, research projects take place in context – of researcher's interests, expertise and experiences; of human contacts; of the physical environment, etc. (Fellows & Liu, 1997).

Research strategy can be defined as the way in which the research objectives can be questioned (Naoum, 1997). Another definition is "the general plan of how the researcher will go about answering the research questions" Saunders et al (2009, pp600)

There are two types of research strategies namely quantitative research and qualitative research (Naoum, 1997). Quantitative approaches seek to gather factual data and to study relationships between facts and how such facts and relationships accord with theories and the findings of any research executed previously (Fellows & Liu, 1997), where qualitative approaches seek to gain insights and to understand people's perception of "the world" whether as individuals or groups (Fellows & Liu, 1997). Qualitative research is "subjective" in nature, emphasizing meanings, experiences and so on (Naoum, 1997).

In this research, a quantitative approach is selected to determine the variables and factors that affect the risk management practices in building projects in Sudan to find out if there is a systematic risk management practices through the contracting companies.

3.3 Research Design

The term "research design" refers to the plan or organization of scientific investigation, designing of a research study involves the development of a plan or strategy that will guide the collection and analyses of data (Polit & Hungler, 1999). Burns & Grove (1997) defined the term design as "some consider research design to be the entire strategy for the study, from identifying the problem to find the plans for data collection. Other limit design to clearly define structural framework within which the study is implemented". The framework that the researcher creates is the design (Wood & Haber, 1998). Much research in the social sciences and management spheres involves asking and obtaining answers to questions through conducting surveys of people by questionnaires, interviews and case studies (Fellows & Liu,1997).

In this research a closed-ended questionnaire with interview is used to collect data from respondents. In structured interview, questions are presented in the same order and with the same wording. The interviewer has full control on the questionnaire throughout the entire process of the interview.

In structured interview, the interviewer administers a questionnaire, perhaps by asking the questions and recording the responses, with little scope for probing those responses by asking supplementary questions to obtain more details and to pursue new and interesting aspects (Fellows & Liu, 1997). Naoum (1998) summarizes the main advantages of structured interview as follows:

- The answers can be more accurate.
- The response rate is relatively high (approximately 60-70 percent), especially if interviewees are contacted directly.

- The answers can be explored with finding out "Why" the particular answers are given.

3.4 Research Population

A population consists of the totality of the observation with which we are concerned (Walpole & Myers, 1998). Polit and Hungler (1999:43, 232) define a population as the totality of all subjects that conform to a set of specifications, comprising the entire group of persons that is of interest to the researcher and to whom the research results can be generalized. In this research, the population is composed of a number of engineers (civil, Architecture, survey, mechanical, and electrical) that work for contracting, or consultant firms or they represent the owner in the project. The sectors namely public, private and multi sectors were all considered. The population size is according to the records of the Sudanese Council of Engineers.

3.5 Sample Size

Sampling defines the process of making the selections; sample defines the selected items (Burns & Grove, 1987). Wood and Haber (1997) defined the sampling as the process of selecting representative units of a population for the study in a research investigation. Scientists derive knowledge from samples; many problems in scientific research cannot be solved without employing sampling procedures (Wood & Haber, 1997).

Unfortunately, without a survey of the population, the representativeness of any sample is uncertain, but statistical theory can be used to indicate representativeness (Fellows & Liu, 1997). One of the most frequent questions asked "what size sample I use?" historically, the responses to this question at least 30 subjects. However, in most cases 30 subjects will be inadequate as a sample size (Burns & Grove, 1987).

For some studies, the population may be small enough to warrant the inclusion of all of them in the study. But a study may entail a large population which cannot all be studied. That portion of the population that is studied is called a sample of the population (Nworgu 1991:69).

Sampling is a process in connection with the selection of people who would be asked questions by interview or questionnaire. There are two kinds of sampling, which are probability and non-probability sampling. Probability sampling is a sample that has been selected so that each unit in the population has a known chance of being selected. There are different types of probability sample, which are:

- Simple random sample.
- Systematic sample.
- Stratified random sampling.
- Multi-stage cluster sampling.

Non-probability sampling is a sample selecting using a random selected method. This implies that some units in the population are more likely to be selected than others. The types of non-probability sampling are:

- Convenience sampling.
- Snowball sampling.
- Quota sampling.
- A statistical calculation was used in order to calculate the sample size. The formula below was used to determine the sample size of unlimited population (Creative Research Systems, 2001):

$$SS = \frac{Z^2 * p * (1 - p)}{C^2}$$

Where:

SS = Sample Size.

Z = Z Value (e.g. 1.96 for 95% confidence interval).

P = Percentage picking a choice, expressed as decimal, (0.50 used for sample size needed).

*C = Confidence interval (0.05)***.**

$$SS = \frac{1.96^2 * 0.5 * (1 - 0.5)}{0.05^2} = 384$$

Correction for finite population

$$SS_{New} = \frac{SS}{1 + \frac{SS - 1}{Pop}}$$

Where pop is the population

$$SS_{New} = \frac{384}{1 + \frac{384 - 1}{78}} = 64.97 \cong 65$$

3.6 Sample Method

A sample design has helped the researcher to obtain representative data which are not biased. A sample design is a definite plan for obtaining a sample from a given population. It refers to the technique or the procedure the researcher would adopt in selecting items for the sample (Kothari, 2004). Kombo & Tromp (2006) defined random sampling as the probability whereby people, place or things are randomly selected.

The objective of sampling is to provide a practical means of enabling the data collection and processing components of research to be carried out whilst ensuring that the sample provide a good representation of the population (Fellows & Liu, 1997). The respondents were selected by a systematic random sampling method which represents the characteristics of the population. The respondents were deemed to be an adequate representation of the population as they varied greatly in the characteristics, but they all work exclusively in the field of construction industry in Khartoum state.

3.7 Limitation of The Research

- Due to time limitation, this research is concerned with building projects only and will not take into account that other categories of construction industry like heavy engineering construction (tunnels, bridges, dams, etc.), industrial projects (factories and workshops), and infra-structure projects (sewage and water supply).
- This study is limited to the construction industry practitioners, especially on residential projects in Sudan.

3.8 Case Study and Research Location

Because of the most of local construction companies are located at Khartoum state, and their headquarters work from the capital; engineers in construction firms in Khartoum state were selected as the targeted respondents for investigation, as well as for reasons of practicality and convenience perceived by the researcher.

To determine how RM theories are used in practice, there is one of residential Compound Project was used as a case study. Next, to get an overview of RM practices used by different professionals, one of parties participating in this project was took part in the research. The respondent was a project manager. Questions were formulated in a way to determine how RM is used in practice and how familiar the actors in the project are with this concept.

3.9 Questionnaire Design

A questionnaire is defined as "a means of eliciting the feelings, beliefs, experiences, perceptions, or attitudes of some sample of individuals" (Key 1997). In this study the questionnaire was used as a survey tool which was assumed to be the most appropriate method to achieve the study's objectives, answering the research question, get a background to the respondents those who have no previous idea about risk management in construction projects, test hypotheses, and compiling data perfectly and to collect all the necessary data that can support the discussion, results, and recommendations of the research.

The objectives of the research were explained to the participants that the results of the questionnaire would be used to improve the ability of contractors and clients to identify, analyze and estimate the risk factors impact on the construction phase of building projects. To ensure obtaining complete and meaningful response to the questionnaire an interview could be conducted with some respondent to explain the objective of the study and to get input towards the questionnaire design, especially towards identifying risk types and management actions for controlling these risks. In addition, their analysis is straight forward (Naoum, 1998).

A close-ended questionnaire was used for its advantages as it is easy to ask and quick to answer, they require no writing by either respondents or interviewer. The questionnaire was composed of six sections to accomplish the aim of this research, as follows:

- The general information.
- General concepts of risk management

- Risk factors that have been identified by literature, experts and by the researcher.
- Risk preventive methods which could be used to avoid risk to take place.
- Risk mitigative methods that could be used to mitigate risk impact or likelihood.
- Risk analysis techniques that could be used to analyze and estimate risk factors impact.

The questionnaire was prepared in English language (Appendix 1), but for the interest of the research and to have more accurate results the questionnaire was translated into Arabic (Appendix 2), as most of the target population are not familiar with the English language. The questionnaire draft with 33 risk factors, prepared from literature and distributed into nine groups - to best fit the nature of the industry in Sudan was discussed with the supervisor who requested test validity content by knowledge experts and local construction practitioners in Khartoum.

3.9.1 Construction Risk Allocation

There are different types of risks associated with the construction activities. These are physical, environmental, design, logistics, financial, legal, political, construction and management risks (Perry & Hayes, 1985, cited in Kartam, 2001). Table (3.1) illustrates different types of risk included in the questionnaire. To get input towards the questionnaire design, especially towards identifying risk types, rather than the related literature. Some of the literature's risk types such as floods, earthquakes, wind damages and pollution were not included in this study because of inapplicability.

3.9.2 Significance of risk and measurement scales

The degree of impact for each risk type was included in the questionnaire under the heading "Significance". The questionnaire was designed to examine practitioners' observations and judgments in determining the relative significance of each risk category. Although the degree of impact varies from project to project, the questionnaire is expected to elicit a general assessment of the significance of risk. Each respondent was required to rank each risk on a scale from A to C (1 to 10) by considering its contributions to project delays. Scale A to C is selected to obtain a greater level of flexibility in choosing statistical procedures. Rank A is assigned to a risk would give the lowest contributions to risk consequences while Rank C is allotted to a risk that would cause the highest contribution.

Table 3.1. *Risk variables (factors) included in the questionnaire*

Construction Project Risk	**Physical**	Occurrence of accidents due to poor safety procedures
		Supplies of defective materials
		Varied labor and equipment productivity
	Environmental \ geographical	Natural disasters
		Difficulty to access the site
		Adverse weather conditions
	Design	Defective/ poor design (incorrect)
		Not coordinated design (structural, mechanical, electrical, etc.)
		Inaccurate quantities
		Awarding the design to unqualified designers
	Logistics	Shortage of labor, materials and equipment
		Poor communications between the home and field offices (contractor side)
	Financial	Financial inflation
		Delayed payments on contract
		Financial failure of the contractor
		Exchange rate fluctuation
	Legal	Difficulty to get permits
		Legal disputes during the construction phase among the parties of the contract
		Delayed disputes resolutions
		No specialized arbitrators to help settle fast
	Construction	Gaps between the implementation and the specifications due to misunderstanding of drawings and specifications
		Undocumented change orders
		Lower work quality in presence of time constraints
		Design changes
		Actual quantities differ from the contract quantities
	Political	Working at hot (dangerous) areas (close to Conflict areas)
		New governmental acts or legislations
		Closure and economic blockade
	Management	Ambiguous planning due to project complexity
		Poor resource management
		Changes in management ways
		Information unavailability (include uncertainty)
		Poor communication between involved parties

In order to quantitatively demonstrate the relative significance of risks to a project, a weighting approach is adopted. The principle is that the risk with the highest contribution rank would be assigned the largest weight. The figures in brackets in Table (3.2) are weighted scores for each risk at different contribution rank. Each individual's weighted score is obtained by multiplying the number of respondents with the corresponding weight. The figures in the last column of the table give the total weighted scores for each risk. The rank range of 1 to 3 (A) denotes risks that are not significant, 4 to 7 (B) indicates significant risks and 8 to 10 (C) shows very high significant risks.

Table 3.2 *An example for contribution of risks to a project (risk significance).*

Types of risks	**Contribution rank**										**Total weighted stores**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
	A			**B**				**C**			
Defective materials	4 (4)	2 (4)	2 (6)	1 (4)	4 (20)	8 (48)	5 (35)	3 (24)	0 (0)	4 (40)	**185**
Inaccurate quantities	2 (2)	2 (4)	8 (24)	2 (8)	5 (25)	4 (24)	3 (21)	7 (56)	6 (54)	7 (70)	**288**

3.9.3 Risk Management Actions

Managing risks means minimizing, controlling, and sharing of risks, and not merely passing them off onto another party (Fisk, 1992, cited in Katram, 2001). The methods of managing risks are retention, transfer, mitigation, and prevention of risks or any combination thereof.

There are two kinds of management actions: preventive action and mitigative action. Preventive actions are used to avoid and reduce risks at the early stage of project construction, yet they may lead to submitting and excessive high bid for a project. Where the study is concerned with the construction phase; the survey addressed mitigative actions are remedial steps aimed at minimizing the effects of risks through the construction phase. The survey presents six mitigative actions. These actions were generated based on related research work on construction risk management.

3.9.3.1 Preventive actions

Table (3.3) illustrates the seven preventive methods that proposed to respondents to measure the effectiveness for each. Preventive actions are used to avoid and reduce risks at the early stage of project construction, yet they may lead to submitting an excessive high bid for a project. The relative degree of effectiveness between the methods will be quantitatively demonstrated as shown previously.

Table 3.3 *Relative effectiveness of preventive methods*

Preventive method	Effectiveness of preventive methods						Total weighted score
	Very high	High	Moderate	Low	Very low	In applicable	
	5	**4**	**3**	**2**	**1**	**0**	
Utilize quantitative risk analysis techniques for accurate time estimate	16 (80)	7 (28)	…	…	…	…	…
Depend on subjective judgment to produce a proper program	…	…	…	…	…	…	…
Produce a proper schedule by getting updated project information	…	…	…	…	…	…	…
Plan alternative methods as stand-by	…	…	…	…	…	…	…
Consciously adjust for bias risk premium to time estimation	…	…	…	…	…	…	…
Transfer or share risk to/ with other parties	…	…	…	…	…	…	…
Refer to previous and ongoing similar projects for accurate program	…	…	…	…	…	…	…

3.9.3.2 Mitigative actions

Whilst some project delay risks can be reduced though various preventive actions at early stages, the delay of progress still occurs in many projects during the construction process. A recent industry study has indicated that over 80% of projects exceed their scheduled time even with the employment of software techniques for project development (Katram, 1992). When delay happens, contractors can adopt various mitigative actions to minimize the effects of the delay. Table (3.4) represents the six mitigative methods being proposed to the respondents to measure the effectiveness for each of the methods. The relative degree of effectiveness between the methods will be quantitatively demonstrated as shown previously.

Table 3.4 *Relative effectiveness of mitigative methods*

Remedial method	**Effectiveness of remedial methods**						**Total weighted score**
	Very high	High	Moderate	Low	Very low	In applicable	
	5	**4**	**3**	**2**	**1**	**0**	
Increase manpower and/ or equipment	15 (75)	8 (32)	…	…	…	…	…
Increase the working hours	…	…	…	…	…	…	…
Change the sequence of work by overlapping activities	…	…	…	…	…	…	…
Coordinate closely with subcontractors	…	…	…	…	…	…	…
Close supervision to subordinates for minimizing abortive work	…	…	…	…	…	…	…
Close supervision to subordinates for minimizing abortive work	…	…	…	…	…	…	…

3.9.4 Risk analysis techniques

Table (3.5) below shows the risks analysis techniques. Respondents were asked to determine the relative use of those techniques. Six methods were included to highlight the construction industry practitioners concerns about risk analysis and its approaches.

Table 3.5 *Relative effectiveness of risk analysis techniques*

Risk analysis techniques	**Use of risk analysis techniques**						**Total weighted score**
	Very high	High	Moderate	Low	Very low	In applicable	
	5	**4**	**3**	**2**	**1**	**0**	
Expert systems (including software packages, decision support systems, computer-based analysis techniques such as @Risk	12 (60)	9 (36)	…	…	…	…	…
Probability analysis (analyze historical data)	…	…	…	…	…	…	…
Direct judgment using experience and personal skills	…	…	…	…	…	…	…

Comparing analysis (compare similar projects through similar conditions)	…	…	…	…	…	…	…

3.10 Validity of Research

Validation is concerned with whether the findings are really about they appear to be about (Saunders et al, 2009). According to Adams et al (2007), validation is a process of how conclusions are drawn, assumptions are identified or suggestions are proposed.

Validity refers to the degree to which an instrument measures what it is supposed to be measuring (Pilot and Hungler, 1985). High validity is the absence of systematic errors in the measuring instrument. When an instrument is valid; it truly reflects the concept it is supposed to measure (Wood and Haber, 1998). Validity has a number of different aspects and assessment approaches (Polit and Hangler, 1985). Below, several routes to evaluating an instrument's validity are listed:

- Content validity
- Criterion-related validity
- Construct validity

Questionnaire was reviewed to identify whether the questions agreed with the scope of the items and the extent to which these items reflect the concept of the research problem. And to identify that the instrument used is valid statistically and that the questionnaire was designed well enough to provide relations and tests between variables. The revision confirmed that the questionnaire was valid and suitable enough to measure the concept of interest.

3.11 Reliability of Research

Reliability of an instrument is the degree of consistency with which it measures the attribute it is supposed to be measuring (Polit & Hunger, 1985). The less variation an instrument produces in repeated measurements of an attribute, the higher its reliability. Reliability can be equated with the stability, consistency, or dependability of a measuring tool. For the most purposes reliability coefficients above 0.7 are considered satisfactory.

3.12 Data collection

In order to collect appropriate data for the study, different sources have been used. For the theoretical background, a literature study was conducted, using both scientific articles written by professionals in the field as well as books and reports in the area of project and risk management. For the practical application, designed questionnaire was designed and revised, and then was distributed to the respondents, 65 of the questionnaires returned out of 78 and 2 questionnaires has been excluded because they were not fully answered. The total number of the questionnaires to be analyzed was 63 questionnaires which represents 81% of the total population size.

3.13 Data Analysis

Analysis is an interactive process by which answers to be examined to see whether these results support the hypothesis underlying each question (Backstorm and Cesar, 1981 cited in Hallaq, 2003). Quantitative statistical analysis for questionnaire was done by using Statistical Package for Social Sciences SPSS (Statistical Package for the Social Sciences) version 20 with assistance of a qualified statistician. The analysis of data is done to rank the severity of causes of contractor's failure in Khartoum. Ranking was followed by comparison of mean values within groups and for the overall sub-factors.

The opinion of respondents regarding the severity of each cause was checked by analysis of variance (ANOVA).

The following statistical analysis steps were done:

- Coding and defining each variable.
- Summarizing the data on recording scheme.
- Entering data to a work sheet.
- Cleaning data.
- Mean and rank of each cause.
- Comparing of mean values for each main group and overall sub-factors.
- ANOVA test was done to test the difference of answers of contractors regarding to variables.

Chapter Four

DATA ANALYSIS, RESULTS AND DISCUSSION

Data analysis, Results and Discussion

4.1 Preamble

This study is to examine how were the parties involved in any construction project deal with the concept of risk during the construction phase and to determine the risk factors in construction industry, allocation of these factors, methods used to deal with risks and the techniques adopted in analyzing these risks. After distribution and collection processes the returned questionnaires and the valid ones were 60 questionnaires out of 65 which represented 92.3% 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 Data analysis

Before analyzing the questionnaires which were received to be analyzed, a Cronbach Alpha test was carried out in order to ascertain the reliability of the questionnaire's questions. Cronbach Alpha test is a test of reliability that measures the internal consistency of the questions using the Likert scale (Mohamed 2015). From this test there is an internal consistency because the Cronbach Alpha coefficient of questions is 0.785. Therefore, we concluded that our test and questions were reliable.

The data was analyzed using descriptive statistics and inferential statistics. The descriptive statistical analysis carried out includes frequency distribution and measures of central tendency like mean and standard deviation while the inferential statistics include Analysis of Variance (ANOVA) and regression analysis.

4.1.1 General Information

Table 4.1 Respondent's education level

	Frequency	Percent %
Diploma	6	10
Bachelor	39	65
Master	13	21.7
Doctorate	2	3.3
Total	60	100

The above table 4.1 and the following figure 4.1 present the education level of the respondents that were divided into four levels (Diploma, Bachelor's degree, Master's degree, Doctorate's degree). The respondents' level of education as follow: Diploma 6 (10%), Bachelor's degree 39 (65%), Master's degree 13 (21.7%), and Doctorate's degree 2 (3.3%).

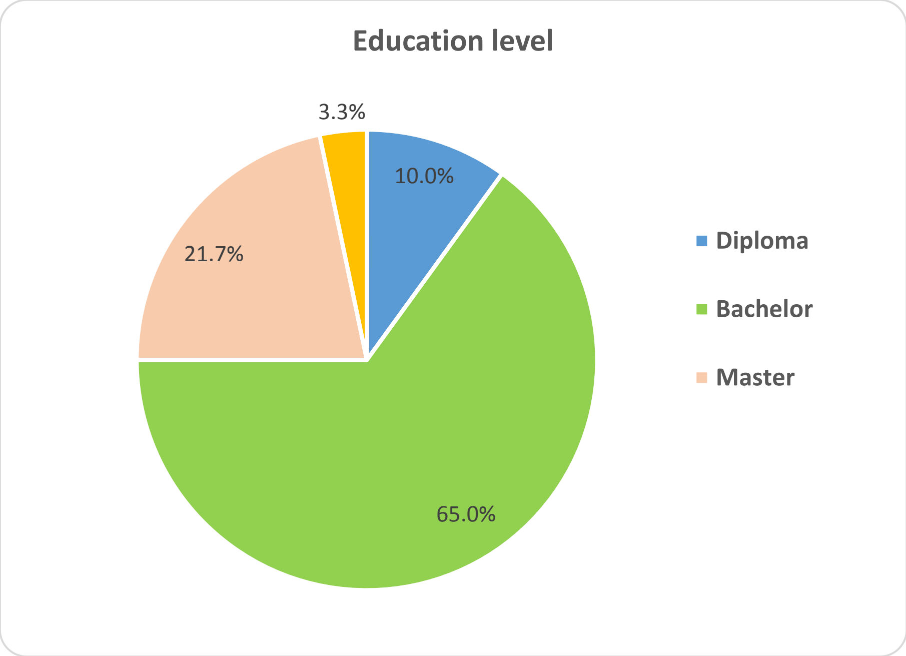

Figure 4.1 Respondent’s education level

Table 4.2 Respondent’s specialties

	Frequency	Percent %
Civil Engineer	44	73.3
Architect	12	20
Other	4	6.7
Total	60	100

The above able 4.2 and following figure 4.2 shows that out of the 60 questionnaires returned, 44 (73.3%) of the respondents were Civil Engineers, 12 (20.0%) were Architects, and 4 (6.7%) were other specialties.

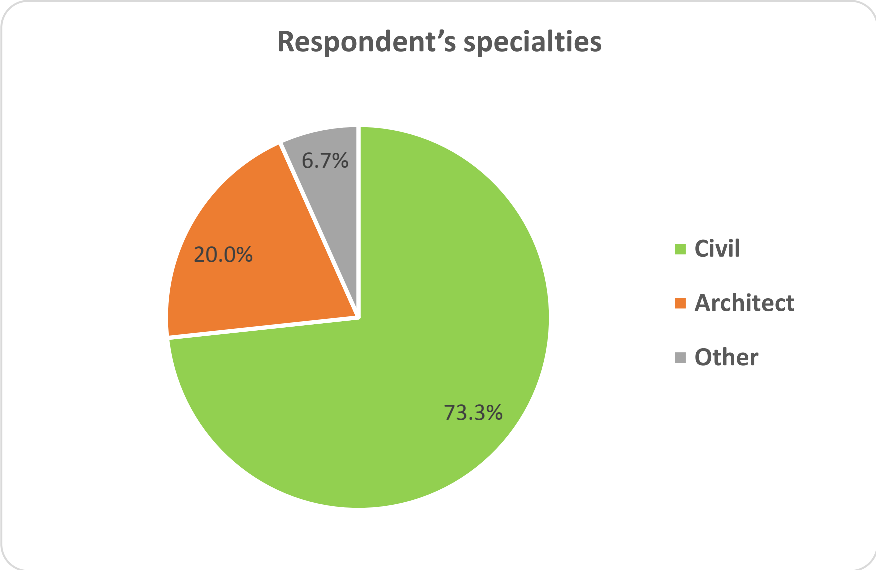

Figure 4.2 Respondent's specialties

Table 4.3 Respondent's gender

	Frequency	Percent %
Male	48	80
Female	12	20
Total	60	100

The above table 4.3 and the following figure 4.3 shows that out of the 60 questionnaires returned, 48 (80%) of the respondents were males, 12 (20%) were females.

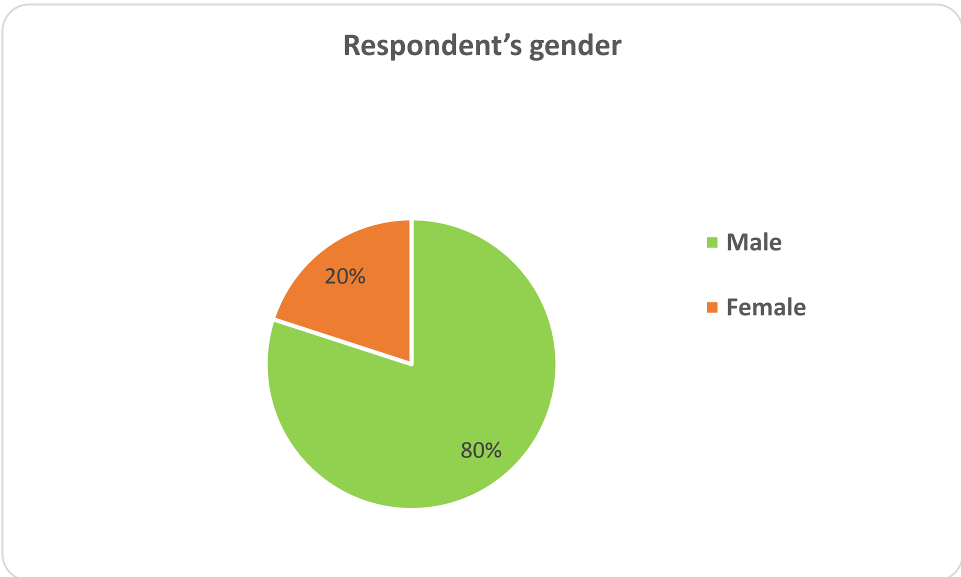

Figure 4.3 Respondent's gender

Table 4.4 Respondent's position

	Frequency	Percent %
Director	5	8.3
Deputy Director	3	5
Project Manager	11	18.3
Site/ Office Engineer	41	68.3
Total	60	100

The above table 4.4 and the following figure 4.4 present the position of the firm in the project, the results were as follow: 5 (8.3%) were directors, 3 (5%) were deputy directors, 11 (18.3%) work as project managers and 41 (68.3%) were site/ office engineers.

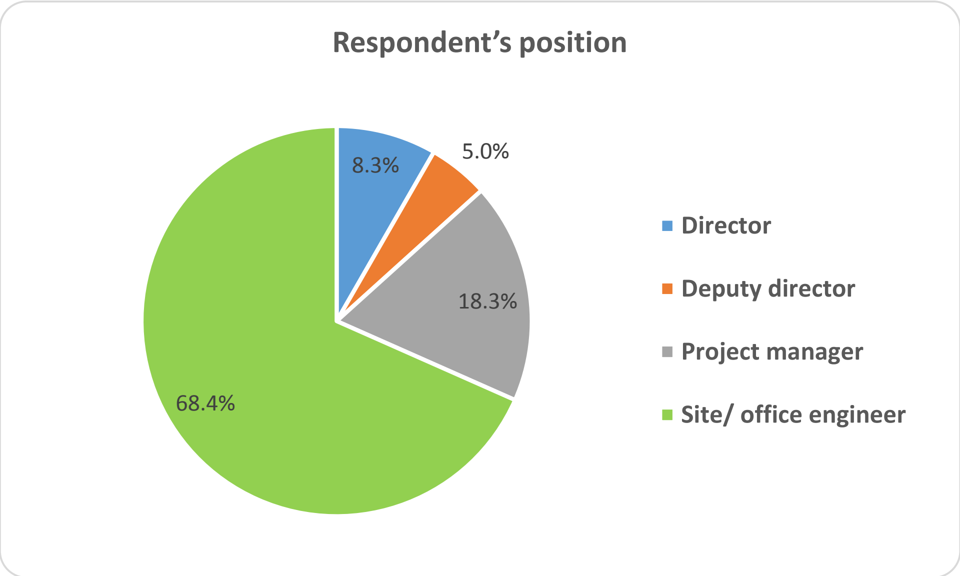

Figure 4.4 Respondent's position

Table 4.5 Sectors where respondent work for

	Frequency	Percent %
Public	34	56.7
Private	19	31.7
Other	7	11.7
Total	60	100

The above table 4.5 and the following figure 4.5 present the sectors that the respondents work for, the results were as follow: 34 (56.7%) of the respondents work for public sector, 19 (31.7%) of the respondents work for private sector, and 7 (11.7%) of the respondents work for other sector.

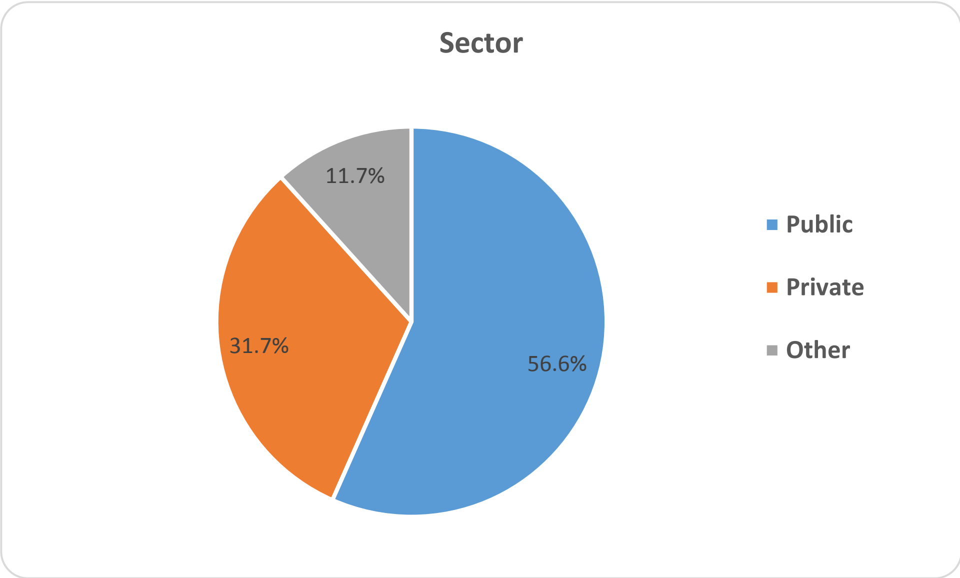

Figure 4.5 Sectors where respondent work for

Table 4.6 Respondent's years of experience

	Frequency	Percent %
0 – 5 years	26	43.3
5 – 10 years	13	21.7
10 – 15 years	6	10
More than 15 years	15	25
Total	60	100

The above table 4.6 and the following figure 4.6 present the years of experience of the respondents that were divided into four levels (0-5years, 5-10years, 10-15years, and more than 15years). The respondents' experiences were as follow: 26 (43.3%) have experience from zero to five years, 13 (21.7%) have 5 - 10 years of experience, 6 (10%) have 10 - 15 years of experience, and 15 (25%) have more than 15 years of experience in the field of construction projects.

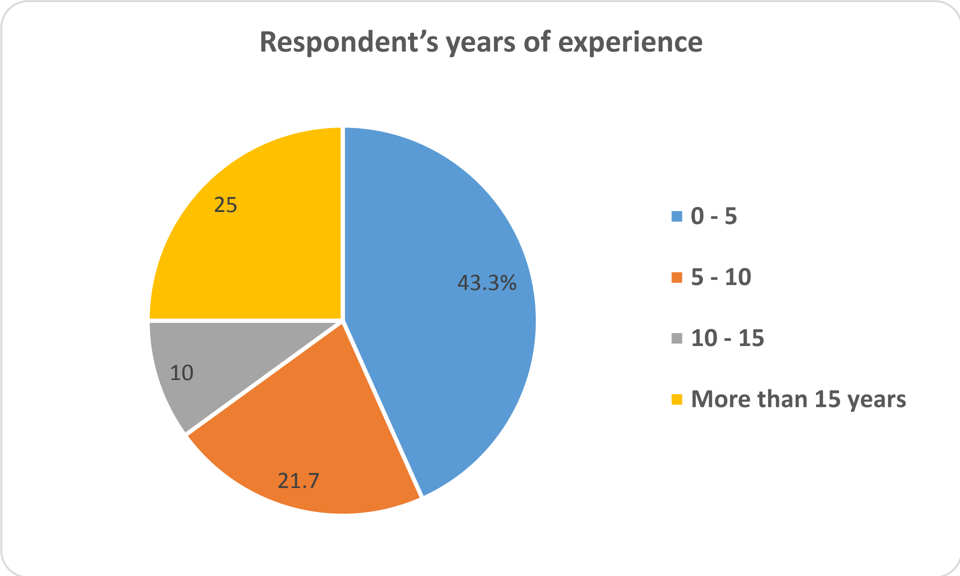

Figure 4.6 Respondent's years of experience

Table 4.7 Respondent's work in other countries except Sudan

	Frequency	Percent %
Yes	15	25
No	45	75
Total	60	100

The above table 4.7 and the following figure 4.7 present whether the respondents work in other countries except Sudan or not, the results were as follow: 15 (25%) of the respondents work in other country, 45 (75%) of the respondents didn't work in other country out of Sudan.

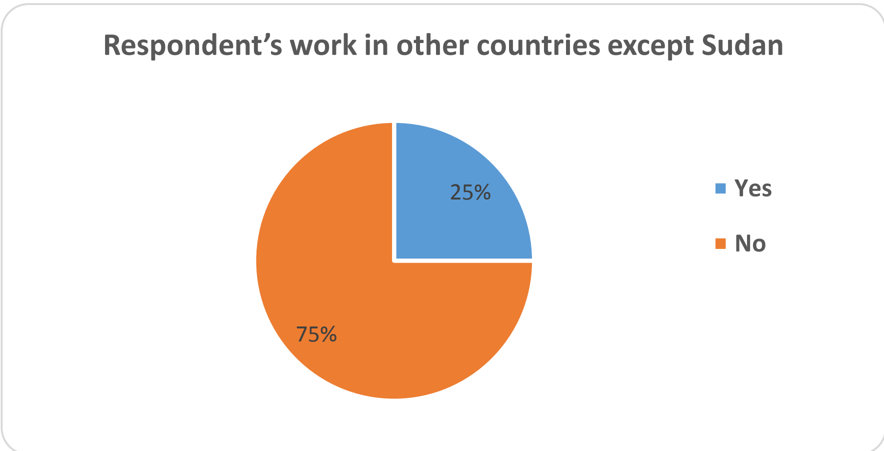

Figure 4.7 Respondent's work in other countries except Sudan

4.2.1 General concepts on risk management in construction projects

Table 4.8 Respondents applied risk management techniques during their work in construction projects.

	Frequency	Percent %
Yes	26	43.3
No	34	56.7
Total	60	100

The above table 4.8 and the following figure 4.8 present whether the respondents ever applied risk management techniques during their work in construction projects or not, the results were as follow: 26 (43.3%) of the respondents were applied risk management techniques during their work in construction projects, 34 (56.7%) of the respondents didn't applied risk management techniques during their work in construction projects.

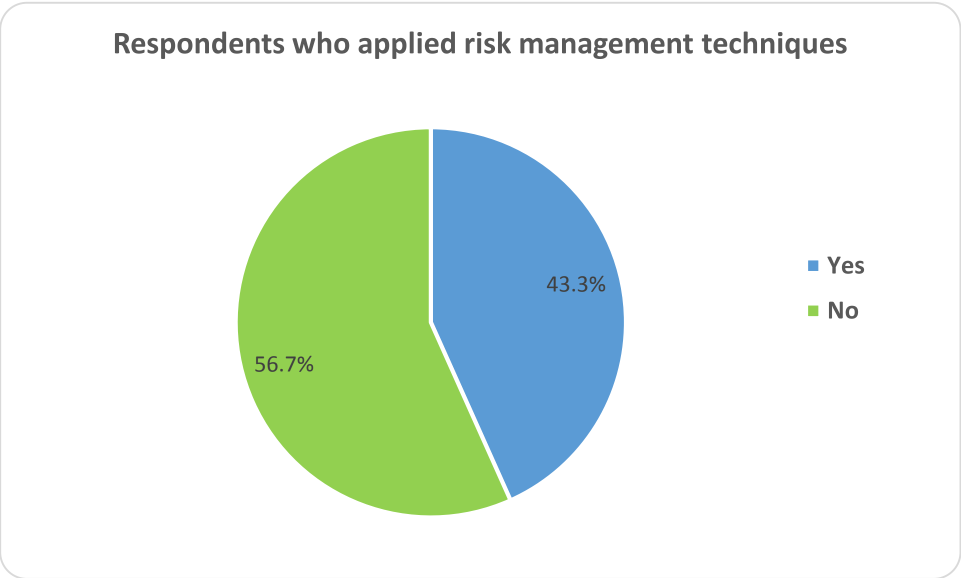

Figure 4.8 Respondents who applied risk management techniques during their work in construction projects.

Table 4.9 To the respondents who applied risk management techniques, their risk management experience in construction projects in Sudan.

	Frequency	Percent %
Week	4	15.4
Good	15	57.7
Very Good	7	26.9
Excellent	0	0
Total	26	100

The above Table 4.9 and the following Figure 4.9 present risk management experience in construction projects in Sudan of the respondents who applied risk management techniques during their work in construction projects, the results were as follow: 4 (15.4%) of the respondents have week risk management experience in construction projects in Sudan, 15 (57.7%) of the respondents have good risk management experience in construction projects in Sudan, 7 (26.9%) of the respondents have very good risk management experience in construction projects in Sudan and 0 (0%) of the respondents have excellent risk management experience in construction projects in Sudan.

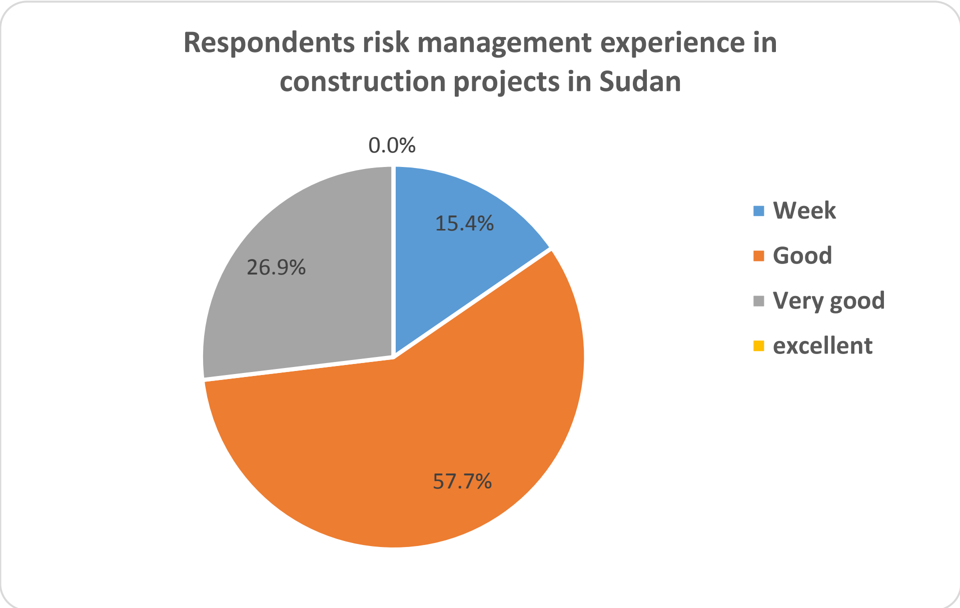

Figure 4.9 To the respondents who applied risk management techniques, their risk management experience in construction projects in Sudan.

Table 4.10 To the respondents who didn't applied risk management techniques, to what extent do they want to know the concepts of risk management in construction projects.

	Frequency	Percent %
Week	3	8.8
Good	9	26.5
Very Good	12	35.3
Excellent	10	29.4
Total	34	100

The above Table 4.10 and the following Figure 4.10 present to what extent do the respondents who didn't applied risk management techniques want to know the concepts of risk management in construction projects, the results were as follow: 3 (8.8%) of the respondents have week ability to know the concepts of risk management in construction projects, 9 (26.5%) of the respondents have good ability to know the concepts of risk management in construction projects, 12 (35.3%) of the respondents have very good ability to know the concepts of risk management in construction projects and 10 (29.4%) of the respondents have excellent ability to know the concepts of risk management in construction projects.

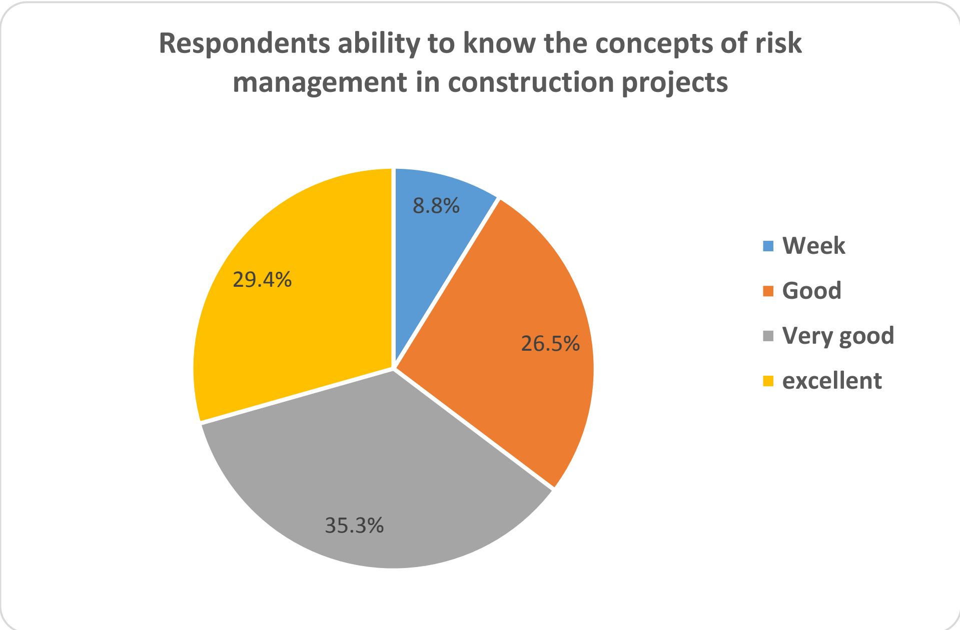

Figure 4.10 To the respondents who didn't applied risk management techniques, to what extent do they want to know the concepts of risk management in construction projects.

Table 4.11 It is important to use software to manage risks in construction projects in Sudan

	Frequency	Percent %
Strongly Agree	26	43.3
Agree	24	40
Somewhat	9	15
Disagree	1	1.7
Total	60	100

The above Table 4.11 and the following Figure 4.11 present the importance to use software to manage risks in construction projects in Sudan, the results were as follow: 26 (43.3%) of the respondents were strongly agree that it's importance to use software to manage risks in construction projects in Sudan, 24 (40%) of the respondents were agree that it's importance to use software to manage risks in construction projects in Sudan, 9 (15%) of the respondents were to somewhat agree that it's importance to use software to manage risks in construction projects in Sudan and 1 (1.7%) of the respondents were disagree that it's importance to use software to manage risks in construction projects in Sudan.

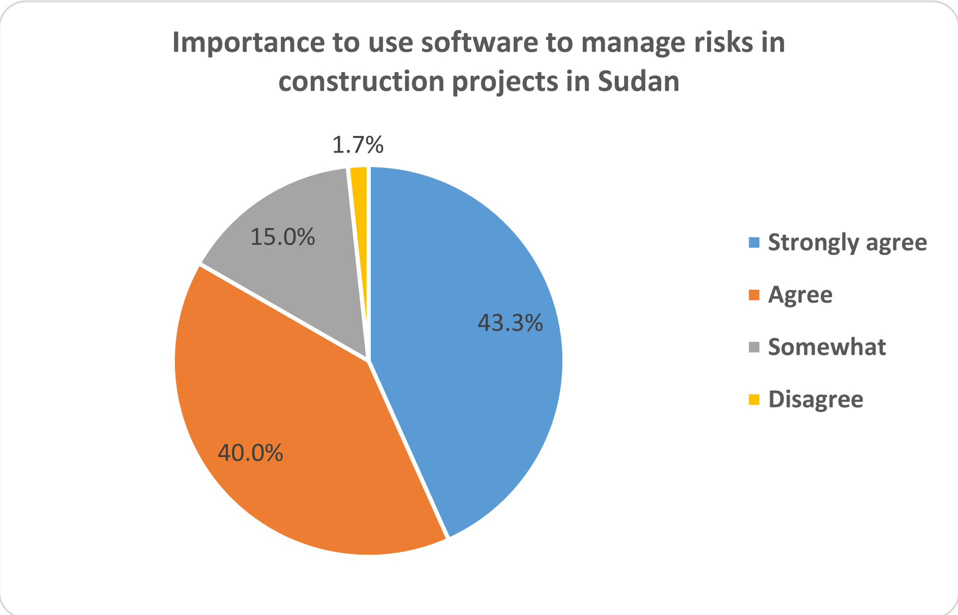

Figure 4.11 It is important to use software to manage risks in construction projects in Sudan.

Table 4.12 Risk is believed to dominate the contract structure, procurement strategy, and contract form

	Frequency	Percent %
Strongly Agree	10	16.7
Agree	38	63.3
Somewhat	10	16.7
Disagree	2	3.3
Total	60	100

The above Table 4.12 and the following Figure 4.12 present the risk is believed to dominate the contract structure, procurement strategy, and contract form, the results were as follow: 10 (16.7%) of the respondents were strongly agree that the risk is believed to dominate the contract structure, procurement strategy, and contract form, 38 (63.3%) of the respondents were agree that the risk is believed to dominate the contract structure, procurement strategy, and contract form, 10 (16.7%) of the respondents were to somewhat agree that the risk is believed to dominate the contract structure, procurement strategy, and contract form and 2 (3.3%) of the respondents were disagree that the risk is believed to dominate the contract structure, procurement strategy, and contract form.

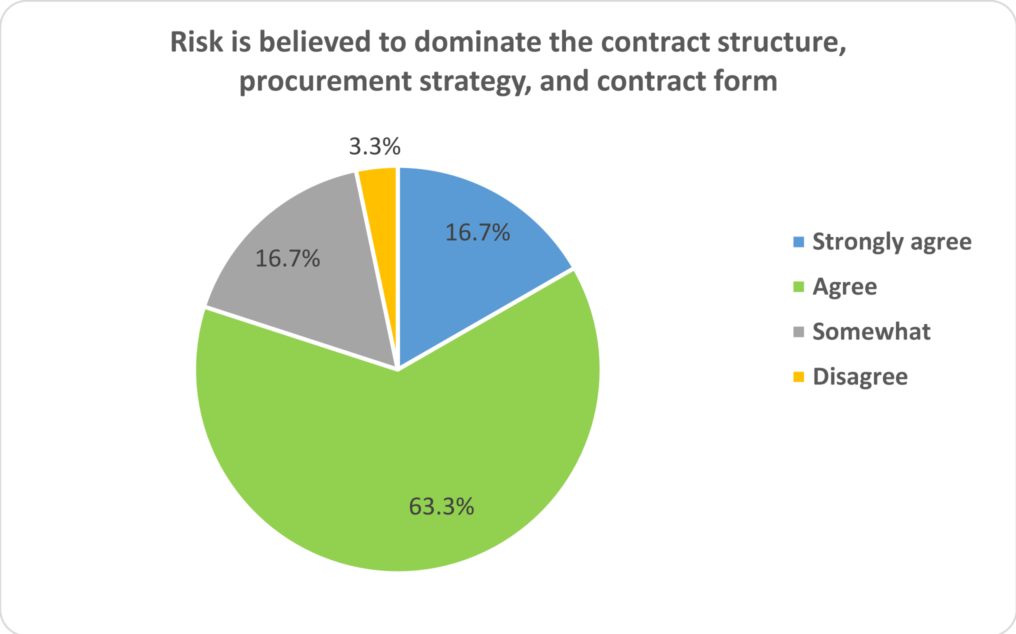

Figure 4.12 Risk is believed to dominate the contract structure, procurement strategy, and contract form.

Table 4.13 What kind of risks normally occur in your projects?

	Frequency	Percent %
Government regulations	31	51.7
Natural hazards	21	35
Material availability and delays in delivery	27	45
Labor stoppages	47	78.3
Cash flow problems	38	63.3
Changes in technology	22	36.7
Design issues	8	13.3
Subcontractor performance	32	53.3
Total	226	100

The above Table 4.13 and the following Figure 4.13 present the kind of risks normally occur in your projects, the results were as follow: 31 (51.7%) of the respondents were noticed that the government regulations risk is normally occur in their projects, 21 (35%) of the respondents were noticed that the natural hazards is normally occur in their projects, 27 (45%) of the respondents were noticed that the material availability and delays in delivery risk is normally occur in their projects, 47 (78.3%) of the respondents were noticed that the labor stoppages risk is normally occur in their projects, 38 (63.3%) of the respondents were noticed that the cash flow risk is normally occur in their projects, 22 (36.7%) of the respondents were noticed that the changes in technology risk is normally occur in their projects, 8 (13.3%) of the respondents were noticed that the design issues are normally occur in their projects and 32 (53.3%) of the respondents were noticed that the subcontractor performance *is* normally occur in their projects.

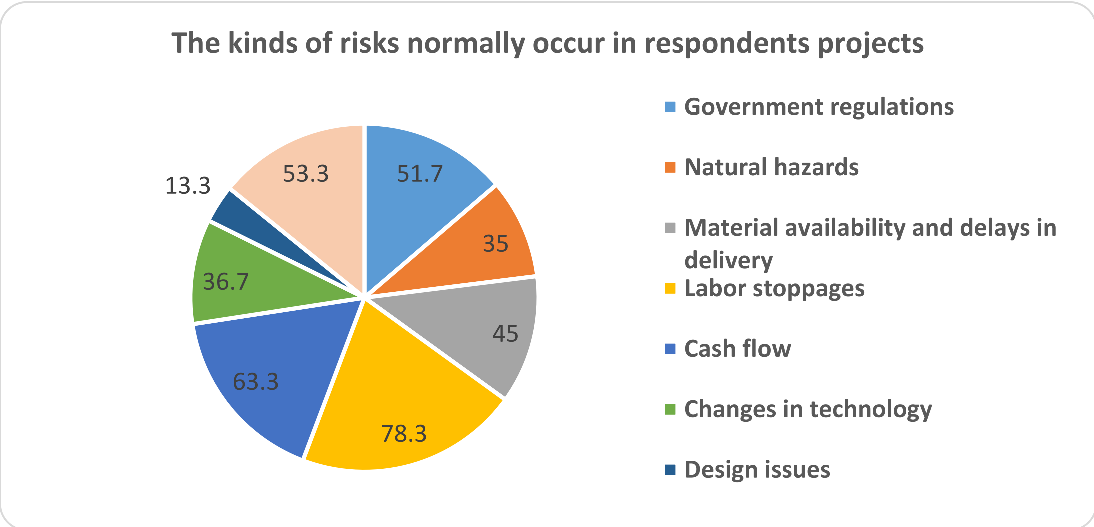

Figure 4.13 What kind of risks normally occur in your projects

4.3 Risk factors

As mentioned in chapter 3, the questionnaire included 33 risk factors, which have been categorized in nine main groups, these groups were: physical group, environmental\ geographical group, design group, logistics group, financial group, legal group, construction group, political group and management group. The factors of each group will be demonstrated in the terms of severity and allocation according to the participant's answers.

4.3.1 Physical risks group

4.3.1.1 Risk severity

Results showed that the defective supply materials are the most important risk in the physical factors (72.9%), these results indicate the concerns about absence of a standardized description method for building materials in Sudan. Occurrence of accidents was the second from importance (68.3%), and the third was decline in the productive capacity of workers and machinery breakdowns (30.0%) this result is supported by results of other researchers, (Ahmed, et al. (1999) and the findings of National Audit Office (2001) which considered the risks of defect materials and safety measures as very important risks).

Table 4.14 Physical risks ranking and impact

No	*Physical group risks ranking*	*Weight*	*Severity (A – C)*
1	Occurrence of accidents due to poor safety procedures	152	C
2	Supplies of defective materials	154	C
3	Varied labor and equipment productivity	123	B

Physical risk factor	*Low impact risks %*	*Medium impact risks %*	*High impact risks %*
Occurrence of accidents due to poor safety procedures	8.3	23.3	68.3
Supplies of defective materials	6.8	20.3	72.9
Varied labor and equipment productivity	11.7	58.3	30

4.3.1.2 Risk responsibility (allocation)

As indicated that the contractor is responsible for all the physical risk factors, being the highest risk factor is the varied labor and equipment productivity (83%), and this finding is supported by the Sudanese terms & conditions for construction and Fidic Conditions.

Figure (4.14) present that (25%) of respondents share the consequences of accidents, (62%) of respondents tried to shift the consequences of accidents to the contractors, (7%) of them seemed to ignore these consequences, (3%) of respondents allocate the consequences to the owners and (3%) of them tried to shift the consequences of accidents to other parties such as insurance. That means that contractors are undecided about the allocation of safety risks as well as Hong Kong contractors (Ahmed et al, 1999) and unlike Kuwait contractor who accepted to bear the safety risks (Kartam, 2001). In fact, contractors are better able to control such risks by supervising the application of safety precautions inside the construction sites. Contractors should consciously pay more effort to mitigate the accidents costs and other consequences by applying effective training and increasing awareness of safety precautions. The majority of respondents (58%) accepted the risks of supplying defect materials and variation in labor and equipment productivity (83%). In fact, not only did contractors designate them as their responsibilities, but most researchers also support this position (Oglesby cited in Kartam, 2001).

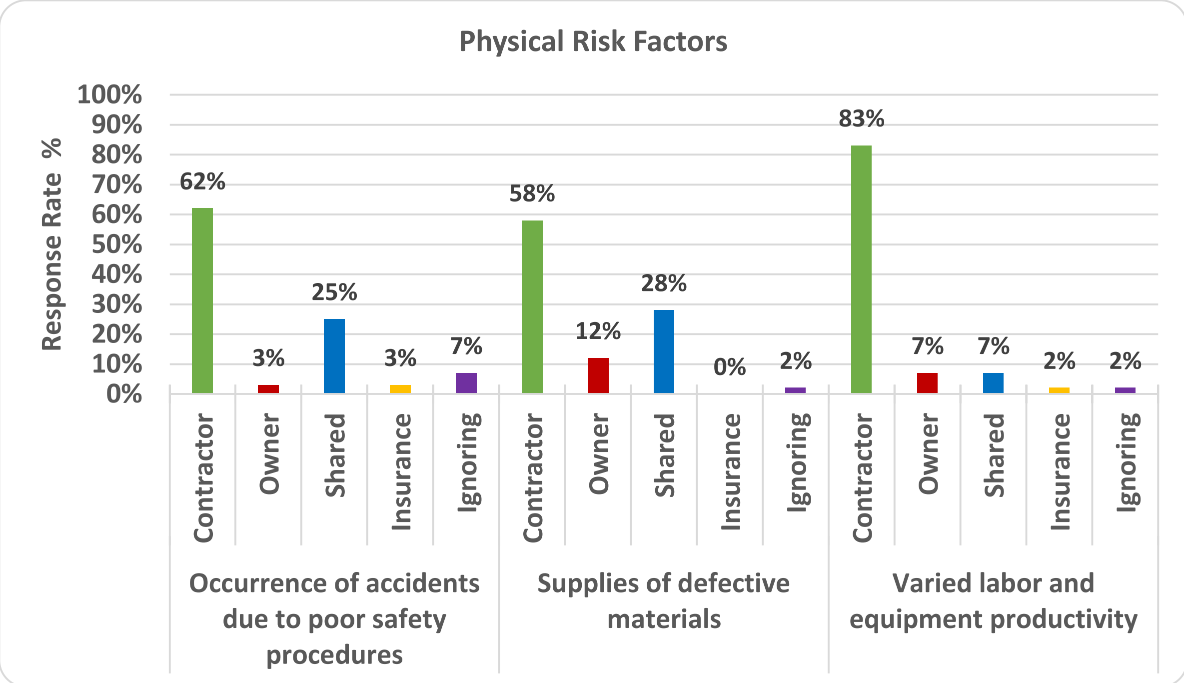

Figure 4.14 Physical risks allocation

4.3.2 Environmental\ geographical risks group

4.3.2.1 Risk severity

As appear in Table (4.15), respondents considered that the difficulty to access the site as a main cause of delay 111 (48.3%); that due to this risk category increase the probability of uncertain, unpredictable and even undesirable factors in the construction site. However, the risks of adverse weather conditions and natural disasters did not appear with high significant risks among the surveyed risks. Environmental factors occurred hardly ever, that is why the impact (weight) of the risk of environmental factors was relatively low.

Table 4.15 Environmental risks ranking and impact

No	Environmental risks ranking	Weight	Severity (A – C)
1	Natural disasters	106	B
2	Difficulty to access the site	111	B
3	Adverse weather conditions	99	B

Environmental/ geographical risk factor	Low impact risks %	Medium impact risks %	High impact risks %
Natural disasters	28.8	45.8	25.4
Difficulty to access the site	22.4	48.3	29.3
Adverse weather conditions	32.8	44.8	22.4

4.3.2.2 Risk responsibility (allocation)

Figure (4.15) demonstrates that (33%) of respondents chose that the responsible of natural disaster is to the insurance, risk of site access was considered as a high allocation to contractors by the majority of respondents (39%), as a matter of fact, site access risk need to be borne by the owner who should evaluate the needs during the planning phase (Smith & Gavin, cited in Ahmed el al, 1999), but due to the on-going tense situation, contractors and owners have to coordinate their efforts to get a best handling of such risks. (40%) of respondents supposed to ignore the risks of adverse weather conditions, but it is known that weather conditions are out of control and such risk should be shared to get better handling and to reduce conflicts probabilities.

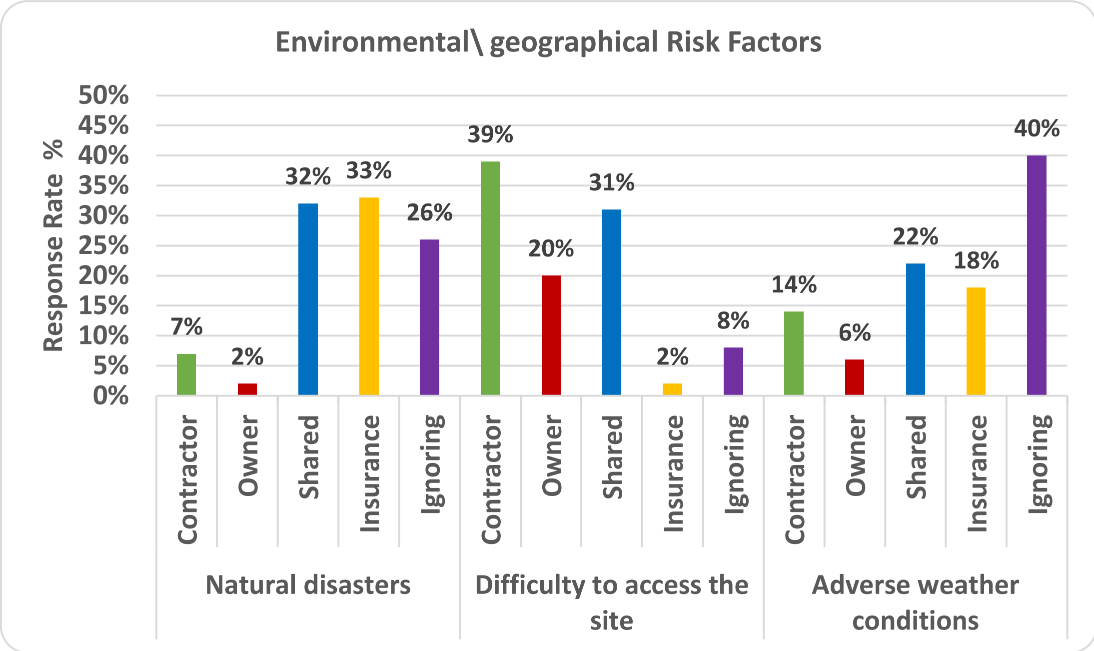

Figure 4.15 Environmental risks allocation

4.3.3 Design risks group

4.3.3.1 Risk severity:

Regarding the design group factors included one of the most important surveyed risks. As illustrated in Table (4.16), defective design with (C) severity and lack of awarding the design to unqualified designer with (C) severity are the most important factors. These results show that respondents suffer from insufficient or incorrect design information. These results complied with the results of Kartam (2001), (Lemos et al, 2004) and (Shen, 1997). It has to be noted that contractors concerned about defective design issues because they could be responsible about any critical issues could happen due to incorrect design. Respondents assigned the risks of un-coordinated design and lack of coordination in design as high significance risks, on the other hand these risks can be overcome by paying true attention and coordinate correctly between design disciplines. Other design risk factors considered medium risks by respondents.

Table 4.16 Design risks ranking and impact

No	Design risks ranking	Weight	Severity (A – C)
1	Defective/ poor design (incorrect)	158	C
2	Awarding the design to unqualified designers	151	C
3	Not coordinated design (structural, mechanical, electrical, etc.)	139	C
4	Inaccurate quantities	122	B

Design risk factors	Low impact risks %	Medium impact risks %	High impact risks %
Defective/ poor design (incorrect)	6.7	18.3	75
Not coordinated design (structural, mechanical, electrical, etc.)	6.7	45	48.3
Inaccurate quantities	16.9	45.8	37.3
Awarding the design to unqualified designers	6.7	28.3	65

4.3.3.2 Risk responsibility (allocation)

Figure (4.16) illustrates that (71%) of respondents indicated that the owner is responsible for the awarding the design to unqualified designers, although the greater part of respondents allocates design risks onto shared as shown below:

- Defective design (46%)
- Not coordinated design (53%)
- Inaccurate quantities (57%)

Major allocation percent were heading towards owners who are in a better position to supply sufficient and accurate drawings on the design and services.

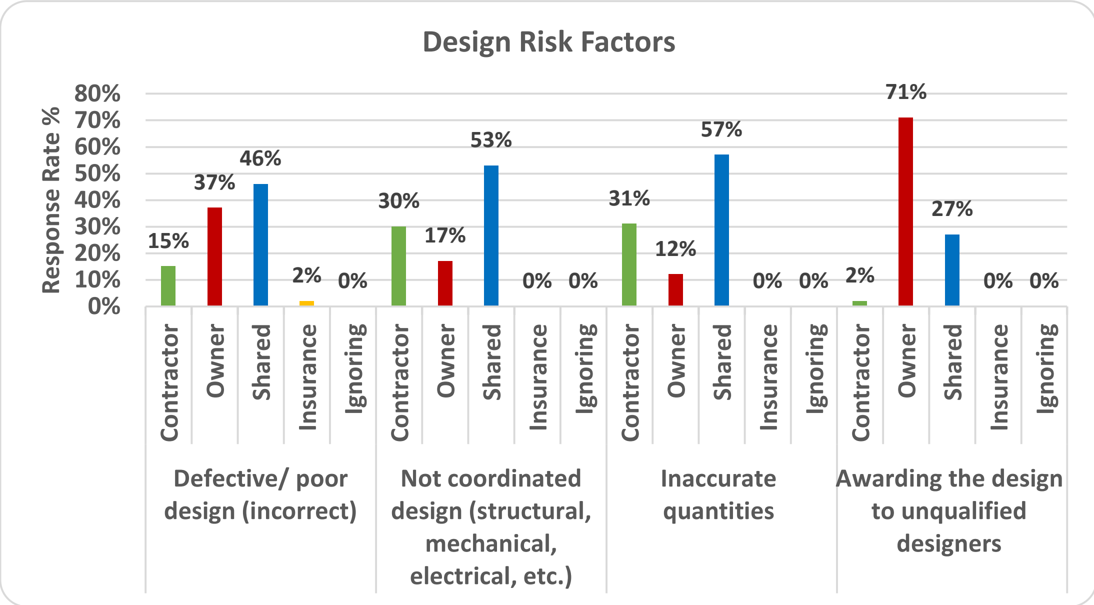

Figure 4.16 Design risks allocation

4.3.4 Logistics risks group

4.3.4.1 Risk severity

Table (4.17) presents the weights (impact%) of logistic group factors. Respondents believed that the risks of unavailability of labor and materials 126 (56.7%) and poor communication among contractor's teams 123 (51.7%) are relatively medium significant risks. It is obvious that the mentioned issues are serious risks that could be faced. The unavailability of labor and materials is somehow connected to the managing of the project and political situations; if closure takes place, materials will be subject to increase in prices, reinforcement steel is a good example. Respondents worried about poor communications in the contractor's side; this reflects its occurrence, contractors should take care of this problem by working out and applying management standards to control such problems.

Table 4.17 Logistic risks ranking and impact

No	*Logistic risks ranking*	*Weight*	*Severity (A – C)*
1	Shortage of labor, materials and equipment	126	B
2	Poor communications between the home and field offices (contractor side)	123	B

Design risk factors	*Low impact risks %*	*Medium impact risks %*	*High impact risks %*
Shortage of labor, materials and equipment	10	56.7	33.3
Poor communications between the home and field offices (contractor side)	15	51.7	33.3

4.3.4.2 Risk responsibility (allocation)

Figure (4.17) indicates that contractors should give attention of unavailability of labor, materials and equipment & poor communication among contractor's teams risks by working out and applying management standards to control such problems. It should be the contractor's responsibility to make sure that labor and materials are available to execute the works, in the same time, contracting firms should teach its teams how to communicate and exchange information

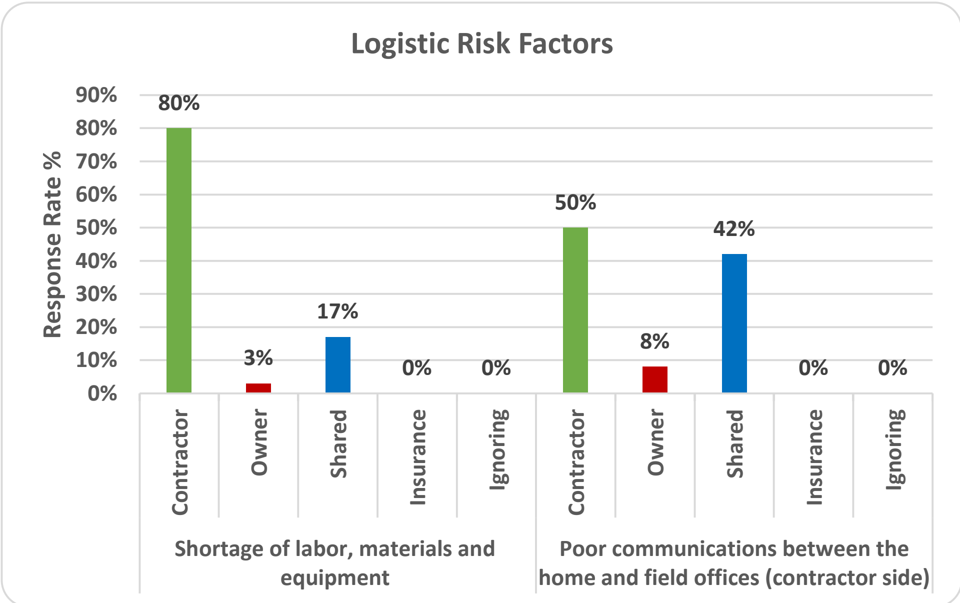

Figure 4.17 Logistic risks allocation

4.3.5 Financial risks group

4.3.5.1 Risk severity

As seen in table (4.18), respondents considered the financial failure of contractor is the most sever (impact) risk (70%) in the financial factors group that's due to the situations of the Sudan. Exchange rate fluctuation was the second from importance (55.4%) that's could be because of lack of exports to bring in hard currency that lead to the general economic stability of the country.

According to Argenti (cited in Hallaq, 2003), small firms don't pay as much attention to financial ratios as do larger firms. Small firms have not an accounting department that publishes reports on a regular basis and therefore, financial ratios are difficult to monitor since they hire private accountants.

Table 4.18 Financial risks ranking and impact

No	*Financial risks ranking*	*Mean weight*	*Severity (A – C)*
1	Financial failure of the contractor	157	C
2	Delayed payments on contract	143	C
3	Exchange rate fluctuation	133	C
4	Financial inflation	132	B

Design risk factors	*Low impact risks %*	*Medium impact risks %*	*High impact risks %*
Financial inflation	10	48.3	41.7
Delayed payments on contract	6.7	40	53.3
Financial failure of the contractor	3.3	26.7	70
Exchange rate fluctuation	8.9	35.7	55.4

4.3.5.2 Risk responsibility (allocation)

In figure (4.18), respondents indicated that the owners and contractors are responsible and appear be ready to bear the risks of all the financial factors separately or by sharing, this finding explains the role of the them in financing the project.

Majority of respondents (70%) allocated the delayed payments risk to the owners. This risk category is one of the most debated ones. These results are supported by (Kartam, 2001). Respondents were undecided on who should take inflation risk, but (42%) of them considered it as an owner's. Respondents are considering this risk category as an oscillating risk category, where its threat increases when inflation increases, and vice versa. Respondents were undecided about exchange rate fluctuation. Inflation and exchange rate fluctuation risks should be best shared between the owner and the contractor by including contract clauses that define the required parameters and conditions for sharing. These are risks where each party may be able to manage better under different conditions and could be specified in contracts as suggested above.

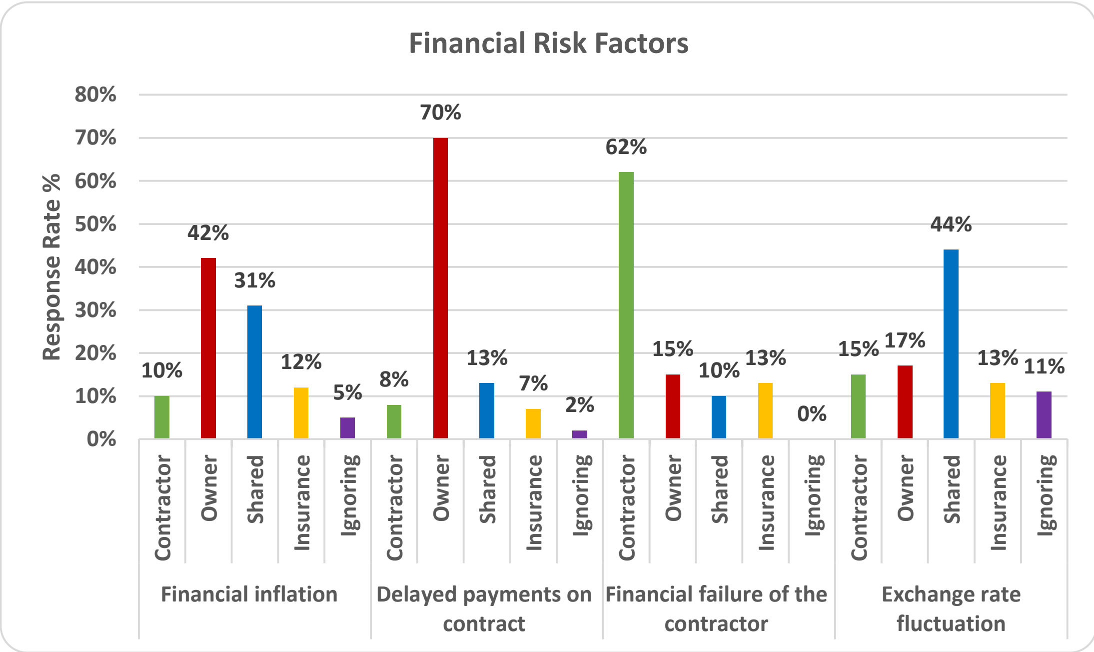

Figure 4.18 Financial risks allocation

4.3.6 Legal risks group

4.3.6.1 Risk severity

Table (4.19) presents that disputes are normal in their occurrences; it is very important to resolve any rising dispute before the increase of their impact. 63.3 % of the respondents believe that the legal disputes during the construction phase among the parties of the contract represent a high score in impact causing by risk factors. Lack of specialized arbitrators and difficulty to get permits came in the tail. However, the low weight indicates that respondents are not suffering of these risks.

Table 4.19 Legal risks ranking and impact

No	*Legal risks ranking*	*Weight*	*Severity (A – C)*
1	Delayed disputes resolutions	128	B
2	Legal disputes during the construction phase among the parties of the contract	126	B
3	Difficulty to get permits	121	B
4	No specialized arbitrators to help settle fast	121	B

Legal risk factors	*Low impact risks %*	*Medium impact risks %*	*High impact risks %*
Difficulty to get permits	10.2	61	28.8
Legal disputes during the construction phase among the parties of the contract	6.7	63.3	30.0
Delayed disputes resolutions	13.6	44.0	42.4
No specialized arbitrators to help settle fast	16.8	47.6	35.6

4.3.6.2 Risk responsibility (allocation)

The respondents indicated that the owner is responsible for difficulty to get permits (58%) in the legal risk factors and that is a fact, this finding explains the role of the owner figure (4.19) illustrates the allocation of legal risk factors according to respondents. It is obvious that the greatest part of respondents deals with legal risks as shared risks. The greatest part of respondents (81%) preferred to share lack of specialized arbitrators and difficulty to get permits, (78%) of respondents allocate the legal disputes as shared and (76%) prepared to share the delayed resolution with. Disputes could originate due to mistake or misunderstanding by either party.

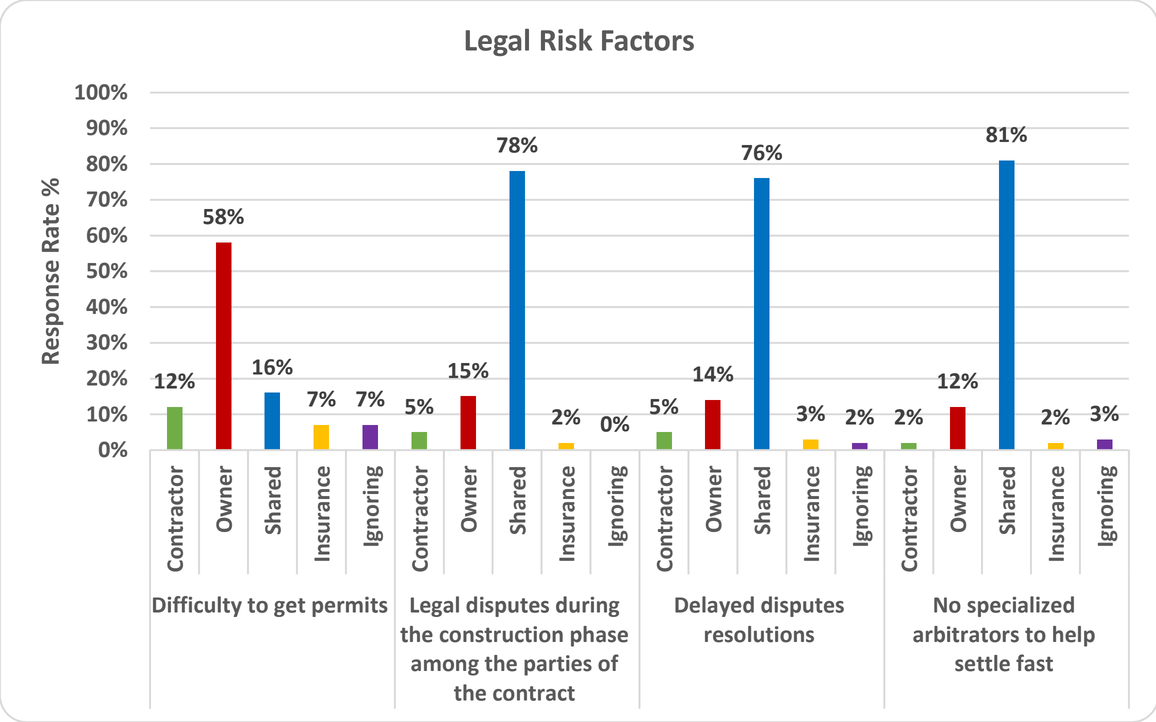

Figure 4.19 Legal risks allocation

4.3.7 Construction risks group

4.3.7.1 Risk severity

As illustrated in table (4.20) risks associated with construction, the highest risk impact (63.8%) was gaps between the implementation and the specifications due to misunderstanding of drawings and specifications this risk can cause significant work delays, that is why contractors exhibit an awareness towards this risk, it's a fact in Sudan that's some delays happened due to misunderstanding drawing because of unqualified site engineers, the second factor from severity is undocumented change orders (52.5%), lower work quality in presence of time constraints (43.3%) due that contractors avoid any penalties written in the contract because of the delay of submitting the work in the planned time. Design changes (55%), difference between actual and contract quantities (45.8%).

Table 4.20 Construction risks ranking and impac

No	Construction risks ranking	Weight	Severity (A – C)
1	Gaps between the implementation and the specifications due to misunderstanding of drawings and specifications	146	C
2	Undocumented change orders	137	C
3	Lower work quality in presence of time constraints	131	B
4	Design changes	131	B
5	Actual quantities differ from the contract quantities	127	B

Construction risk factors	Low impact risks %	Medium impact risks %	High impact risks %
Gaps between the implementation and the specifications due to misunderstanding of drawings and specifications	5.2	31	63.8
Undocumented change orders	10.2	37.3	52.5
Lower work quality in presence of time constraints	13.3	43.3	43.3
Design changes	8.3	55	36.7
Actual quantities differ from the contract quantities	13.5	45.8	40.7

4.3.7.2 Risk responsibility (allocation)

Figure (4.20) shows the allocation of construction risks. respondents allocated the risk of undocumented change orders to the contractors (47%); but (46%) allocate it to be shared between owner and contractor, and that is could be a fact due contractor cannot bear all the responsibility; it shows that contractors should understand that the documentation of change order is their job. (58%) of respondents allocate design changes risk category to the owner and that reflects a trend in which contractors are not very much concerned with changes in the work. (53%) of respondents decided to share the risk of difference between actual and contract quantities. (45%) of respondents were decided to allocate the risk of lower quality of work in presence of time constraints to the contractor, because they are in a better position to control this risk (Kartam, 2001). (62%) of respondents allocate misunderstanding of drawings and specifications to the contractors.

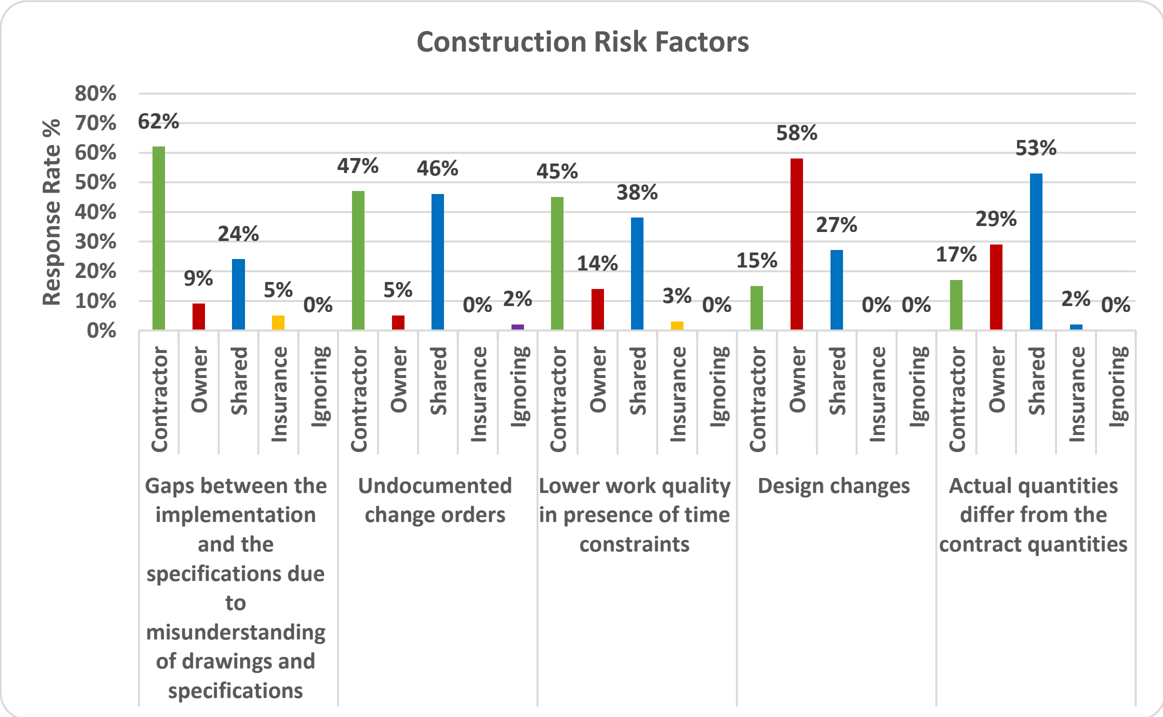

Figure 4.20 Construction risks allocation

4.3.8 Political risks group

4.3.8.1 Risk severity

Table (4.21) demonstrates the ranking and impact of political risks. Respondents appear that Political risk factors have no high risk impact, the reason is that these acts have limited effects on construction issues, and rarely when it happens. Almost all the political risks are considered very significant risks that is due to the unstable ongoing tense situation. Working at hot areas risk is considered a very high risk, contractors can't be enforced to work at such areas. Closure could cause unavailability of materials as well as inflation due to monopoly.

Table 4.21 Political risks ranking and impact

No	*Political risks ranking*	*Weight*	*Severity (A – C)*
1	Working at hot (dangerous) areas (close to Conflict areas)	151	C
2	New governmental acts or legislations	140	C
3	Closure and economic blockade	135	B

Political risk factors	*Low impact risks %*	*Medium impact risks %*	*High impact risks %*
Working at hot (dangerous) areas (close to Conflict areas)	5	31.7	63.3
New governmental acts or legislations	5	46.7	48.3
Closure and economic blockade	8.4	48.3	43.3

4.3.8.2 Risk responsibility (allocation)

Figure (4.21) allocation of political risks is viewed. Clearly, respondents are willing to share most of risks with owners. Working at hot areas, new legislations and closure were considered shared risks with (63%), (38%) and (42%) respectively. It is thought that all risks that can't be controlled should be shared risks. This indicates the low effects of such category.

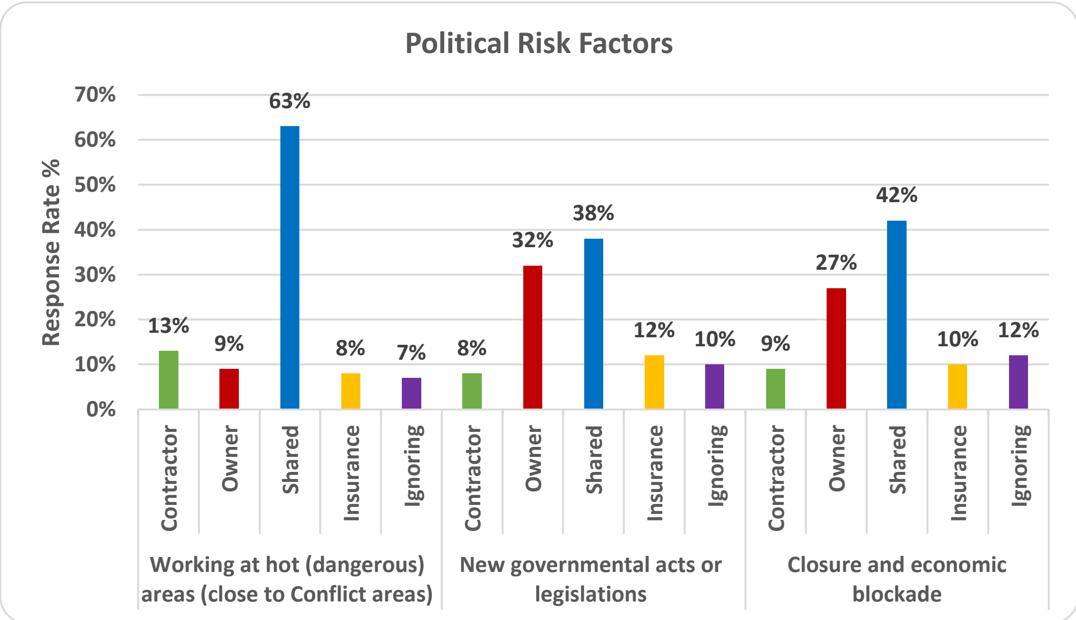

Figure 4.21 Political risks allocation

4.3.9 Management risks group

4.3.9.1 Risk severity

Management group factors ranks and impact are listed in Table (4.22). Poor Resource management was the medium important risk with (54.2%) in management factors, the 2nd, 3rd and 4th was project complexity, Changes in management ways and poor communication respectively with medium importance with risk impact of (50%) impact, the last one is information unavailability (include uncertainty) with (43.3%) impact. These figures indicate the importance of management topics for contractors and indicates the existence of these risks, which need more and more applying management rules. It is thought that management of projects need more and more training to properly manage projects specially the large ones.

Table 4.22 Management risks ranking and impact

No	*Management risks ranking*	*Weight*	*Severity (A – C)*
1	Poor resource management	135	B
2	Ambiguous planning due to project complexity	133	B
3	Poor communication between involved parties	131	B
4	Information unavailability (include uncertainty)	126	B
5	Changes in management ways	122	B

Management risk factors	*Low impact risks %*	*Medium impact risks %*	*High impact risks %*
Ambiguous planning due to project complexity	8.3	50	41.7
Poor resource management	3.4	54.2	42.4
Changes in management ways	16.7	50	33.3
Information unavailability (include uncertainty)	16.7	43.3	40
Poor communication between involved parties	10	50	40

4.3.9.2 Risk responsibility (allocation)

Figure (4.22) illustrates the respondent's allocation of management risks. Respondents considered that contractors should be ready to accept the resource management, ambiguous planning and change in management ways risks with (65%), (58%) and (42%) respectively. It is predictable for contractor to deal with these risks. Respondents decided to share poor communication and uncertainty risks with (72%) and (43%) respectively. These two issues should be really shared risks, it is the contractor's and owner's duty to put a clear plan for the project execution, to clarify any ambiguous information and to maintain a good communication manner in favor of project accomplishment.

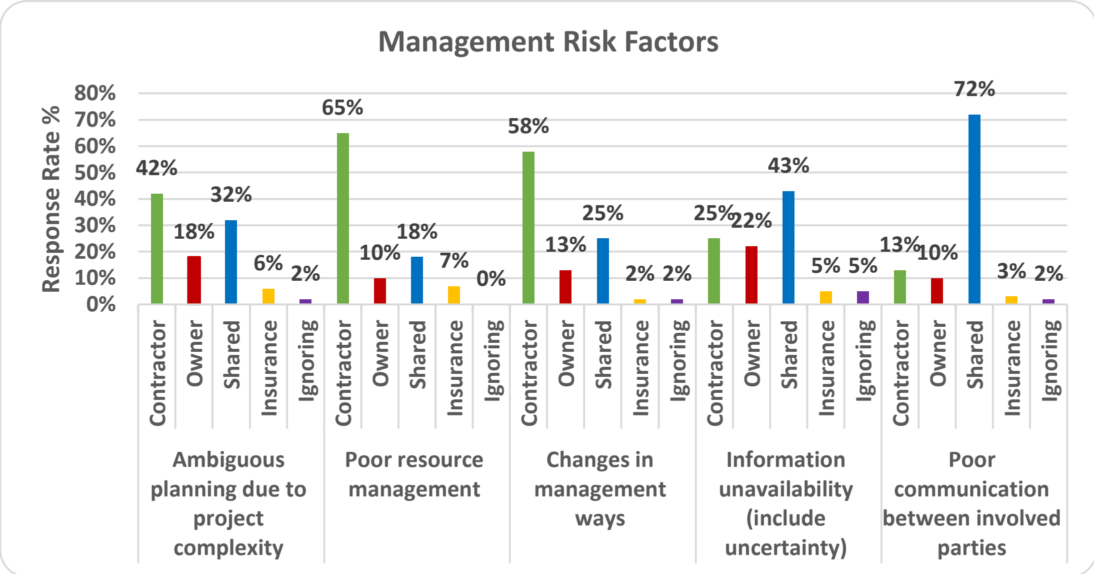

Figure 4.22 Management risks allocation

4.4 Risk management actions

4.4.1 Preventive actions

According to the survey results (Figure 4.23), respondents show the most used preventive method is usually depending on subjective judgment to produce a proper program is the most effective risk preventive actions. 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 is 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 near perfect estimates, decision making about risk is a difficult task. Thus depending only on experience and subjective judgment may not be enough, and updated project information should be obtained and applied. Consequently, respondents considered getting updated project information and add risk premiums to time estimation at the project planning stage to be effective risk preventive method. Yet, this result was expected since taking into consideration such risks' premiums would increase the priced bid and would consequently decrease the probability of gaining the bid due to the highly competitive Sudan construction industry market. Make more accurate time estimation through quantitative risk analyses techniques such as Ms. project Primavera Monte Carlo program was not considered to be an effective preventive method for reducing the effects of risk. This tends to support Kartam (2001) that the approach of risk analysis is largely based on the use of checklists by managers, who try to think of all possible risks. Insufficient knowledge and experience of analysis techniques and the difficulty of finding the probability distribution for risk in practice could be the main two reasons for such result. Referring to similar projects for accurate program was recommended by the practitioners to be an effective preventive method. The percentage above the column is effectiveness proportion for each method.

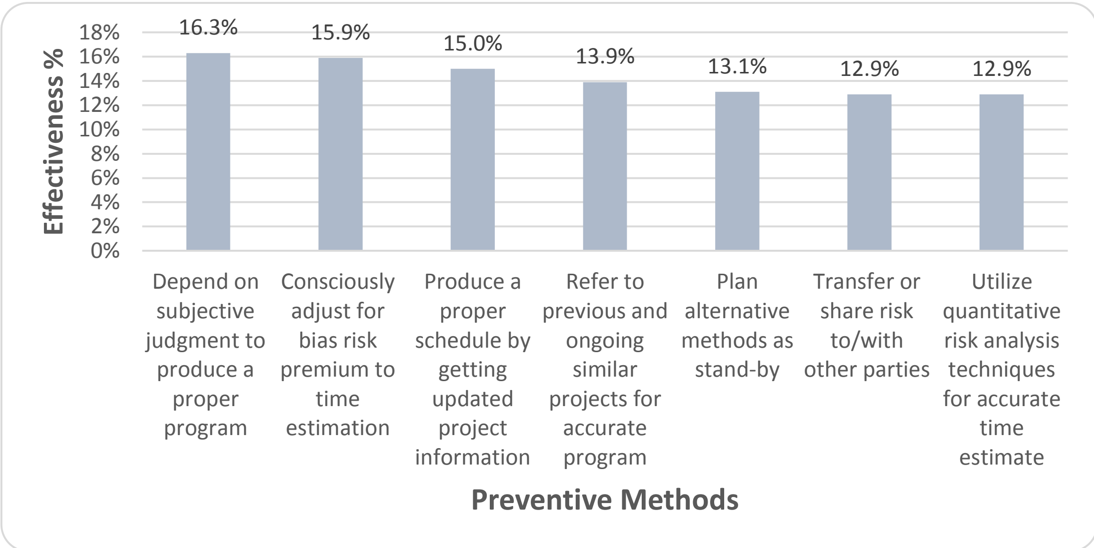

Figure 4.23 Preventive methods effectiveness

4.4.2 Mitigative actions

Figure (4.24) represents the five mitigative methods being proposed. The percentage above the column is effectiveness proportion for each method. The first mitigative method recommended by the respondents is close supervision to subordinates for minimizing abortive work, and the last recommended mitigative method is change the construction method.

Increase working hours and Increase manpower and/ or equipment were the second most effective mitigative methods for minimizing the impacts of delay while Change the construction method was rarely used as a mitigative method. This could mean that the effort driven on site is one of the most important variables to project progress, since construction projects generally include many labor-intensive operations. In fact, as pointed out before, shortage of manpower in subcontractors' firms is one of the most serious risks to project delays. Therefore, increasing the work hours normally speeds up progress subject to the availability of materials and supervisors, physical constraints of the site, and construction sequence.

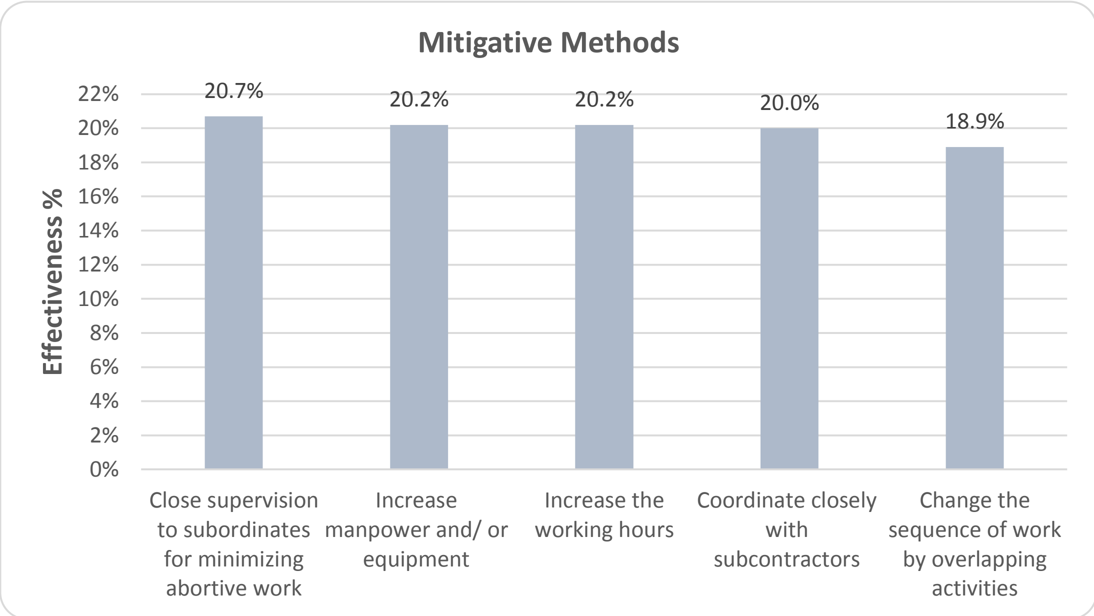

Figure 4.24 Mitigative methods effectiveness

4.5 Use of risk analysis techniques

Figures (4.25) demonstrate the results gained. respondents had results regarding the consequence. The first technique used was depend on the direct judgment and personal skills, the last was probability analysis (analyze historical data). These results reflected the insufficient knowledge and experience of analysis techniques and the difficulty of applying them. Expert techniques are available such as @Risk system, which integrates with time schedules and spread sheets software, should be learned and applied to obtain a precise risk estimation.

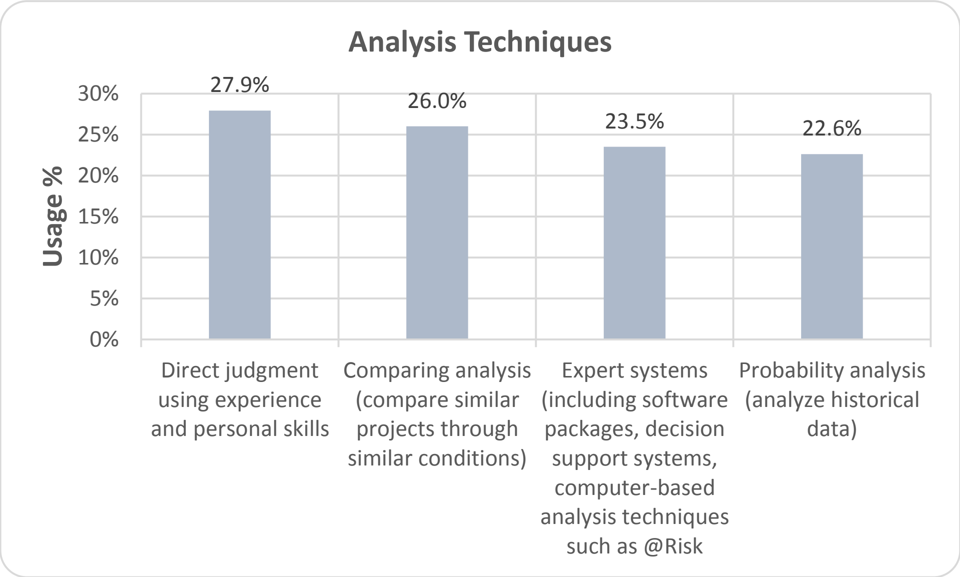

Figure 4.25 Use of risk analysis techniques

4.6 A case Study

With a view to testing the results of this research, the case of construction the Al-Basheer residential compound at Khartoum state (Omdurman locality) is studied, in order to get in-depth information about the actual risk factors influences in a real case. The client of the project is the ministry of defense.

4.6.1 Project description

The Al-Basheer residential compound is located in Al-muhandiseen area western of military academic beside Al- muhandiseen army. In Omdurman locality and consists of main buildings, mosque, mall, maintenance room, three electrical transformers, landscapes, and two guard towers in addition to three football fields plus one multifunctional playground, all these in a total space of 22000 m^2. The main building of the compound consists of fifteen towers with a total area of 9000 m^2, the mosque with space of 1200 m^2. The project includes the construction of an underground water tank with a capacity of 200 m^3.

4.6.2 Contract type

The contract of the project is a measuring contract with security deposit.

4.6.3 Contract price

The contract price was 210 Billion SDG.

4.6.4 Contract period

The duration allowed to accomplish all the works included in the project is 1450 calendar days approximately starting from 2012 which is the contract date.

4.6.5 Site description

The site is flat with unrestricted working space and there are no entry and exit problems. Since the soil is almost clay.

4.6.6 Market conditions

The market conditions were subject to many factors such as closure, the basic contract was adjusted by price escalation because of the scarcity of the dollar, where the owner bears the price difference.

4.6.7 Design and construction

The project was designed with isolate**,** where different structural elements were used such as retaining walls, double columns, and stair bearing walls. full set of drawings was prepared to have a good buildability of the project. Most of the construction materials could be purchased locally, some special equipment such as chillers and boilers should be delivered with lead-time, the contractor was aware to this issue and ordered them in early stages.

4.6.8 Work starting date

After seven months from submitting date, the work at the site has been started. The work started by cleaning the site using loaders and trucks.

4.6.9 Risk factors effects on the project

All the information below was collected after an interview with one the project parties (contractor representative).

Table 4.6.9.1 Physical factors group

Risk factor	Effects
Occurrence of accidents due to poor safety procedures	There is one accident recorded during the project period.
Supplies of defective materials	Supplies of defective reinforcement steel, and they were returned to suppliers, but they have no effects on the project construction time.
Varied labor and equipment productivity	No productivity effects were recorded.

Table 4.6.9.2 Environmental factors group

Risk factor	Effects
Natural disasters	No natural disasters effects were counted.
Difficulty to access the site	The site has good access.
Adverse weather conditions	No rain or other adverse weather conditions caused a delay time of the contract period.

Table 4.6.9.3 Design factors group

Risk factor	Effects
Defective/ poor design (incorrect)	No delay happens to the project period due errors in design and redesign.
Not coordinated design (structural, mechanical, electrical, etc.)	No physical effects were recorded.
Inaccurate quantities	Quantities were accurate.
Awarding the design to unqualified designers	The design products were suitable.

Table 4.6.9.4 Logistics factors group

Risk factor	Effects
Shortage of labor, materials and equipment	No problems was occurred.
Poor communications between the home and field offices (contractor side)	No problems was occurred.

Table 4.6.9.5 Financial factors group

Risk factor	Effects
Financial inflation	The impact of inflation was high due to the instability of the dollar, where the it was 5 SDG at the beginning of the project in 2012, and by the end of the project in 2016 the dollar price was 13 SDG.
Delayed payments on contract	No delay in payments.
Financial failure of the contractor	No financial failure occurred.
Exchange rate fluctuation	Contractor claimed this risk, so the escalation was made to the main contract.

Table 4.6.9.6 Legal factors group

Risk factor	Effects
Difficulty to get permits	There was no effect.
Legal disputes during the construction phase among the parties of the contract	No disputes were recorded.
Delayed disputes resolutions	No disputes were recorded.
No specialized arbitrators to help settle fast	No disputes were recorded.

Table 4.6.9.7 Construction factors group

Risk factor	Effects
Gaps between the implementation and the specifications due to misunderstanding of drawings and specifications	This risk has low effect on the project time, where it caused less than 1% delay to the duration.

Undocumented change orders	Every change order was documented.
Lower work quality in presence of time constraints	No rework processes recorded
Design changes	In the first design the slabs were Slab with beams, and were changed to flat slabs. Which reduced the amount of reinforcing steel from 42 tons to 27 tons per a slab.
Actual quantities differ from the contract quantities	The quantities of the contract were accurate enough.

Table 4.6.9.8 Political factors group

Risk factor	Effects
Working at hot (dangerous) areas (close to Conflict areas)	The site is in a safe place.
New governmental acts or legislations	No effect.
Closure and economic blockade	No effects.

Table 4.6.9.9 Management factors group

Risk factor	Effects
Ambiguous planning due to project complexity	The contractor overcame this risk by hiring specialized subcontractors.
Poor resource management	There was no effect in resource management.
Changes in management ways	No effects recorded.
Information unavailability (include uncertainty)	There were no unforeseen conditions.
Poor communication between involved parties	The communications between parties are in a satisfactory manner.

4.6.10 Conclusion and discussion

The findings obtained from the case study show that the most three important risk factors that seriously caused the project to delay are in a descending order:

5 Occurrence of accidents due to poor safety procedures

6 Financial inflation

7 Exchange rate fluctuation

Chapter Five

CONCLUSIONS AND RECOMMENDATIONS

Conclusions and Recommendations

5.1 Preamble

This chapter was carried out to identify the construction industry risk factors, their importance and their allocation. Furthermore, risk management actions, risk analysis techniques and their effectiveness and usage were settled on. These objectives were brought out, some tendencies were concluded and some actions that may improve risk management practices were recommended.

5.2 Conclusions

Risk management is not about predicting the future. It is about understanding a project and making a better decision regarding the management of the project. Contractors are more willing to adopt the risk management concept especially the identification process of risk management as a first step. Because, in this stage they can use their experience in order to develop their way in identifying the risks and also to use the feedback information like the work breakdown structure from the planning process.

Since experience is available, it will be easy to establish risk management by encouraging the engineers or key personnel to study the tools and techniques of the risk management. However, the art of performing risk management is not learned on a three-day course, it is a matter of learning and improving over time. Some companies think that they do not have the time for risk management, but instead they spend vast amounts of time and money on correcting projects deviating from previously outlined plans.

Most of the consulting firms and construction companies in Sudan have no idea about the concept of risk management as a managing tool. Also they have no known systematic way to deal with the risk. But, somehow the way they use to manage their risks in any projects, considered to be a kind of risk management procedure. This kind of procedure is known as the informal approach to the management of risk; which views the risks in a subjective manner and due to the nature of this approach many organizations implement these methods without realizing that. One of the techniques used in the informal approach is the provision of contingency funds, which can be a lump sum contingency or a percentage contingency. The danger of this approach is that a contingency fund is not financially representative of all the possible risks in a project, because it is unlikely that all risks would be realized.

The construction is considered a risky business because it has unique characteristics which sharply distinguish it from other sectors of the economy. It is fragmented, very sensitive to economic cycles, and highly competitive because of the large number of firms and relative ease of entry. In this study, identifying the risk factors faced by construction industry is based on collecting information about construction risks, their consequences and corrective actions that may be done to prevent or mitigate the risk effects. Risk analysis techniques were investigated too. However, determination of severity and allocation of these risk factors was the main result of this research.

The main point of this research is to explore the key risk factors and identify these factors that could be faced in construction industry in Sudan. Analysis of these risk factors was carried out to measure their effects on building projects and to allocate each risk factor on the party who is in the best position to handle such situations. The risk factors that were identified are shown in Table (3.1). These factors were investigated to measure the severity of each. The most eight sever risk factors are appeared in Table (5.1).

Table 5.1 Most eight sever risk factors and allocation according to respondents

Rank	***Risk description***	***Allocation***
1	Varied labor and equipment productivity	Contractor
2	No specialized arbitrators to help settle fast	Shared
3	Shortage of labor, materials and equipment	Contractor
4	Legal disputes during the construction phase among the parties of the contract	Shared
5	Delayed disputes resolutions	Shared
6	Poor communication between involved parties	Shared
7	Awarding the design to unqualified designers	Owner
8	Delayed payments on contract	Owner

5.3 Recommendations

- Contracting companies should compute and consider risks by adding a risk premium to quotation and time estimation. This trend has to be supported by organizations like Sudanese Contractors Union, and other organizations concerned about the construction industry.
- Contractors should struggle to prevent financial failure by practicing a stern cash flow management and minimizing the dependence on bank loans.
- There is an essential need for more standardization and effective forms of contract, which address issues of clarity, fairness, roles and responsibilities, allocation of risks, dispute resolution and payment – this could be done by adopting a standard form of contracts e.g. "FIDIC".
- A satisfactory level of communications between parties should be maintained to exchange needed information using documents.
- Exchange rate fluctuation should be considered as a risk factor by clients and donors and they should offer a compensation mechanism if there was any damage due to this risk.
- Clients should conduct continuous training programs to advance managerial and financial practices to explain the internal and external risk factors affecting the construction industry and to initiate the proper ways to deal with such factors.
- Contracting firms should compute and consider risks by adding the risk factors before quotation and time estimation.
- Contracting firms should utilize computerized approaches used for risk analysis and evaluation such as Primavera which integrates with widely used programs like Ms Project and Microsoft Excel. Otherwise, apply manual approach.
- Moreover, contractors should work on training their personnel to properly apply management principles. It is the duty of institutes to provide such training.
- The design process is the most important phase in the construction process. Design products should be at the highest level of quality, because of that it should have more focus by clients.
- Possible risks should be allocated contractually and clearly on each party. That could be done by defining the potential risk factors and allocate them on the party which is in the best place to manage these risks.

- Documentation works should be applied widely in the industry. In addition, contractors and clients are requested to keep computerized historical data of finished projects. This may help in rights reservation and to be an information source for future comparison.
- Assign responsibility for risk mitigation activities, and monitor progress through a formal tracking system.

5.4 Proposed Future Studies

Through the scientific experiences the researcher carried out in the construction industry in Sudan, it is uncovered that the projects in the construction projects lacked applying the risk management means, as well as the managers of the projects lacked in taking the correct and effective decisions, so the researcher recommends of necessity to concern on the risk management and taking the correct decisions as basic process in the construction projects in Sudan till not be failed and to achieve objectives. The researcher also recommended widening in the dependent studies to the risk management and decision taking because it is one of the important vital issues that effects on the all construction projects in the Sudan. Contractors should provide the professional staff to manage the project properly, which will considerably reduce the cost and time of execution. Contracting companies should maintain a satisfactory level of communication between the home office and field offices and apply appropriate management practices. It is necessary to repeat this research every 2 years by an authorized institute to survey the new risk factors and their allocation, and publish the results for construction project’s parties.

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ANNEXES

Annex 1 : Questionnaire - English Version

Annex 2: Questionnaire - Arabic Version

بسم الله الرحمن الرحيم

كلية الدراسات العليا

Annex 1

Sudan University of Science and Technology

College of Graduate Studies

(Master of Science in Construction Engineering)

<u>Questionnaire</u>

Risk Management in Construction Projects in Sudan (Case Study of Residential Compound Projects)

Researcher: Mohammed A. A. Burma

Supervised by: Dr. Awad Saad Hassan

March 2017

Dear respondent,

This questionnaire is for academic purpose only. It is designed as one of the tools for collecting data concerning the subject matter. Please answer the questions laid down to the best of your knowledge; Be insured that this information will be confidential and used for academic purpose only as indicated above. It takes approximately 15 minutes to answer the questionnaire.

Thank you.

First Part - A: General Information

Please choose the appropriate choice by putting (√)

- **Respondent's Gender, Specialty and Educational Qualifications:**

Education level: ☐ Diploma ☐ Bachelor ☐ Master ☐ Doctorate

Specialty: ☐ Civil Engineer ☐ Architect ☐ Other

Gender: ☐ Male ☐ Female

- **The position of the respondent:**

  ☐ Director ☐ Deputy Director

  ☐ Project Manager ☐ Site/ Office Engineer

- **The sector type you work for:**

  ☐ Public ☐ Private ☐ Other

- **Years of experience in construction projects:**

  ☐ 0 – 5 ☐ 5 – 10 ☐ 10 – 15 ☐ More than 15

- **Have you ever worked in construction projects outside Sudan?**

  ☐ Yes ☐ No

First Part - B: General concepts of risk management

1. **Have you ever applied risk management techniques during your work in construction projects?**

   ☐ Yes ☐ No

2. **If yes, your experience with risk management in construction projects in Sudan**.

   ☐ Low ☐ Moderate ☐ High ☐ Very High

3. **If no, How much do you want to know the concepts of risk management in construction projects?**

   ☐ Low ☐ Moderate ☐ High ☐ Very High

4. **It is important to use software to manage the risks of construction projects in Sudan:**

   ☐ Strongly Agree ☐ Agree ☐ Somewhat ☐ Disagree

5. **Risk is believed to dominate the contract structure, procurement strategy, and contract form:**

   ☐ Strongly Agree ☐ Agree ☐ Somewhat ☐ Disagree

6. **What kind of risks normally occur in your projects?**

   (You can tick more than one)

☐ Government regulations ☐ Natural hazards ☐ Labor stoppages

☐ Cash flow problems ☐ Design issues ☐ Changes in technology

☐ Material availability and delays in delivery ☐ Subcontractor performance

Second Part -A: Risk Factors Severity and Allocation

1. **Below is the table which contains the risk factors, please assign the severity of each factor, and allocate each on one of the parts shown.**

Symbol	Meaning
A	Low risks
B	Medium risks
C	High risks

Risk factors		Severity of risk factor			Risk responsibility (Allocation)				
		A	B	C	Contractor	Owner	Shared	Insurance	Ignoring
A	**Physical**								
1	Occurrence of accidents due to poor safety procedures								
2	Supplies of defective materials								
3	Varied labor and equipment productivity								
B	**Environmental\ geographical**								
4	Natural disasters								
5	Difficulty to access the site								
6	Adverse weather conditions								
C	**Design**								
7	Defective/ poor design (incorrect)								
8	Not coordinated design (structural, mechanical, electrical, etc.)								
9	Inaccurate quantities								
10	Awarding the design to unqualified designers								
D	**Logistics**								
11	Shortage of labor, materials and equipment								
12	Poor communications between the home and field offices (contractor side)								
E	**Financial**								
13	Financial inflation								
14	Delayed payments on contract								
15	Financial failure of the contractor								

16	Exchange rate fluctuation								
F	**Legal**								
17	Difficulty to get permits								
18	Legal disputes during the construction phase among the parties of the contract								
19	Delayed disputes resolutions								
20	No specialized arbitrators to help settle fast								
G	**Construction**								
21	Gaps between the implementation and the specifications due to misunderstanding of drawings and specifications								
22	Undocumented change orders								
23	Lower work quality in presence of time constraints								
24	Design changes								
25	Actual quantities differ from the contract quantities								
H	**Political**								
26	Working at hot (dangerous) areas (close to Conflict areas)								
27	New governmental acts or legislations								
28	Closure and economic blockade								
I	**Management**								
29	Ambiguous planning due to project complexity								
30	Poor resource management								
31	Changes in management ways								
32	Information unavailability (include uncertainty)								
33	Poor communication between involved parties								

<u>**Second Part -B: Remedial Methods**</u>

2. In the table shown below, please determine the relative use of each preventive method in the table:

		Never	Rarely	Sometime	Often	Always
I	***Preventive Method***	**1**	**2**	**3**	**4**	**5**
1	Utilize quantitative risk analysis techniques for accurate time estimate					
2	Depend on subjective judgment to produce a proper program					
3	Produce a proper schedule by getting updated project information					
4	Plan alternative methods as stand-by					
5	Consciously adjust for bias risk premium to time estimation					
6	Transfer or share risk to/with other parties					
7	Refer to previous and ongoing similar projects for accurate program					

3. In the table shown below, please determine the relative use of each mitigative method in the table:

		Never	Rarely	Sometime	Often	Always
I	***Remedial Method***	**1**	**2**	**3**	**4**	**5**
1	Increase manpower and/ or equipment					
2	Increase the working hours					
3	Change the sequence of work by overlapping activities					
4	Coordinate closely with subcontractors					
5	Close supervision to subordinates for minimizing abortive work					

Second Part - C: Risk Analysis Techniques

4. The table below contains some techniques used in risk analyses, please assign the relative use of each technique:

		Never	Rarely	Sometime	Often	Always
I	***Risk Analysis Technique***	**1**	**2**	**3**	**4**	**5**
1	Expert systems (including software packages, decision support systems, computer-based analysis techniques such as @Risk					
2	Probability analysis (analyze historical data)					
3	Direct judgment using experience and personal skills					
4	Comparing analysis (compare similar projects through similar conditions)					

My deepest appreciation for your cooperation

بسم الله الرحمن الرحيم

Annex 2

جامعة السودان للعلوم والتكنولوجيا

كلية الدراسات العليا

كلية الدراسات العليا

إستبيان

- هذا الإستبيان لغرض أكاديمي فقط، وهو مصمم بإعتباره أحد أدوات جع البيانات المتعلقة بالدراسة، وذلك **للحصول على درجة الماجستير في الهندسة المدنية (هندسة التشييد)**. الرجاء الإجابة على الأسئلة المحددة بأفضل ما لديك من معرفة. ثق تماماً أن هذه المعلومات ستكون سرية وإستخدامها لأغراض أكاديمية بحتة كما هو مبين أعلاه.

- عنوان الرسالة: **إدارة المخاطر في مشاريع التشييد بالسودان**

الجزء الأول أ: معلومات عامة

الرجاء وضع علامة (√) لتحديد الخيار المناسب.

1. المؤهلات العلمية، التخصص والنوع:

المستوى التعليمي: ☐ دبلوم ☐ بكالوريوس ☐ ماجستير ☐ دكتوراة

التخصص: ☐ مهندس مدني ☐ مهندس معماري ☐ أخرى ....

النوع: ☐ ذكر ☐ أنثى

2. الموقع الإداري: ☐ مدير ☐ نائب المدير

☐ مدير مشروع ☐ مهندس موقع/ مكتب

3. نوع القطاع الذي تعمل به:

☐ عام ☐ خاص ☐ أخرى

4. عدد سنوات الخبرة في مجال الإنشاءات:

☐ 0 - 5 ☐ 5 - 10 ☐ 10 - 15 ☐ أكثر من 15

5. هل سبق لك أن عملت في مشاريع التشييد خارج السودان؟

☐ نعم ☐ لا

الجزء الأول ب: مفاهيم عامة عن إدارة المخاطر

1. **هل سبق أن طبقت تقنيات إدارة المخاطر خلال عملك في مشاريع التشييد؟**

☐ نعم ☐ لا

2. **إذا كانت الإجابة بنعم، مدى خبرتك حول إدارة المخاطر في مشاريع التشييد بالسودان:**

☐ ضعيف ☐ جيد ☐ جيد جداً ☐ ممتاز

3. **وإذا كانت الإجابة بلا، مدى رغبتك في معرفة مفاهيم إدارة المخاطر في مشاريع التشييد:**

☐ ضعيف ☐ جيد ☐ جيد جداً ☐ ممتاز

4. **هنالك أهمية في إستخدام البرمجيات لإدارة المخاطر في مشاريع التشييد بالسودان:**

☐ أوافق بشدة ☐ أوافق ☐ نوعاً ما ☐ لا أوافق

5. **يعتقد أن المخاطر تسيطر على هيكل العقد، إستراتيجية الشراء وشكل العقد:**

☐ أوافق بشدة ☐ أوافق ☐ نوعاً ما ☐ لا أوافق

6. **أي نوع من المخاطر تحدث عادة في مشاريعك بالسودان؟** (يمكن إختيار أكثر من نوع واحد)

☐ الأنظمة الحكومية ☐ الأخطار الطبيعية ☐ التوقف عن العمل

☐ مشاكل التدفق النقدي ☐ مشاكل التصميم ☐ أداء مقاول الباطن

☐ التغيرات في مجال التكنولوجيا ☐ توفر المواد والتأخر في توريدها

الجزء الثاني – أ: عوامل الخطر (الأهمية والتوزيع)

1- فيما يلي عوامل المخاطرة، الرجاء إعطاء درجة الأهمية لهذه العوامل بالإضافة إلى تحديد الطرف الذي سيتحمل هذه المخاطر بالإستعانة بالرموز الموضحة أدناه:

الرمز	المعنى
أ	**مخاطر قليلة الأهمية**
ب	**مخاطر متوسطة الأهمية**
ج	**مخاطر هامة**

	عوامل المخاطرة	**أهمية عوامل المخاطرة**			**الجهة التي تتحمل الأخطار**				
		أ	ب	ج	المقاول	المالك	مشتركة	شركات التأمين	إهمال الأخطار
أ	**فيزيائية**								
1	وقوع الحوادث بسبب قلة إحتياطات الأمان								
2	توريد المواد غير الصالحة للإستخدام								
3	تغير القدرة الإنتاجية للعمال والآلات								
ب	**بيئية/ جغرافية**								
4	القضاء والقدر (الكوارث الطبيعية)								
5	تعذر الوصول للموقع								
6	أحوال جوية غير لائقة								
ج	**تصميمية**								
7	الأخطاء في التصميم								
8	إنخفاض مستوى التوافق في التصميم بين التخصصات المختلفة (إنشائي، ميكانيكي، كهربائي، إلخ)								
9	أخطاء في حساب الكميات								
10	تكليف التصميم لمصمم غير كفؤ								
د	**لوجستية**								
11	النقص في العمالة البشرية، الآلات والمواد								

12	عدم وجود مستوى مقبول من الإتصالات بين الموقع والإدارة (طرف المقاول)								
هـ	**مالية**								
13	التضخم المالي								
14	تأخر الدفعيات وفقاً للعقد								
15	فشل المقاول مالياً								
16	عدم إستقرار أسعار صرف العملات								
و	**قانونية**								
17	صعوبة الحصول على بعض التصاريح اللازمة للعمل								
18	ظهور الخلافات القانونية خلال مرحلة التنفيذ بين أطراف المشروع								
19	التأخير في حل الخلافات بين أطراف المشروع								
20	عدم وجود المحكمين المختصين في حل النزاعات الهندسية								
ز	**إنشائية**								
21	أخطاء في التنفيذ بسبب سوء فهم المخططات والشروط والمواصفات								
22	عدم توثيق الأوامر التغييرية								
23	إنخفاض مستوى جودة الأعمال بسبب وجود القيود الزمنية للتنفيذ								
24	التغيير في التصميم								
25	الكميات الحقيقية تختلف عن كميات العقد								
ح	**سياسية**								
26	العمل في المناطق الخطرة (مناطق النزاعات مثلاً)								
27	تشريعات أو قوانين حكومية جديدة تؤثر على سير الأعمال								
28	الإغلاق والحصار الإقتصادي								
ط	**إدارية**								

29	عدم وضوح التخطيط بسبب تعقيد المشروع								
30	سوء إدارة الموارد								
31	تغيير طرق الإدارة								
32	عدم توفر المعلومات اللازمة (ظروف غامضة)								
33	سوء التواصل بين أطراف المشروع								

الجزء الثاني - ب: طرق تدارك آثار المخاطر

2. **الجدول أدناه يحتوي على بعض الطرق لتدارك آثار المخاطر قبل مرحلة التنفيذ، الرجاء تحديد نسبة إستخدام هذه الطرق تبعاً للرموز الموضحة:**

		مطلقاً	نادراً	أحياناً	غالباً	دائماً
	طرق تدارك آثار المخاطر قبل التنفيذ	**1**	**2**	**3**	**4**	**5**
1	إستخدام طرق تحليل المخاطر الكمية لتوقع المدة الزمنية بشكل دقيق					
2	الإعتماد على الخبرة العملية في عمل برنامج عمل قابل للتنفيذ					
3	عمل جدول زمني قابل للتحديث بالحصول على كل المعلومات المحدثة عن المشروع					
4	وضع خطط/ طرق تنفيذ بديلة					
5	إضافة احتياطي زمني للمدة كاحتياط لمخاطر الجدول الزمني					
6	نقل المخاطر أو تقاسمها مع أطراف المشروع					
7	الرجوع إلى المشاريع المشابهة المنفذة أو الجاري تنفيذها والحصول على المعلومات لانتاج برنامج عمل دقيق					

3. **الجدول أدناه يحتوي على بعض الطرق لتدارك آثار المخاطر <u>أثناء التنفيذ</u>، الرجاء تحديد نسبة إستخدام هذه الطرق وفقاً للرموز الموضحة:**

		مطلقاً	نادراً	أحياناً	غالباً	دائماً
	طرق تدارك آثار المخاطر أثناء التنفيذ	**1**	**2**	**3**	**4**	**5**
1	زيادة العمالة و/ أو الآلات					
2	زيادة ساعات العمل					
3	تغيير تتابع عمليات التنفيذ أو التداخل بينها					
4	التنسيق التام مع مقاولي الباطن					
5	الإشراف الدقيق على الأعمال لتلاشي رفض الأعمال وإعادة التنفيذ					

<u>الجزء الثاني - ج: طرق تحليل المخاطر</u>

4. **الجدول أدناه يحتوي على بعض الطرق لتحليل المخاطر، الرجاء تحديد نسبة إستخدام هذه الطرق تبعاً للرموز الموضحة:**

		مطلقاً	نادراً	أحياناً	غالباً	دائماً
	طرق تحليل المخاطر	**1**	**2**	**3**	**4**	**5**
1	إستخدام الأنظمة الحديثة (برامج كمبيوترمتكاملة)					
2	تحليل الاحتمالات بإستخدام معلومات تاريخية					
3	إستخدام الخبرة وإعطاء التقييم مباشرة					
4	التحليل المقارن بتحليل المعلومات عن مشاريع مشابهة					

تعاونكم يجد منا أسمى آيات الإعتبار والتقدير