JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

(CONSTRUCTION ENGINEERING AND MANAGEMENT STREAM)

ASSESSMENT OF RISK MANAGEMENT IN ROAD PROJECTS UNDER ETHIOPIAN ROAD AUTHORITY, JIMMA DISTRICT

By: Meazadingil Shewanketaw

Advisor: Associate Professor Joselito R. Lacuarin

Co-Advisor: Ato Mamuye Busier (MSc.)

June, 2015

Jimma, Ethiopia

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By Meazadingil Shewanketaw

A Thesis submitted to the
School of Graduate Studies of Jimma University in
partial fulfillment of the requirements of the Degree of Master of Science
in Construction Engineering and Management

Advisor: Associate Professor Joselito R. Lacuarin
Co-Advisor: Ato Mamuye Busier (MSc.)

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Approved by Board of Examiners

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Internal Examiner	**Signature**	**Date**
External Examiner	**Signature**	**Date**

DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

Meazadingil Shewanketaw _____ _____

(Student) Signature Date

This thesis has been submitted for examination with my approval as university supervisor.

Ass. Prof. Joselito R. Lacuarin _____ _____

(Advisor) Signature Date

Ato Mamuye Busier _____ _____

(Co-Advisor) Signature Date

ABSTRACT

Road construction sector is one of the key economic sectors and is the main force motivating Ethiopian national economy. However, it suffers from a number of problems that affect time, cost and quality performances. On the other hand, Risk management increase level of control over the whole project and is more efficient problem solving process. This research aimed to investigate risk management practice affecting project deliverables in road construction projects under Ethiopian Road Authority, Jimma district and recommend remedial measures.

Road construction projects prone to delay in the past ten years have been identified and the risk management practice of project stakeholders has been assessed in comparison with standard risk management plan on literatures using questionnaire and case study.

Findings of the investigation tools proved that risk management is not practiced in road projects in a structured way but some of its components exist in terms of Environmental Impact Assessment (EIA), Social Impact Assessment (SIA), Quality Management System and insurance. However, the proper practice of risk management having its own structure is crucial to avoid failures in achieving project objectives. Therefore, the research has made recommendations for the road construction industry, to develop risk management manual that would be prepared including basic theoretical information as well as ready-to-use guidance for each risk management process to be an effective tool for project managers in setting priorities and showing places of success and failure to maximize profit.

Keywords: Risk management plan, Risk Identification, Risk Analysis, Risk Response, Risk Control, Road construction.

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I would like to express my deepest gratitude for ERA, Jimma district for supplying me with important information at the inception of this research. My gratitude extends to ERA, west region department in Addis Abeba and all the contractors and consultants who took time to respond to my questionnaire and gave me valuable inputs for my research.

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ACRONYMS

AS/NZS	Australian/New Zealand Standard
B/C	Benefit to Cost ratio
EIA	Environmental Impact Assessment
ERA	Ethiopian Road Authority
EV	Earned Value
EMV	Expected Monetary Value
ETA	Event Tree Analysis
FIDIC	Federation Internationale Des Ingenieurs-Conseils (International Federation of Consulting Engineers)
FMEA	Failure Mode and Effect Analysis
FTA	Fault Tree Analysis
IFB	Invitation for Bid
NPV	Net Present Value
NCHRP	National Cooperative Highway Research Program
OBS	Organizational Breakdown Structure
PERT	Program Evaluation and Review Technique
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PPA	Public Procurement Agency
RBS	Risk Breakdown Structure

RFI	Request for Information
RFP	Request for Proposal
RSDP	Road Sector Development Program
SIA	Social Impact Assessment
SWOT	Strengths, Weaknesses, Opportunities and Threats
WBS	Work Breakdown Structure
WSDOT	Washington State Department of Transportation

OPERATIONAL DEFINITION

Activity cost estimates The projected cost of the schedule activity that includes the cost for all resources required to perform and complete the activity, including all cost types and cost components.

Activity duration estimates A quantitative assessment of the likely amount or outcome for the duration of an activity.

Cost management plan A component of a project or program management plan that describes how costs will be planned, structured, and controlled.

Enterprise environmental factors Conditions, not under the immediate control of the team, that influence, constrain, or direct the project, program, or portfolio.

Failure Mode and Effect Analysis For each potential failure, an estimate is made of its effect on the total system and of its impact. In addition, a review is undertaken of the action planned to minimize the probability of failure and to minimize its effects.

Human resource management plan describes how the roles and responsibilities, reporting relationships, and staff management will be addressed and structured.

Issue Log A project document used to document and monitor elements under discussion or in dispute between project stakeholders.

Monte Carlo Simulation A process which generates many probable performance outcomes based on probability distributions for cost and schedule on individual tasks.

Organizational process assets Plans, processes, policies, procedures, and knowledge bases that are specific to and used by the performing organization

Project documents provide the project team with information about decisions that help better identify project risks. Project documents improve cross-team and stakeholder communications

Procurement documents The documents utilized in bid and proposal activities, which include the buyer's Invitation for Bid, Invitation for Negotiations, Request for Information, Request for Quotation, Request for Proposal, and seller's responses.

Project management plan The document that describes how the project will be executed monitored, and controlled.

Project charter A document issued by the project initiator or sponsors that formally authorizes the existence of a project and provides the project manager with the authority to apply organizational resources to project activities.

Quality management plan A component of the project or program management plan that describes how an organization's quality policies will be implemented.

Schedule management plan A component of the project management plan that establishes the criteria and the activities for developing, monitoring, and controlling the schedule.

Scope baseline The approved version of a scope statement, work breakdown structure (WBS), and its associated WBS dictionary, that can be changed only through formal change control procedures and is used as a basis for comparison.

Stakeholder register A project document including the identification, assessment, and classification of project stakeholders.

Work performance data The raw observations and measurements identified during activities being performed to carry out the project work.

Work Performance reports The physical or electronic representation of work performance information compiled in project documents, intended to generate decisions, actions, or awareness

CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND

Road construction is one of the key sectors that support the integrated development and alienation of poverty nationwide. According to Worku, 2011, the Ethiopian Government has been implementing various reforms that have involved the processes of structural adjustment programs along with commercialization of agriculture, private sector development and a number of related poverty alleviation programs. "*The issue of market access is more relevant for a country like Ethiopia where rural population accounts for about 85% of the national population who are engaged in production for both the domestic and international market*." (Worku, 2011) Successful implementation of the programs requires an efficient infrastructural system. "*In particular, road transport is supposed to create a network over a wide array of infrastructural facilities and considered as the crucial one."* (Worku, 2011)

Country Report prepared by Africa Infrastructre Country Diagnostic (AICD), describes that rular road accessibility is very low in Ethiopia. "*According to a GIS-based analysis, only 10 percent of Ethiopia's rular population lives within two kilometers of an all-weather road*." (Foster, 2010)

The proper level of road network is assessed by road density, which is measured by road length per 1000 persons or by road length per 1000 km2. "*In the RSDP III phase, road density of Ethiopia has reached 0.57km per 1000km2 and 42.6 km per 1000km2, where 1.5km per 1000 perosons and 116 km per 1000 km2 were the targets."* (Worku, 2011) This indicates that a lot has to be done in expanding the road network, which requires about four fold of the existing road network.

Ethiopian Road Authority has stated that in 2013, out of the 2168km upgrading projects of Ethiopian Road Authority, 1978.8km (91%) have been accomplished. And out of 726km maintenance project plan 815.6km (112%) has been achieved. 16710.8 km out of 16878km plan (99%) routine maintenance was made during the fiscal year. For this accomplishment, more than 22.91 billion birr was expended.

Road projects covering 318km gravel road and 837km asphalt road were completed and opened for traffic in 2013 as shown in table 1.1

Table 1.1 Road Projects of Ethiopia completed in 2013 (ERA, 2014)

S.no	Project Name	Road Type	Length (km)	Contract Amount (Million)
1	Endeto-Gasera	Gravel	60	660.0
2	Shashmene-Wendogenet-Gemeto	Asphalt	36	168.0
3	Adiabune-Sherey	Asphalt	85	429.0
4	Maytseberi-Dima	Asphalt	76	258.7
5	Hargle-kimey	Gravel	60	428.7
6	Asosa-Kurmuk	Asphalt	100	502.8
7	Ginir-Berdimtu	Gravel	90	436.3
8	Berdimtu-Imi	Gravel	83.89	366.5
9	Gonder-Debark	Asphalt	100	774.0
10	Mojo-Arereti	Asphalt	64	512.0
11	Arereti-Gobenesa	Asphalt	36	530.0
12	Wadera-Negele	Asphalt	66.6	276.2
13	Durbete-Shahura	Gravel	23.8	155.0
14	Alamata-Hewaney	Asphalt	116.53	645.0
15	Sherey-Adigoshu	Asphalt	156	930.5
	Total Sum		1154.82	7072.7

In the five years of national growth and transformation plan, 782km main road improvement, 1089km main road upgrading project, 3934km supplementary road improvement, 4700km routine maintenance project is planned. (ERA, 2014) To achieve this plan, and complete road projects in time with desirable quality and reasonable cost, risk management plays a crucial role.

Jimma zone, consisting of 11 wereda and 365 kebele is located in south west area of Ethiopia. Having a population of around 1,890,579 people, it is one of the oldest cities of Ethiopia more than 100 years of history. But the infrastructural development of the zone

is not facilitated as much as its history. So road construction which is a basic input to accelerate urban development needs more attention. Roads should be constructed with the appropriate cost, time and quality and serve their intended service life without degradation with minimum amount of maintenance.

Risks are ever present. Depending on the uncertainties and the consequences, they are routinely accepted and measures are taken to minimize their consequences. Risks are appreciated when driving a car and, as a response to this, a motor insurance policy provides 'cover' in case of an accident. The extension to the management of the risks within the construction industry is not as straight forward.

In the construction industry, the common practice of shifting risk to the contracting party with the least amount of bargaining power is recognized as "risk misallocation" defined as: *"The practice of allocating risk without separately considering which party may be in the optimum position to evaluate, control, bear the cost of, and/or benefit from the assumption of the risk."* (Swanson, 2006)

There are a number of potential explanations for the increased interest in risk management. Some of them are:

- financial constraints;
- remote location of the project;
- projects becoming larger and more complex;
- construction being filled with many uncertainties that include:
    - Unforeseeable ground conditions;
    - Design defect
    - Lack of safety precaution
- lack of ability to identify, analyze and assess risk associated with running the business;
- Clients are more likely to engage in litigation when things go wrong

Due to the current inappropriate and inefficient management of risk experienced in the highway construction industry, road projects need to develop Risk Management Plan to control the variable environment surrounding the construction project that affect decisions to be made concerning the use of labor, materials and equipment.

1.2 STATEMENT OF THE PROBLEM

Risk is an integral part of the daily challenge of construction. Unmanaged risk threatens to destroy value. Each activity that is present in the construction industry could result in physical injury or fatality, financial disasters, delayed operation, etc. Properly managed risks can create opportunities and competitive advantage.

In the past ten years, several road projects have been undertaken under Ethiopian Road Authority, Jimma District. In all projects, project delay is observed ranging from (40%-255%) which depicts the strong need of time risk management in road projects.

Table 1.2 Road Projects under Ethiopian Road Authority, Jimma district constructed in the past 10 years. (Report found from ERA, Jimma district)

No.	Segment Name	Commencement date G.C. (A)	Actual Completion date G.C. (B)	Original (Expected) Completion date G.C. (C)	Delay in Percent D=((B-A)-(C-A))*100 (C-A)
1	Didessa River (Dembi) - Bedelle	June 26, 2006	August 02, 2013	June 26, 2008	254.86%
2	Metu - Gore	August 31, 2007	August 31, 2010	Feb 20, 2009	103.34%
3	Gore - Bure	March 01, 2007	May 15, 2011	Feb 28, 2010	40.27%
4	Bure - Gambella	March 01, 2007	May 15, 2011	Feb 28, 2010	40.27%
5	Eliya - Adura	July 28,2005	July 28, 2012	Dec 03, 2008	108.91%
6	Gambela - Itang	May 15, 2007	Nov 09, 2014	Nov 09, 2010	114.68%
7	Itang - Jikawo	May 15, 2007	Nov 09, 2014	Nov 09, 2010	114.68%
8	Jimma - Bonga	April 21, 2008	Not yet completed	Feb 22, 2011	134.23%
9	Bonga - Mizan	April 22, 2008	Not yet completed	Feb 22, 2011	134.36%
10	Wacha - Maji	Sept 27, 2007	June 6, 2013	March 25, 2011	66.23%

Report on project completion found from Ethiopian Road Authority, Jimma District (Table 1.2) revealed that too many projects overrun both cost and time forecasts and prove definite evidence that greater attention to project management, which includes risk management, is significant for improvement in meeting targets.

Presently, there is no existing risk management plan that aims to help a project team to define, communicate and monitor their management focuses. It is still unclear how project teams can utilize this process for improving Risk Action Plan.

One of the major reasons why projects fail to meet their objectives is the inefficient management of risk. Either risks are not properly planned and prepared for, or action is not taken at the right time to lessen the consequence. A good risk management strategy will help ease the tension associated with planning for the unknown.

Risks should be conducted at all stages of a project life cycle, from feasibility to commissioning within the construction industry. Detailed management of risks should be routinely carried out. Increased knowledge concerning risk management process is needed to understand how risk management could be improved in the construction industry.

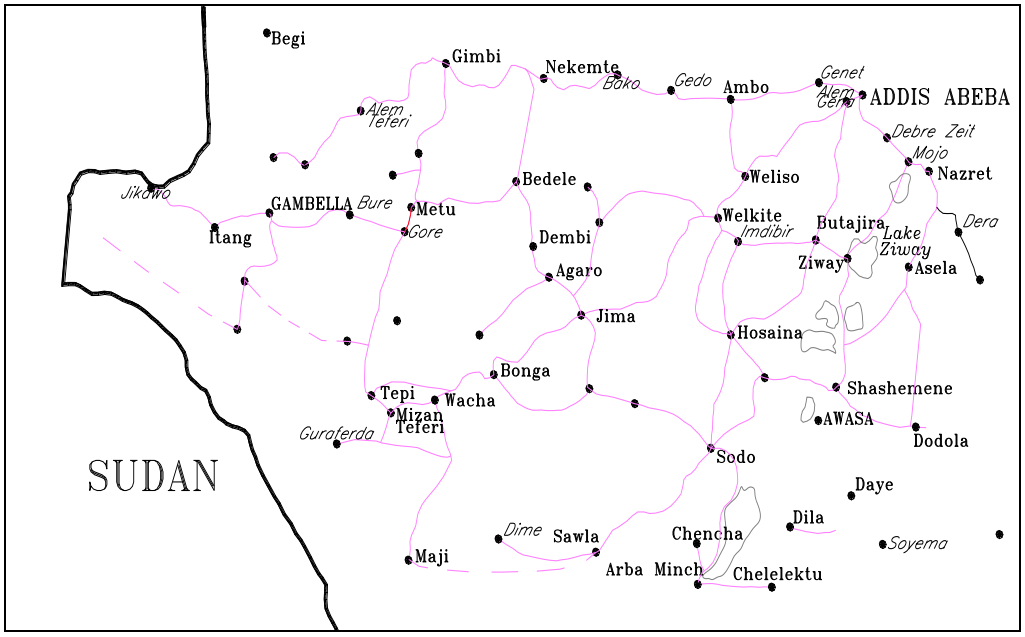

Figure 1.1 Map showing route of Project Road

1.3 OBJECTIVES

1.3.1 GENERAL OBJECTIVE

The main objective of this research is to assess the risk management techniques being used currently in road projects and compare this technique with standard risk management plan to show the gap between the two that is causing failure in achieving project deliverables.

1.3.2 SPECIFIC OBJECTIVE

Specific objectives of this research were:

a. To identify risk management plan and practice among ERA projects
b. To assess risk identification tools and techniques
c. To assess qualitative and quantitative risk analysis methods
d. To assess risk response planning system
e. To evaluate risk monitoring and control mechanism being used in road projects

1.4 RESEARCH QUESTIONS

a. What is the current practice in ERA projects concerning risk management plan?
b. What types of risk identification tools and techniques are being used?
c. What types of qualitative and quantitative risk identification tools and techniques are being used?
d. What types of risk response methods are being used?
e. What types of risk monitoring and control mechanisms are being used in road projects?

1.5 SCOPE

The scope of the thesis is limited to assessing risk management practice in Road Projects under Ethiopian Road Authority, Jimma District. Projects constructed in the past 10 years will form basis for this assessment research.

CHAPTER TWO

LITRATURE REVIEW

2.1 DEFINITION OF RISK

Project Management Institute defines risk as: *"An uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives*." (PMI, 2013). Similarly McGraw-Hill dictionary of Engineering puts the definition as: *"The potential realization of undesirable consequences from hazards arising from a possible event."* (McGraw-Hill, 2003) On the other hand, Cooper and Fisk describe risk as exposure to the consequences of uncertainty: *"It is the chance of something happening that will have an impact upon objectives. It includes the possibility of loss or gain, or variation from a desired or planned outcome"* (Cooper et al, 2005). *"Risk is a property or an entire probability distribution, where as there is a separate probability for each outcome."* (Fisk, 2000) The model developed by Young, 2007 provides incite about impact of risk on project schedule.

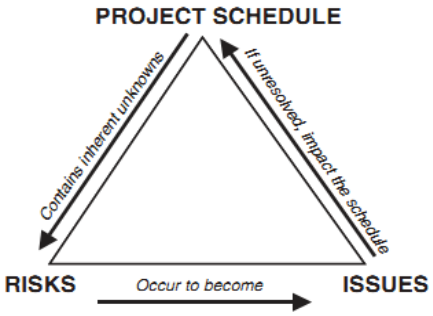

Figure 2.1 Risks and issues: impact on the project schedule (Young, 2007)

Most business decision making takes place on the basis of expectations about the future. Making a decision on the basis of assumptions, expectations, estimates and forecasts of future events involves taking risks. "*Risk and uncertainty characterize situations where the actual outcome for a particular event or activity is likely to deviate from the estimate or forecast value."* (Raftery, 2003) Risks are associated with every project and should be identified in order to avoid negative impacts on the overall performance. ''*The risk management database is used to describe the overall project risk and it includes all risks data.''* (Wu, 2011).

According to (Flanagan, 1993), typical risks on a construction project include:

- Failure to complete within the stipulated design and construction time;
- Failure to obtain the expected outline planning, detailed planning or building code/regulation approvals within the time allowed in the design program;
- Unforeseen adverse ground conditions delaying the project;
- Exceptionally inclement weather delaying the project;
- Strike by the labor force;
- Unexpected price rises for labor and materials
- Failure to let to a tenant upon completion;
- An accident to an operative on site causing physical injury;
- Latent defects occurring in the structure through poor workmanship;
- Force majeure (flood, earthquake etc.);
- A claim from the contractor for loss and expense caused by the late production of design details by the design team;
- Failure to complete the project within the client's budget allowance.

Bhavsar et al. Also broadly catagorize types of Risk associated with construction industry as shown in Table 2.1.

In many circumstances, the larger and more complex the project, the longer the time is required to complete the project, and more severely will it be affected by project uncertainties and risks. "*Specific risks cannot be addressed in isolation from each other; the management of one risk may have an impact on another, or management actions which are effective in controlling more than one risk simultaneously may be achievable."* (The Orange book, 2004) Main categories of risk are shown in Figure 2.2

Table 2.1 Categories of Risk. (Bhavsar et al., 2013)

Types of Risks		
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. Organisational 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		

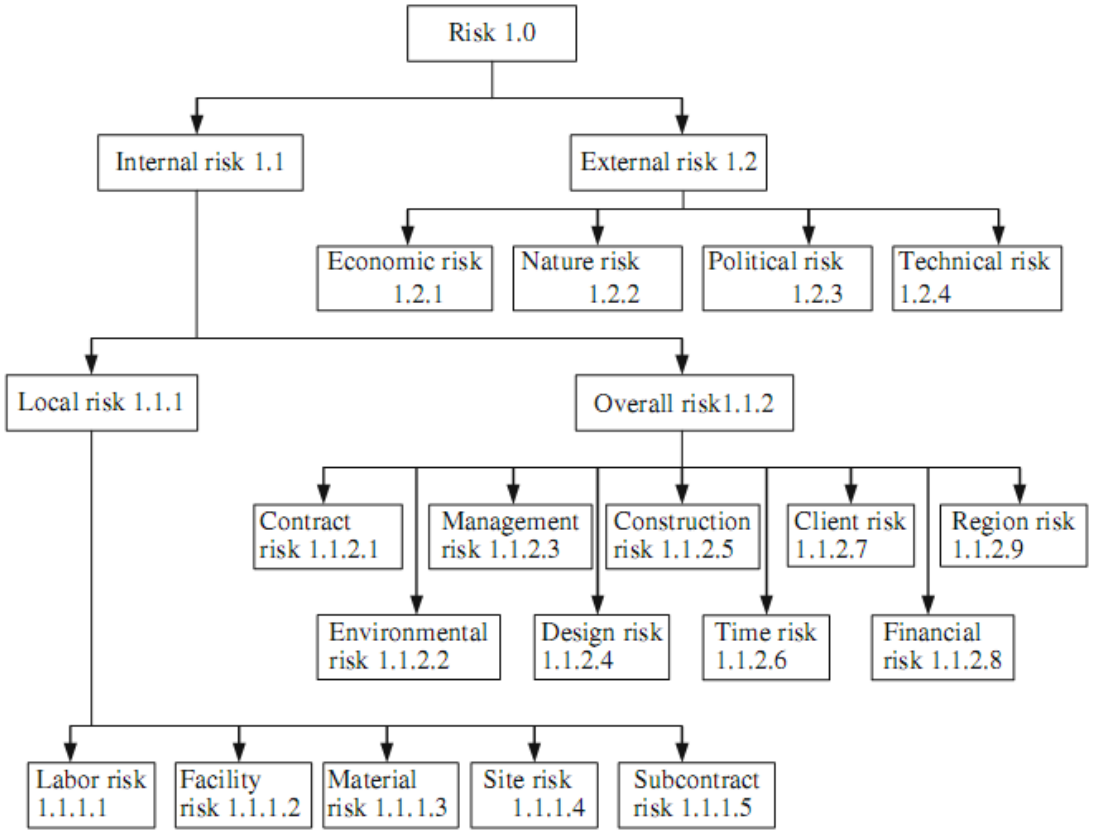

Figure 2.2 Hierarchical risk breakdown structure (Wu, 2011)

(Hanna, 2008) identified the top nine most commonly misallocated risks. Those risks, from most commonly to least commonly misallocated, are:

- Design incomplete or in error
- Constructability of plan
- Unclear or ambiguous specifications
- Validity of construction schedule
- Inadequate geotechnical investigation
- Relocations and coordination of work activities with utilities
- Unknown or unanticipated discovery of utilities
- Differing site conditions
- Unsuitable subgrade material

2.2 RISK AND UNCERTAINITY

Risk and uncertainty are the two most often used concepts in Risk Management. Although these terms are closely related, they have different definition. "*Risk represents an uncertain outcome. Risks may have either positive or negative outcomes."* (Cretu, et al., 2011) "*Risk, defined as the chance of an adverse event, depends on circumstances."* (Godfrey, 1996) "*Risk can travel in two directions: the outcome may be better or worse than originally expected. These are known as upside and downside risks."* (Raftery, 2003)

On the other hand, uncertainty is defined as potential variability in relation to measures. *"Uncertainty refers to a lack of knowledge about current and future information and circumstances. Uncertainty poses a special set of problems to the management of projects as it can potentially affect outcomes for both the good and the bad."* (Cretu, et al., 2011) Uncertainity is measure of the limits of knowledge in a technical area, expressed as a distribution of probabilities around a point estimate. *"Uncertainty is in part about variability in relation to performance measures like cost or duration or quality."* (Chapman, 2002) "*Uncertainty, on the other hand, was used to describe situations where it was not possible to attach a probability to the likelihood of occurrence of an event."* (Raftery, 2003)

Although risk and uncertainity have different meaning, they are correlated to eachother. *"Risk is measurable uncertainty, Uncertainty is immeasurable risk"* (Greenwood, 2002) *"Risk is to be differentiated from the term 'uncertainty'. Whereas risk assumes that the probabilities of the possible results of an event are known, this is not the case with uncertainty. Hence, risk is measurable uncertainty."* (Waters, 2010)

2.3 DYNAMIC AND STATIC RISK

Risk can be dynamic or static depending on the attitude towards risk. Dynamic risk is concerned with maximizing opportunity, for instance: developing a new innovative product, while Static risk concentrates on minimizing losses. *"Dynamic risk is risking the loss of something certain for the gain of something uncertain. Static risks relate only to*

potential losses where people are concerned with minimizing losses by risk aversion." (Flanagan, 1993)

2.4 FACTORS AFFECTING RISK ATTITUDE

According to (PMI, 2013), the risk attitudes of both the organization and the stakeholders may be influenced by a number of factors, which are broadly classified into three themes:

- **Risk appetite**, which is the degree of uncertainty an entity, is willing to take on in anticipation of a reward.
- **Risk tolerance**, which is the degree, amount, or volume of risk that an organization or individual will withstand.
- **Risk threshold**, which refers to measures along the level of uncertainty or the level of impact at which a stakeholder may have a specific interest. Below that risk threshold, the organization will accept the risk. Above that risk threshold, the organization will not tolerate the risk.

2.5 CONTRACTOR'S AND EMPLOYER'S RISK

The primary burden of risk on a construction project falls between the contractor and the client. Insurers will often carry low probability, high impact risks, such as fire or collapse. On the other hand, factors such as inflation are beyond the control of the contractor. *"In times of low inflation, contractors will carry the risk, but an allowance for inflation will be included in the contractor's tender price plus an appropriate risk premium, which is an allowance for risk."* (Flanagan, 1993)

MDB FIDIC, 2006, defines liabilities belonging to the contractor and the employer. Clause 17.2, Contractor's care of the work says: *"The Contractor shall take full responsibility for the care of the Works and Goods from the Commencement Date until the Taking-Over Certificate is issued for the Works, when responsibility for the care of the Works shall pass to the Employer."* (FIDIC, 2006) Similarly, Employer's risk are defined in Clause 17.3 as follows:

a. *War, hostilities (whether war be declared or not), invasion, act of foreign enemies,*

b. *Rebellion, terrorism, sabotage by persons other than the Contractor's Personnel, revolution, insurrection, military or usurped power, or civil war, within the Country,*
c. *Riot, commotion or disorder within the Country by persons other than the Contractor's Personnel,*
d. *Munitions of war, explosive materials, ionising radiation or contamination by radio-activity, within the Country, except as may be attributable to the Contractor's use of such munitions, explosives, radiation or radio-activity,*
e. *Pressure waves caused by aircraft or other aerial devices travelling at sonic or supersonic speeds,*
f. *Use or occupation by the Employer of any part of the Permanent Works, except as may be specified in the Contract,*
g. *Design of any part of the Works by the Employer's Personnel or by others for whom the Employer is responsible, and*
h. *any operation of the forces of nature which is Unforeseeable or against which an experienced contractor could not reasonably have been expected to have taken adequate preventive precautions.*

PPA, 2006, Standard Bidding Document (SBD) For Procurement of Works: For International Competitive Biddings (ICB) Section 7 also defines contractor's and employer's risk. Employer's risks stated in Clause 11 are the following:

a) *The risk of personal injury, death, or loss of or damage to property (excluding the Works, Plant, Materials, and Equipment), which are due to:*
    i. *Use or occupation of the Site by the Works or for the purpose of the Works, which is the unavoidable result of the Works, or*
    ii. *Negligence, breach of statutory duty, or interference with any legal right by the Employer or by any person employed by or contracted to him except the Contractor.*
b) *The risk of damage to the Works, Plant, Materials, and Equipment to the extent that it is due to a fault of the Employer or in the Employer's design, or due to war or radioactive contamination directly affecting the country where the Works are to be executed.*

On the otherhand, Contractor's risk are defined in Clause 12. "*From the Starting Date until the Defects Correction Certificate has been issued, the risks of personal injury, death, and loss of or damage to property (including, without limitation, the Works, Plant, Materials, and Equipment) which are not Employer's risks are Contractor's risks".* (PPA, 2006)

2.6 RISK PRINCIPLES

A risk process will be effective when it is based on a strong and well defined risk discipline that permeates the entire organization. The eight fundamental risk principles shown in Figure 2.3 allow such a discipline to develop.

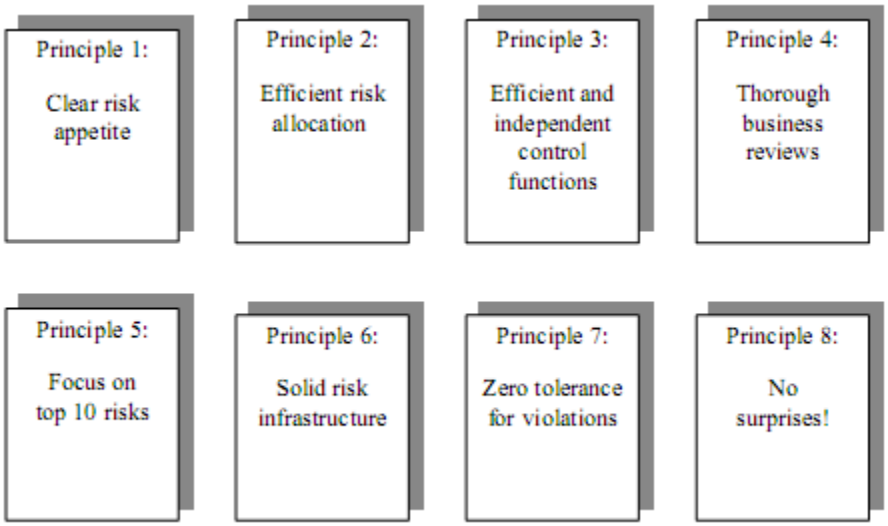

Figure 2.3 Risk principles (Banks, 2003)

2.7 RISK MANAGEMENT PROCESS

In recent years, there has been a growing awareness of the presence of risk on projects and the need to manage it consciously. "*Official recognition of risk as a special concern of project management came in the late 1980s, when the Project Management Institute declared risk management a part of its core Project Management Body of Knowledge"* (Frame, 2002) Risk management is a tool used to facilitate project decisions based on sufficient information. "*Risk management is the term used to describe a sequence of analysis and management activities focused on creating a project-specific response to the*

inherent risks of developing a new capital facility." (NCHRP, 2010) "*Soil notations shown on the plans are for information only and shall not be construed to relieve bidders of their responsibility to satisfy themselves by examining the site of the proposed work as to the actual soil conditions in their plans and specifications.*" (Hanna, 2008)

Risk management is systematic application of management policies, procedures and practices to the tasks of analyzing, evaluating and controlling risk. Risk mangement process model developed by NCHRP is shown in Figure 2.4. It varies by project phase and complexity.

Figure 2.4. Risk management process framework (NCHRP, 2010)

Risk management is an iterative process in which the effectiveness of control actions is constantly evaluated. New risks are discovered and existing risks are reassessed. New or revised control actions are implemented as needed. By managing risk, the process helps achievement of one or more project objectives such as scope, schedule, cost and quality. "*The value and risk management project appraisal model presented focuses heavily upon the identification, analysis and response to risk. However, the process of risk review is essential to maintain and improve future appraisals and assessments of projects".* (Smith et al, 2006). "*Risk Management is one of the 10 pillars of knowledge area building project management which are: Integration management, Scope management, Time management, Cost management, Quality management, Human resource management, Communication management, Risk management, Procurement management and Stakeholder management."* (PMBOK, 2013)

Monte Carlo Simulation and Fuzzy FMEA developed by Alotaibi, 2012 is shown in Figure 2.5.

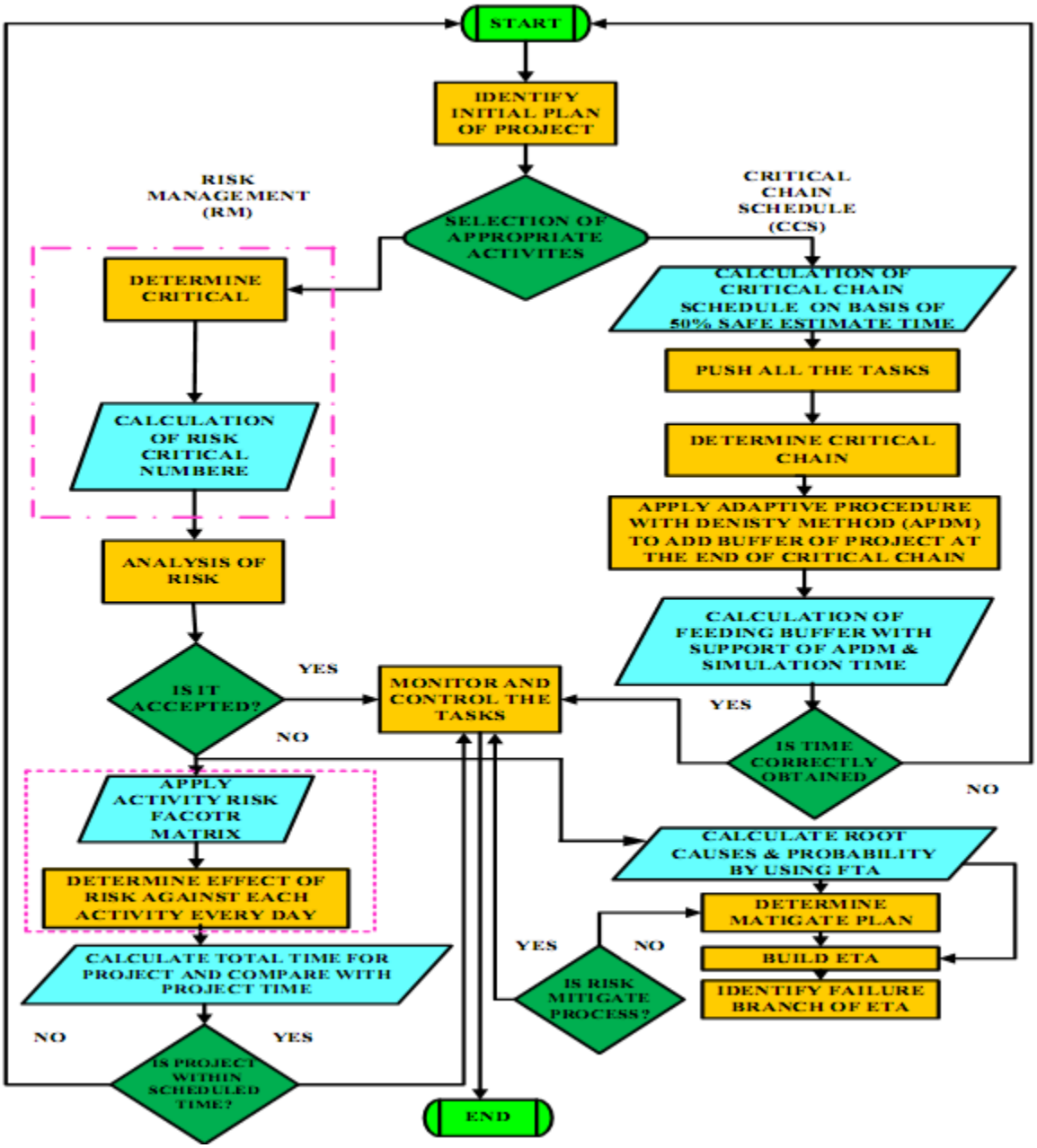

Figure 2.5 Monte Carlo Simulation and Fuzzy FMEA (Alotaibi et al, 2012)

The standard risk management model developed by Smith et al is shown in Figure 2.6

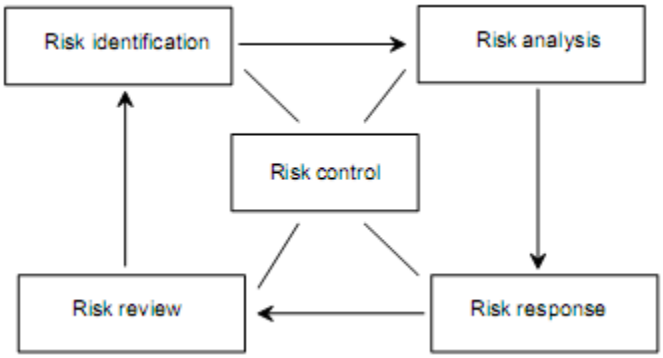

Figure 2.6 The risk control process (Smith et al, 2006)

Risk management is needed such that risk can be continually evaluated and managed in order to increase the probability of project and activity success by focusing attention on problem areas early and reducing the amount of negative consequences in the future. The main elements of the risk management process, developed by Australian/New Zealand Standard (AS/NZS 4360, 2004) as shown in Figure 2.7

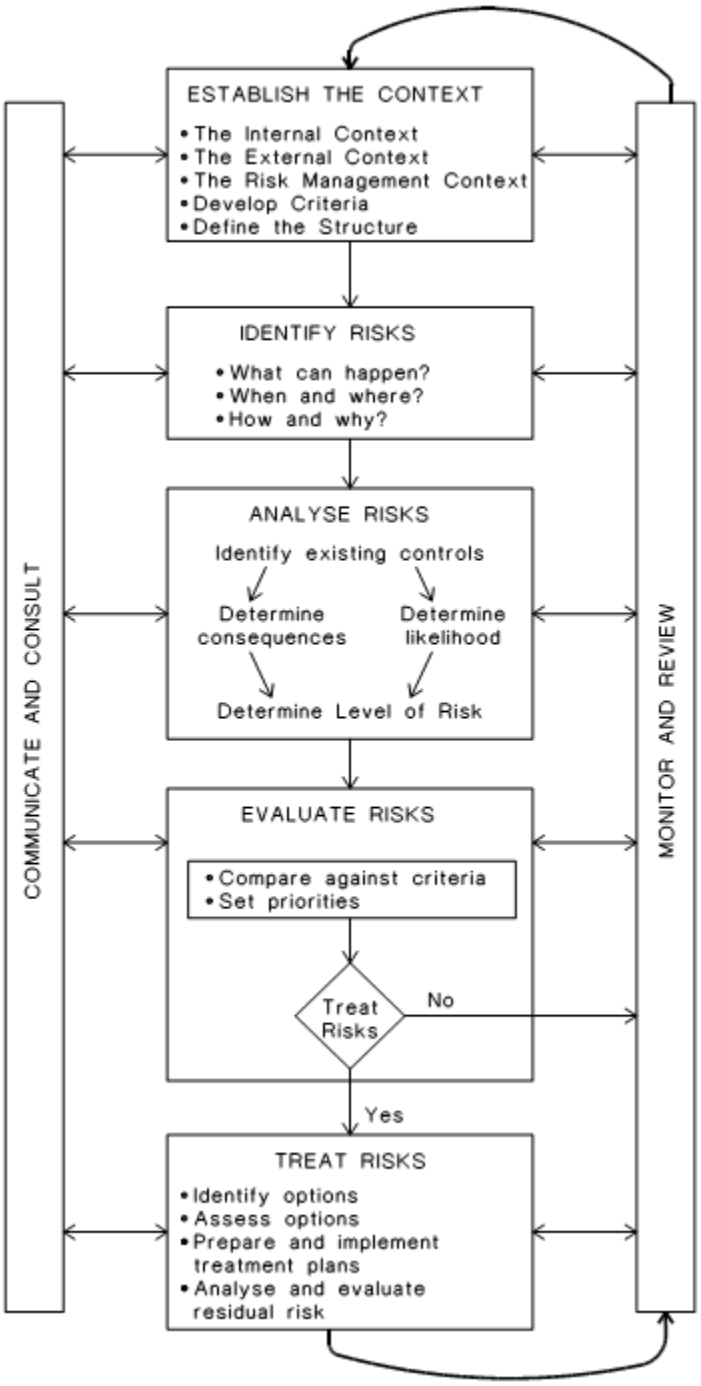

Figure 2.7 Risk Management Process – In Detail (AS/NZS 4360, 2004)

(a) ***Communicate and consult:*** *Communicate and consult with internal and external stakeholders as appropriate at each stage of the risk management process and concerning the process as a whole.*

(b) ***Establish the context****: Establish the external, internal and risk management context in which the rest of the process will take place. Criteria against which risk will be evaluated should be established and the structure of the analysis defined.*

(c) ***Identify risks****: Identify where, when, why and how events could prevent, degrade, delay or enhance the achievement of the objectives.*

(d) ***Analyse risks****: Identify and evaluate existing controls. Determine consequences and likelihood and hence the level of risk. This analysis should consider the range of potential consequences and how these could occur.*

(e) ***Evaluate risks****: Compare estimated levels of risk against the pre-established criteria and consider the balance between potential benefits and adverse outcomes. This enables decisions to be made about the extent and nature of treatments required and about priorities.*

(f) ***Treat risks****: Develop and implement specific cost-effective strategies and action plans for increasing potential benefits and reducing potential costs.*

(g) ***Monitor and review****: It is necessary to monitor the effectiveness of all steps of the risk management process. This is important for continuous improvement. Risks and the effectiveness of treatment measures need to be monitored to ensure changing circumstances do not alter priorities.* (AS/NZS 4360, 2004)

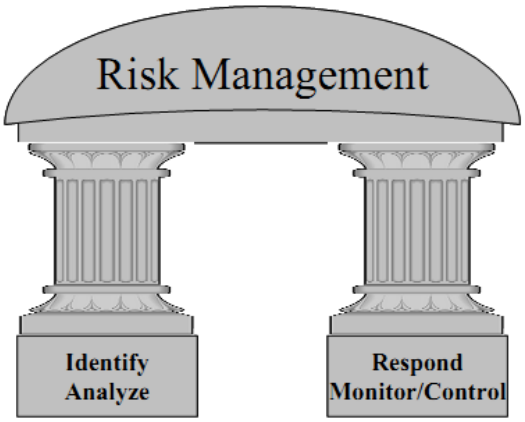

Figure 2.8 Pillars of Risk Management (WSDOT, 2013)

As shown in Figure 2.8, unless we incorporate the second pillars of risk management, we are not realizing the full value of risk management. We must include both pillars of risk management in our plan.

On the other hand, Project management institute defines risks management as follows. An overview of the Project Risk Management processes is shown in Figure 2.9.

> *Project Risk Management includes the processes of conducting risk management planning, identification, analysis, response planning, and controlling risk on a project. The objectives of project risk management are to increase the likelihood and impact of positive events, and decrease the likelihood and impact of negative events in the project*. (PMI, 2013)

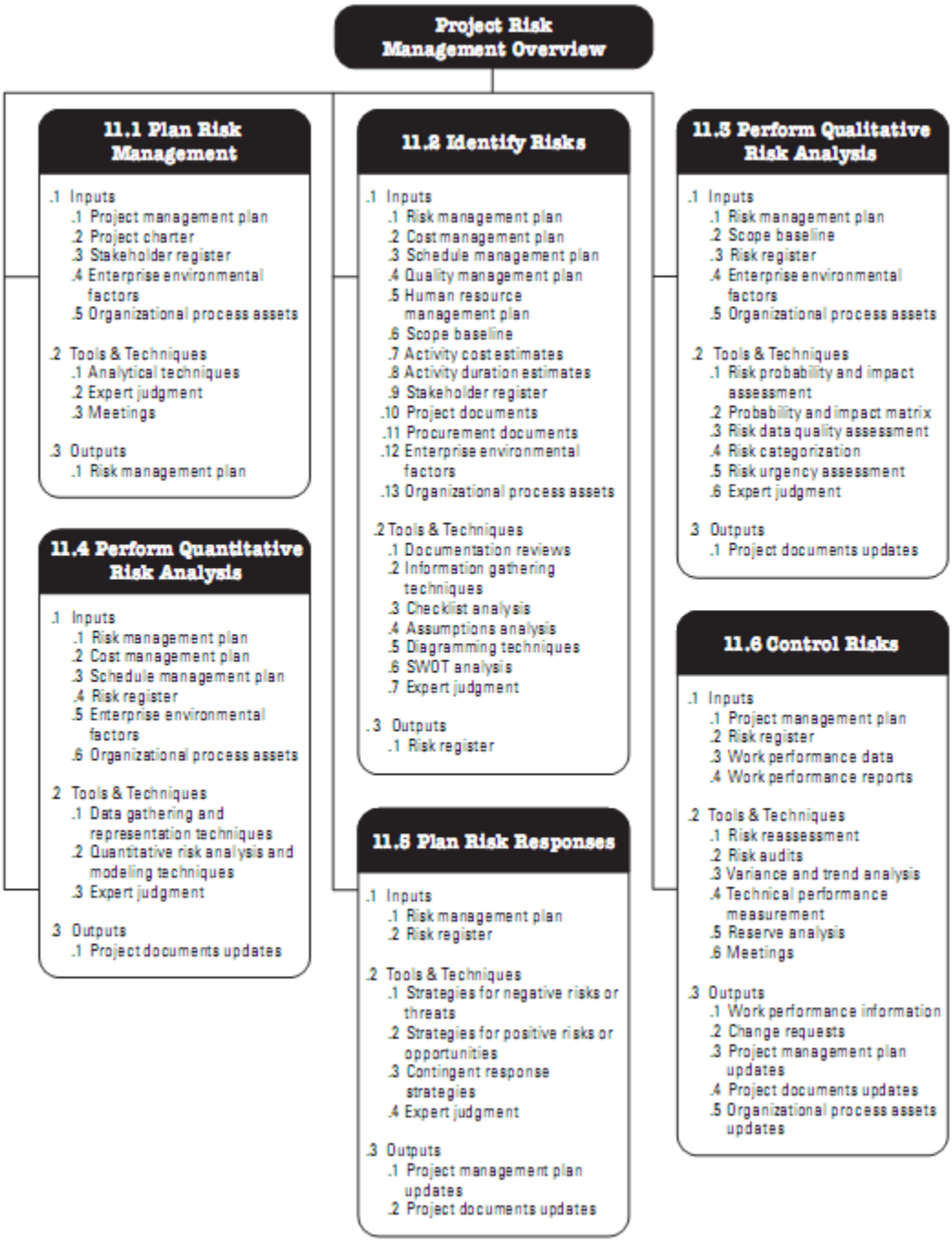

Figure 2.9 Project risk Management overview (PMI, 2013)

An organization should develop a risk management policy, plan and support arrangements. This will enable risk management to be implemented effectively throughout the organization. The plan should address strategies for embedding risk management in the organization's systems, processes and practices.

2.7.1 RISK MANAGEMENT PLAN

At the project risk management planning stage, activities in the proposed baseline (scope, schedule and cost) are evaluated to determine their potential for risk. This evaluation or risk screening assesses all activities against a set of screening categories. "*Careful and explicit planning enhances the probability of success for other risk management processes. Planning is also important to provide sufficient resources and time for risk management activities and to establish an agreed-upon basis for evaluating risks."* (PMI, 2013) The inputs, tools and techniques, and outputs of this process are depicted in Figure 2.10.

Figure 2.10 Plan risk Management: Inputs, tools & techniques, and outputs (PMI, 2013)

"*The risk management plan will also serve as a baseline for the construction project to track variances, validate assumptions based on objective information and the potential probability, and impact of the risk of the events."* (Lambeck, 2009) Kenrzner agrees the same: "*Risk planning is iterative and includes the entire risk management process, with activities to assess (identify and analyze), handle, monitor (and document) the risk associated with a program. An important output of the risk planning process is the Risk Management Plan (RMP).*" (Kenrzner, 2003)

As it is shown in Figure 2.10, risk management plan is a process having inputs, tools and techniques and outputs. These techniques are defined below.

- **Tools and techniques for Risk Management Plan**

a) Analytical techniques

Analytical techniques are various techniques used to evaluate, analyze, or forecast potential outcomes based on possible variations of project or environmental variables

and their relationships with other variables. Depending on these assessments, the project team can allocate appropriate resources and focus on the risk management activities.

b) Expert Judgment

Expert Judgment provided based upon expertise in an application area, knowledge area, discipline, industry, etc., as appropriate for the activity being performed. Such expertise may be provided by any group or person with specialized education, knowledge, skill, experience, or training such as:

- *Senior management,*
- *Project stakeholders,*
- *Project managers who have worked on projects in the same area (directly or through lessons learned),*
- *Subject matter experts (SMEs) in business or project area,*
- *Industry groups and consultants, and*
- *Professional and technical associations.*

c) Meetings

Project teams hold planning meetings to develop the risk management plan. Attendees at these meetings may include the project manager, selected project team members and stakeholders, anyone in the organization with responsibility to manage the risk planning and execution activities, and others, as needed. (PMI, 2013)

➢ Outputs of Risk Management Plan

a) Risk Management Plan

Risk Management Plan is a component of the project, program, or portfolio management plan that describes how risk management activities will be structured and performed. It inlcudes:

- ***Methodology**: the approaches, tools, and data sources that will be used to perform risk management on the project.*
- ***Roles and responsibilities:** of team members for each type of activity in the risk management plan.*

- ***Budgeting***. *Estimates funds needed, for inclusion in the cost baseline and establishes protocols for application of contingency and management reserves.*
- ***Timing.*** *Defines when and how often the risk management processes will be performed throughout the project life cycle, for inclusion in the project schedule.*
- ***Risk categories.*** *Provide a means for grouping potential causes of risk.*
- ***Definitions of risk probability and impact.*** *General definitions of probability levels and impact levels are tailored to the individual project during the Plan Risk Management process for use in subsequent processes.*
- ***Probability and impact matrix.*** *The specific combinations of probability and impact that lead to a risk being rated as "high," "moderate," or "low" importance are usually set by the organization.*
- ***Revised stakeholders' tolerances.*** *Stakeholders' tolerances, as they apply to the specific project, may be revised in the Plan Risk Management process.*
- ***Reporting formats.*** *Reporting formats define how the outcomes of the risk management process will be documented, analyzed, and communicated. It describes the content and format of the risk register as well as any other risk reports required.*
- ***Tracking.*** *Tracking documents how risk activities will be recorded for the benefit of the current project and how risk management processes will be audited* (PMI, 2013)

2.7.2 RISK IDENTIFICATION

The risk identification stage is where all the potential risks that are foreseeable or predictable are recognized, as well as attempting to determine the unforeseen risks. This stage could be argued to be the most important of all the risk management process. As Webb pointed out "*Formalized analysis can only deal with identifiable risks and in so doing demands perfect knowledge of the variables and how they will perform*". (Webb, 2003)

In order to find all potential risks which might impact a specific project, different techniques can be applied. *"In this part of the process the entire team is brought together*

to discuss and identify the risks that are specific to the current project. We recommend that the meeting focus solely on risk." (McGary, 2003)

The aim of risk identification is to highlight the potential problems, in order for the project team to be aware of them. *"The key benefit of this process is the documentation of existing risks and the knowledge and ability it provides to the project team to anticipate events."* (PMI, 2013) The inputs, tools and techniques, and outputs of risk identification process are shown in Figure 2.11.

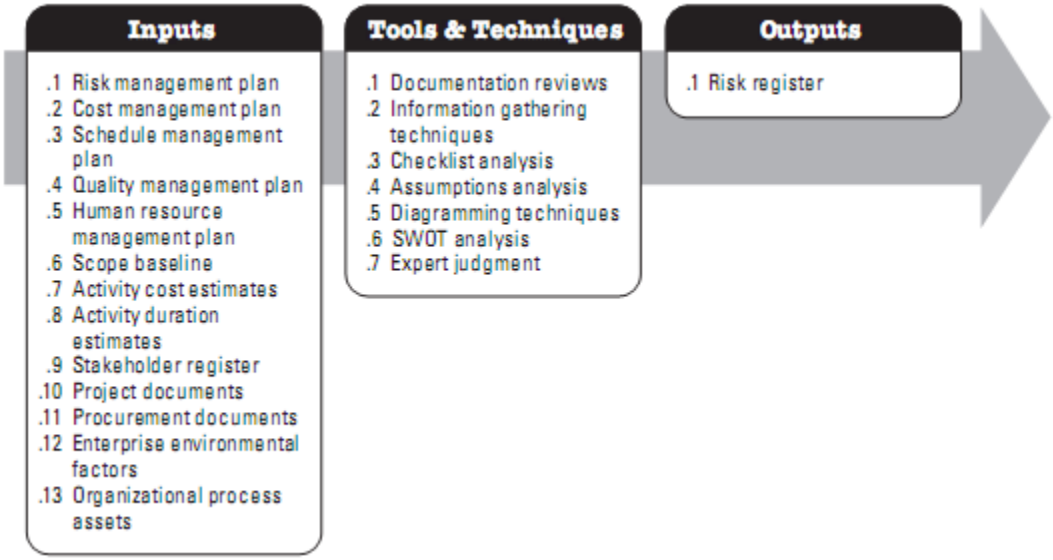

Figure 2.11. Identify risks: Inputs, tools & techniques, and outputs (PMI, 2013)

A good starting point to identify risks will be prior experience of managing similar projects. "*Don't spend time worrying about things that are outside of your control. Focus your attention on risks and issues you can influence directly."* (Barker, 2009) When identifying risk factors associated with construction projects, the different approaches for considering risk should be clearly distinguished to avoid inconsistency while categorizing risk factors. "*Identification of risk must be linked to a clear statement of the client's priorities for a project. For example, if the timing of the project is critical, the severity of time-related risks is automatically increased."* (Hughes, 2000)

The following are techniques used to identify risk and issues by (Barker, 2009):

- ***Assumptions review.*** *Consider how safe each important assumption underpinning your plan is.*
- ***Lessons learned.*** *Look at what's gone wrong with other (similar) projects in your neighborhood.*
- ***Checklists.*** *Work through lists of things to think about and other handy mnemonics.*

As it is shown in Figure 2.11, risk identification is a process having inputs, tools and techniques and outputs. These techniques are defined below.

➢ Identify risks: tools and techniques

a) Documentation reviews

A structured review of the project documentation may be performed, including plans, assumptions, previous project files, agreements, and other information. The quality of the plans, as well as consistency between those plans and the project requirements and assumptions, may be indicators of risk in the project.

b) Information Gathering techniques

Examples of information gathering techniques used in identifying risks can include:

Brainstorming: *to obtain a comprehensive list of project risks from a multidisciplinary set of experts who are not part of the team.*

Delphi technique*: is a way to reach a consensus of experts. Project risk experts participate in this technique anonymously. A facilitator uses a questionnaire to solicit ideas about the important project risks. The responses are summarized and are then recirculated to the experts for further comment. Consensus may be reached in a few rounds of this process.*

Interviewing: *experienced project participants, stakeholders, and subject matter experts helps to identify risks.*

Root cause analysis: *is a specific technique used to identify a problem, discover the underlying causes that lead to it, and develop preventive action.* (PMI, 2013)

c) Checklist Analysis

Risk identification checklists are developed based on historical information and knowledge from previous similar projects. The lowest level of the RBS can also be used as a risk checklist. The team should also explore items that do not appear on the checklist. Additionally, the checklist should be pruned from time to time to remove or archive related items.

d) Assumptions Analysis

Assumptions analysis explores the validity of assumptions as they apply to the project. It identifies risks to the project from inaccuracy, instability, inconsistency, or incompleteness of assumptions.

e) Diagramming techniques

Risk diagramming techniques may include:

- **cause and effect diagrams:** *are also known as Ishikawa or fishbone diagrams and are useful for identifying causes of risks.* (PMI, 2013)

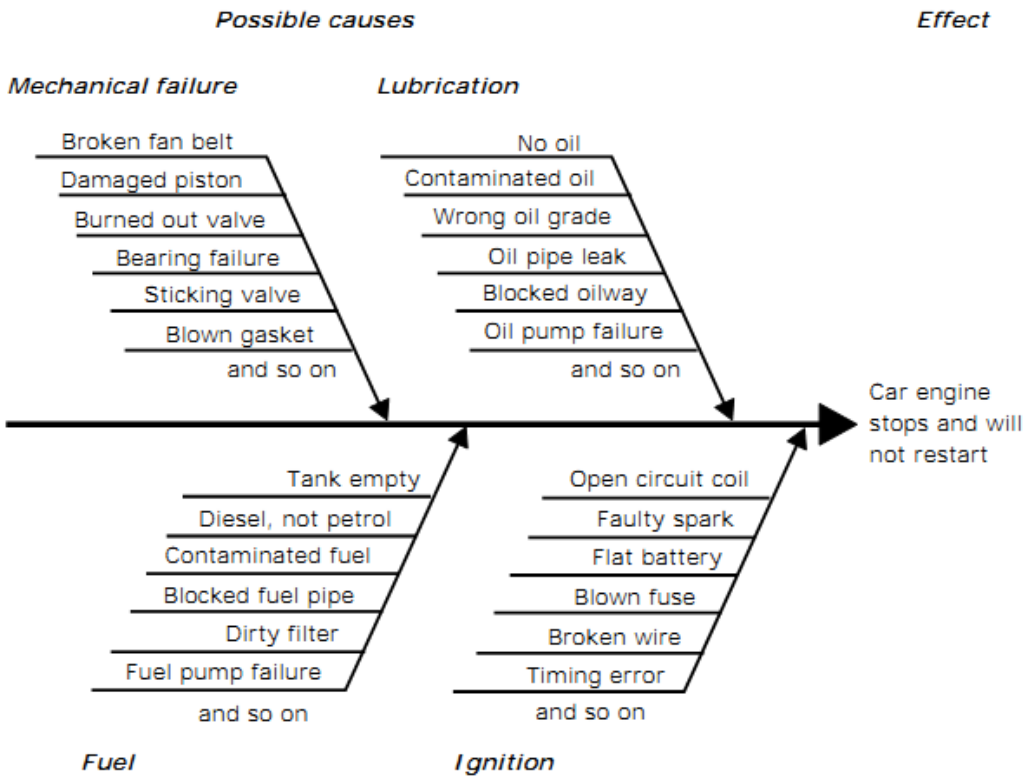

Figure 2.12 Ishikawa fish bone diagram (Lock, 2007)

- **System or process flow charts:** *show how various elements of a system interrelate and the mechanism of causation.*
- **Influence diagrams:** *are graphical representations of situations showing causal inluences, time ordering of events, and other relationships among variables and outcomes.*

f) SWOT Analysis

This technique examines the project from each of the strengths, weaknesses, opportunities, and threats (SWOT) perspectives to increase the breadth of identified risks by including internally generated risks.

g) Expert Judgment

Risks may be identified directly by experts with relevant experience with similar projects or business areas. Such experts should be identified by the project manager and invited to consider all aspects of the project and suggest possible risks based on their previous experience and areas of expertise. The experts' bias should be taken into account in this process. (PMI, 2013)

➢ Identify risks: outputs

a) Risk register

The risk register is a document in which the results of risk analysis and risk response planning are recorded. It contains the outcomes of the other risk management processes as they are conducted, resulting in an increase in the level and type of information contained in the risk register over time. The preparation of the risk register begins in the Identify Risks process with the following information, and then becomes available to other project management and risk management processes:

- **List of identified risks:** *are described in as much detail as is reasonable. A structure for describing risks using risk statements may be applied, for example, EVENT may occur causing IMPACT, or If CAUSE exists, EVENT may occur leading to EFFECT. In addition to the list of identiied risks, the root causes of those risks may become more evident.*
- **List of potential responses:** *to a risk may sometimes be identified during the Identify Risks process. These responses, if identified in this process, should be used as inputs to the Plan Risk Responses process.* (PMI, 2013)

Table 2.2 shows an example risk register as described in NCHRP 658, 2010.

Table 2.2 Sample risk register (NCHRP 658, 2010)

	DIST- EA 06-12345					Project Name:			Project Manager:
						Co - Rte - PM:			Telephone:
ITEM	ID #	Status	Threat / Opport-unity	Category	Date Risk Identified	Risk Discription	Root Causes	Primary Objective	Overall Risk Rating
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	i)
1	06-12345-01	Active	Threat	CON	03/26/07	Risk Description	Root Cause(s)	TIME	Probability 4=High (40-59%) **High** Impact 8 =High
2									Probability Impact

Table 2.2 Sample risk register continued (NCHRP 658, 2010)

						Date Created:
Cost/Time Impact Value	Risk Owner	Risk Trigger	Strategy	Response Actions w/ Pros & Cons	Adjusted Cost/Time Impact Value	WBS Item
(j)	(k)	(l)	(m)	(n)	(o)	(p)
Cost/Time Impact Value	Risk Owner (545) 454-5454 (212) 121-2121 Risk Owner@dot.ca.gov	Risk Trigger(s)	AVOID	Response Actions	Adjusted Cost/Time Impact Value	165 PERFORM ENVIRONMENTAL STUDIES AND PREPARE DRAFT ENVIRONMENTAL DOCUMENT Additional WBS

2.7.3 QUALITATIVE RISK ANALYSIS

Risk analysis is a systematic use of available information to identify hazards and to estimate the risk to individuals or populations, property and the environment There are various techniques that are at present available for risk analysis. They can be broadly grouped into two categories: Qualitative and Quantitative. "*The approach here may be qualitative, based on subjective judgments, or quantitative using numerical estimates of risk based on probability and severity derived from empirical data."* (Rees, 2004) Qualitative techniques are used to distinguish the possibility of a risk occurring and the consequence of that risk in a linguistic manner; for example, a risk is described as low if

that risk is unlikely to occur. "*Qualitative Risk Analysis is the process of prioritizing risks for further analysis or action by assessing and combining their probability of occurrence and impact*." (PMI, 2013)

Risk evaluation initially appraises the risk information once the risks have been qualitatively analyzed. It is a subjective exercise, which gather all the knowledge and judgments of experienced personnel and assesses the extent of the consequences and frequencies of the estimated risks by categorizing them into classifications. *"Risk measurement covers a wide range of quantitative and qualitative risk dimensions… it is impossible to come up with a single one-size-fits-all asset allocation model." (*Crowder et al, 2010) "*Risk analysis step is analysis of each risks, in terms of likely frequency of occurrence, likely severity of impact and the range of possible values in terms of minima, maxima and medians for each of these aspects."* (Hughes, 2000)

The initial qualitative risk analysis usually determines the likelihood of the frequencies or consequences. This initial likelihood is non-numerical and involves applying subjective views. "*There are two major factors in assessing risk. The first one is the probability that the risk event will occur. The second part of risk assessment is the impact the risk will have on the project*." (McGary, 2003) Those risks with a high or intermediate rank may be further analyzed through quantitative techniques. *"If you can deal with the issues, then you reduce the likelihood of the event. If you track and improve your management of issues, you can reduce the exposure."* (Larssen, 2006)

Risk assessment is done to enable control measures to be devised. We need to have an idea of the relative importance of risks and to know as much about them in order to take decision on controls which are both appropriate and cost-effective. (Holt, 2005) The key benefit of this process is that it enables project managers to reduce the level of uncertainty and to focus on high-priority risks. "*Qualitative analysis is based on nominal or descriptive scales for describing the likelihoods and consequences of risks. This is particularly useful for an initial review or screening or when a quick assessment is required."* (Cooper et al, 2005) The inputs, tools and techniques, and outputs of this process are shown in Figure 2.12.

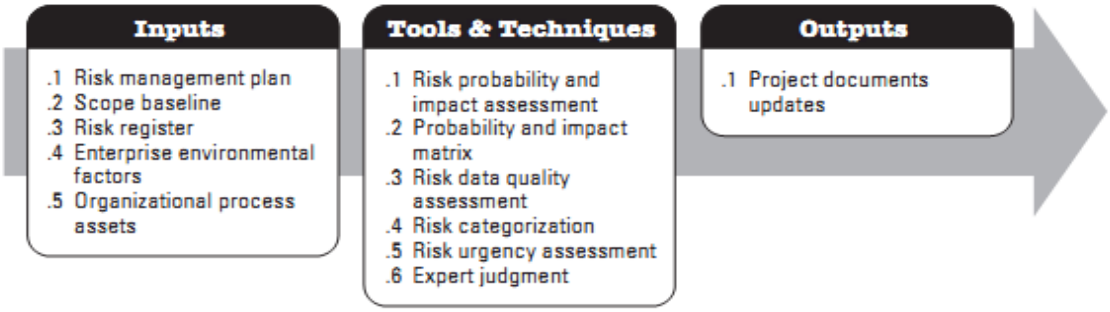

Figure 2.12 Qualitative risk Analysis: Inputs, tools & techniques and outputs (PMI, 2013)

Qualitative risk analysis assesses the importance of the identified risks and develops prioritized lists of these risks for further analysis or direct mitigation. The management team assesses each identified risk for its probability of occurring and its impact on project objectives. *"The impact of a risk can be measured as the likelihood of a specific unwanted event and its unwanted consequences or loss:"* (Godfrey, 1996)

Impact of risk = likelihood x consequence

On the other hand, (Cooper et al., 2005) describe risk factor as a sum of likelihood measure and consequence measure deducting their product. *To calculate risk factors or levels, the descriptive likelihood assessments are converted to numerical measures, to give a risk likelihood measure P (on a scale 0 to 1); and consequence measure C (on a scale 0 to 1). A risk factor RF or combined risk measure is then calculated for each risk.*

$$RF = risk\ factor = P + C - (P*C)$$

Risk priority-setting matrix as described in Table 2.3 can be developed for all types of risk involved in the project and the organization's objectives, criteria and attitudes to risk. Typical numerical value for likelihood and impact rating is defined in Table 2.4.

Table 2.3 Risk priority-setting matrix (Cooper et al, 2005)

	Consequences				
	Insignificant	*Minor*	*Moderate*	*Major*	*Catastrophic*
Likelihood	*E*	*D*	*C*	*B*	*A*
A Almost certain	Medium	Medium	High	High	Extreme
B Likely	Medium	Medium	Medium	High	Extreme
C Possible	Low	Medium	Medium	High	High
D Unlikely	Low	Low	Medium	Medium	High
E Rare	Low	Low	Medium	Medium	Medium

Table 2.4 Typical numerical values for likelihood and impact ratings (Cooper et al, 2005)

Likelihood scale	*Impact scale*	*Letter rating*	*Numerical value*
Almost certain	Catastrophic	A	0.9
Likely	Very high	B	0.7
Possible	Moderate	C	0.5
Unlikely	Low	D	0.3
Rare	Insignificant	E	0.1

As it is shown in Figure 2.12, qualitative risk analysis is a process having inputs, tools and techniques and outputs. These techniques are defined below.

- **Perform Qualitative risk Analysis: tools and techniques**

a) Risk Probability and Impact Assessment

Probability and impact are assessed for each identified risk. Risks can be assessed in interviews or meetings with participants selected for their familiarity with the risk categories on the agenda. Project team members and knowledgeable persons external to the project are included. (PMI, 2013)

b) Probability and Impact Matrix

Risk matrices are usually applied to identify, or rank, the more critical risks, so more focus can ensue on those, by subjecting them to a quantitative analysis. Evaluation of each risk's importance and priority for attention is typically conducted using a look-up table or a probability and impact matrix: Figure 2.13. "*Such a matrix specifies combinations of probability and impact that lead to rating the risks as low, moderate, or high priority. Descriptive terms or numeric values can be used depending on organizational preference."* (PMI, 2013)

Probability and Impact Matrix

Probability	Threats					Opportunities				
0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01
	0.05/ Very Low	0.10/ Low	0.20/ Moderate	0.40/ High	0.80/ Very High	0.80/ Very High	0.40/ High	0.20/ Moderate	0.10/ Low	0.05/ Very Low

Impact (numerical scale) on an objective (e.g., cost, time, scope or quality)

Each risk is rated on its probability of occurring and impact on an objective if it does occur. The organization's thresholds for low, moderate or high risks are shown in the matrix and determine whether the risk is scored as high, moderate or low for that objective.

Figure 2.13 Probability and Impact Matrix (PMI, 2013)

c) Risk data Quality Assessment

Risk data quality assessment is a technique to evaluate the degree to which the data about risks is useful for risk management. It involves examining the degree to which the risk is understood and the accuracy, quality, reliability, and integrity of the data about the risk.

d) Risk categorization

Risks to the project can be categorized by sources of risk (e.g., using the RBS), the area of the project affected (e.g., using the WBS), or other useful categories (e.g., project phase) to determine the areas of the project most exposed to the effects of uncertainty. Risks can also be categorized by common root causes.

e) Risk urgency Assessment

Risks requiring near-term responses may be considered more urgent to address. Indicators of priority may include probability of detecting the risk, time to affect a risk response, symptoms and warning signs, and the risk rating. (PMI, 2013)

f) Expert Judgment: as defined in 2.7.1.

Table 2.5 Risk assessment: timing, issues, objectives, and outcomes. (Ashley, 2006)

PROJECT PHASE	STATUS	TYPICAL RISK ISSUE
LONG-RANGE PLANNING/ PROGRAMMING	■ Focus is on general alignment and mode ■ Project details not defined; environmental reviews incomplete ■ Funding possibly not committed ■ Public support uncertain	■ Fatal or significant environmental economic impacts ■ Funding uncertainty ■ Uncertain political and public support ■ Competing interests and competing projects
PRELIMINARY ENGINEERING	■ Comprehensive definition of project goals ■ Environmental reviews approaching completion (Record of Decision) ■ Initial approvals received but long-term funding commitments still to be determined ■ High cost and schedule contingencies	■ Changes to project scope and budget ■ Costs of environmental compliance ■ Appropriate procurement methods ■ Changes in design requirements ■ Right-of-way acquisition ■ Technical uncertainties ■ Errors or omissions in quantities, inaccurate unit prices ■ Market conditions ■ Funding uncertainty
FINAL DESIGN	■ Project goals communicated to contracting partners ■ Project scope, cost, and schedule well defined ■ Minor open issues since all cost and design detail well advanced ■ Construction approvals, including permits and agreements, not yet final	■ Changes to project scope and budget ■ Errors or omissions in quantities, inaccurate unit prices ■ Changes in design requirements ■ Market conditions, permit requirements
CONSTRUCTION	■ Design complete; project defined ■ Commitments (funding, policy, etc.) in place ■ Construction in progress	■ Contractor performance, construction quality ■ Final permitting, right-of-way acquisition ■ Unanticipated site/working conditions ■ Field design changes ■ Construction safety

OBJECTIVES FOR RISK ASSESSMENT	EXPECTED OUTCOMES
■ Identify implementation challenges— political, public acceptance, approvals ■ Establish order of magnitude costs by option ■ Identify major design and construction risks	■ Better understanding of environmental, engineering, and construction issues facing each project alternative ■ Order of magnitude risk costs and possible total cost range for each option
■ Identification, quantification, and likelihood of major scope, budget, and schedule risks for all major project components ■ General definition of and total probable project costs ■ Risks of alternative design concepts, procurement methods	■ List of major project risks ■ Reasonable estimate of risk costs and probable total project costs and duration ■ Long list of risk mitigation strategies ■ Preliminary risk management plan, focused on design and constructability risks ■ Preliminary risk allocation planning
■ Identification, quantification, and likelihood of all identifiable scope, budget, and schedule risks for all project components ■ Detailed definition of base costs, risk costs, and total probable project costs ■ Validation of reasonableness of contingencies in project budget and schedule	■ List of major critical risks, prioritization of risks based on impacts to total project cost and duration ■ Estimate of risk costs and probable total project costs and duration ■ Costs/benefits of risk mitigation and risk allocation strategies ■ Risk management and allocation plan
■ Targeted assessment of construction problems, causes, and potential cost/ schedule impacts ■ Identification and systematic evaluation of possible corrective actions	■ Analysis of specific problems ■ Costs/benefits of possible corrective actions ■ Corrective action plan that will allow project sponsors/owners to maintain (or recover) schedule and avoid cost overruns

2.7.4 QUANTITATIVE RISK ANALYSIS

Quantitative risk analysis is the identification of hazards and the evaluation of the extent of risk arising there from incorporating calculations based upon the frequency and magnitude of hazardous events. *"Quantitative risk analysis is a way of numerically estimating the probability that a project will meet its cost and time objectives. Quantitative analysis is based on a simultaneous evaluation of the impacts of all identified and quantified risks."* (WSDOT, 2013)

Quantitative analysis is used once the qualitative analysis has been completed. The risks that are deemed not covered by project contingent reserves are considered, estimated and a probability is attached to their consequence and likelihood of occurrence. "*Risk quantification is the estimation of a given risk by a statistical and/or analytical modelling process."* (Bunni, 2003)

Quantitative risk analysis is a way of numerically estimating the probability that a project will meet its cost and time objectives. Quantitative analysis is based on a simultaneous evaluation of the impact of all identified and quantified risks. *"Measuring exposures needs to perform analysis for the small changes that occur in the market place almost every day as well as the "one-hundred-year floods"* (Banks, 2003)

According to (Cooper et al. 2005), Quantitative modelling provides a means of:

- describing the detailed mechanisms at work in a set of risks;
- evaluating the overall uncertainty in the project to which they relate and the overall risk that this places on stakeholders;
- establishing targets, commitments and contingency amounts consistent with the uncertainty the project faces and the risk the managers are willing to accept; and
- exploring the relationship between detailed instances of uncertainty and an overall level of risk, to inform risk management resource allocation.

"Quantitative Risk Analysis is the process of numerically analyzing the effect of identiied risks on overall project objectives. The key beneit of this process is that it produces quantitative risk information to support decision making in order to reduce project

uncertainty." (PMI, 2013) The inputs, tools and techniques, and outputs of Quantitative Risk Analysis process are depicted in Figure 2.14

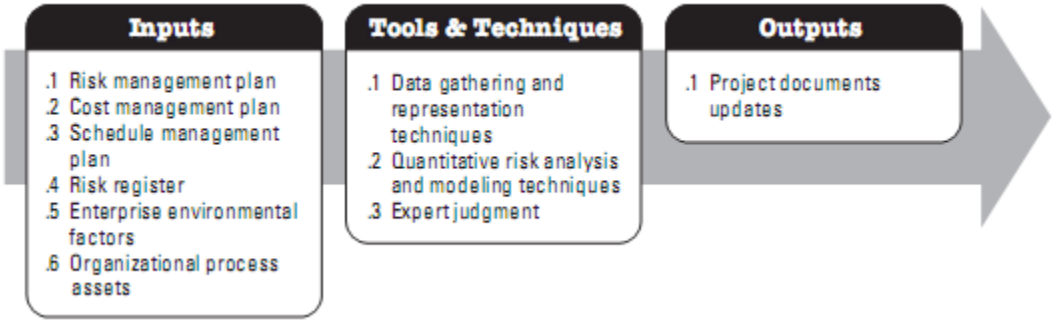

Figure 2.14 Quantitative risk Analysis: Inputs, tools & techniques, and outputs (PMI, 2013)

As it is shown in Figure 2.14, qualitative risk analysis is a process having inputs, tools and techniques and outputs. These techniques are defined below.

➢ Perform Quantitative risk Analysis: Tools & Techniques

a) Data gathering and representation techniques:

- **Interviewing techniques:** *draw on experience and historical data to quantify the probability and impact of risks on project objectives.*
- **Probability distributions:** *Continuous and Discrete probability distributions, which are used in modeling and simulation.* (PMI, 2013)

b) Quantitative risk analysis and modeling techniques:

- **Sensitivity analysis:** *helps to determine which risks have the most potential impact on the project. It helps to understand how the variations in project's objectives correlate with variations in different uncertainties. Figure 2.15 shows tornado diagram, example of sensitivity analysis.* (PMI, 2013)

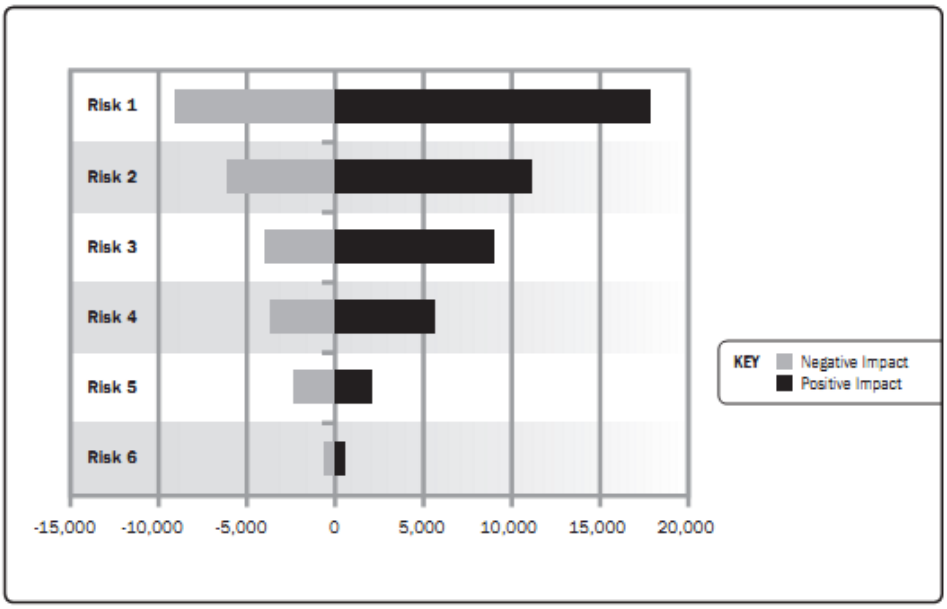

Figure 2.15 Example of Sensitivity analysis: tornado diagram (PMI, 2013)

- **Modeling and simulation.** "*A project simulation uses a model that translates the specified detailed uncertainties of the project into their potential impact on project objectives. Simulations are typically performed using the Monte Carlo technique."* (PMI, 2013) A histogram cost risk simulation for a schedule risk analysis, is shown in Figure 2.17

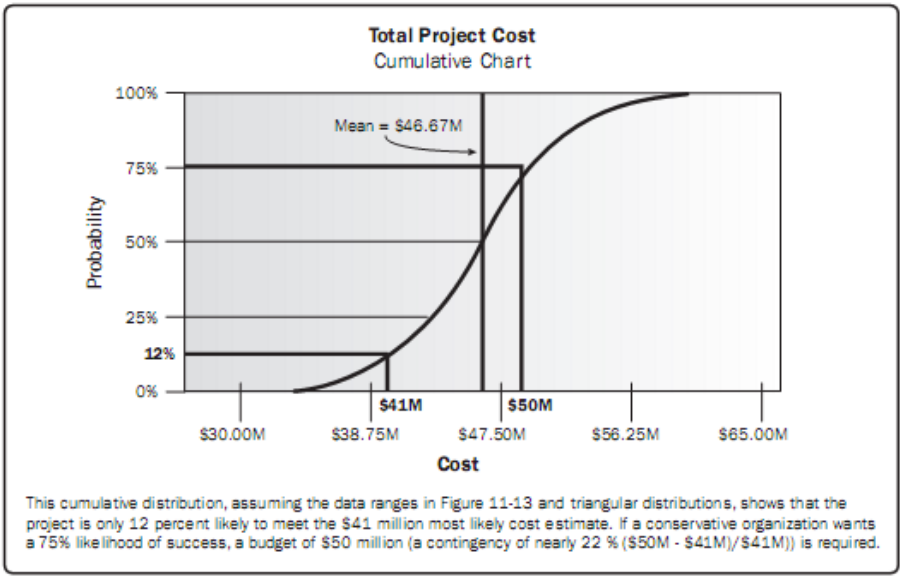

Figure 2.17 cost risk Simulation results (PMI, 2013)

- **Expected monetary value analysis:** "*(EMV) analysis is a statistical concept that calculates the average outcome when the future includes scenarios that may or may not happen (i.e., analysis under uncertainty).*" (PMI, 2013) "*A measure of the value for each possible outcome is required in order to gi*ve meaning to the decision tree. *Expected monetary value (EMV), is the sum of the payoffs (or values) weighted by their probabilities.*" (Flanagan, 1993) Figure 2.16 shows flow diagram of calculating EMV.

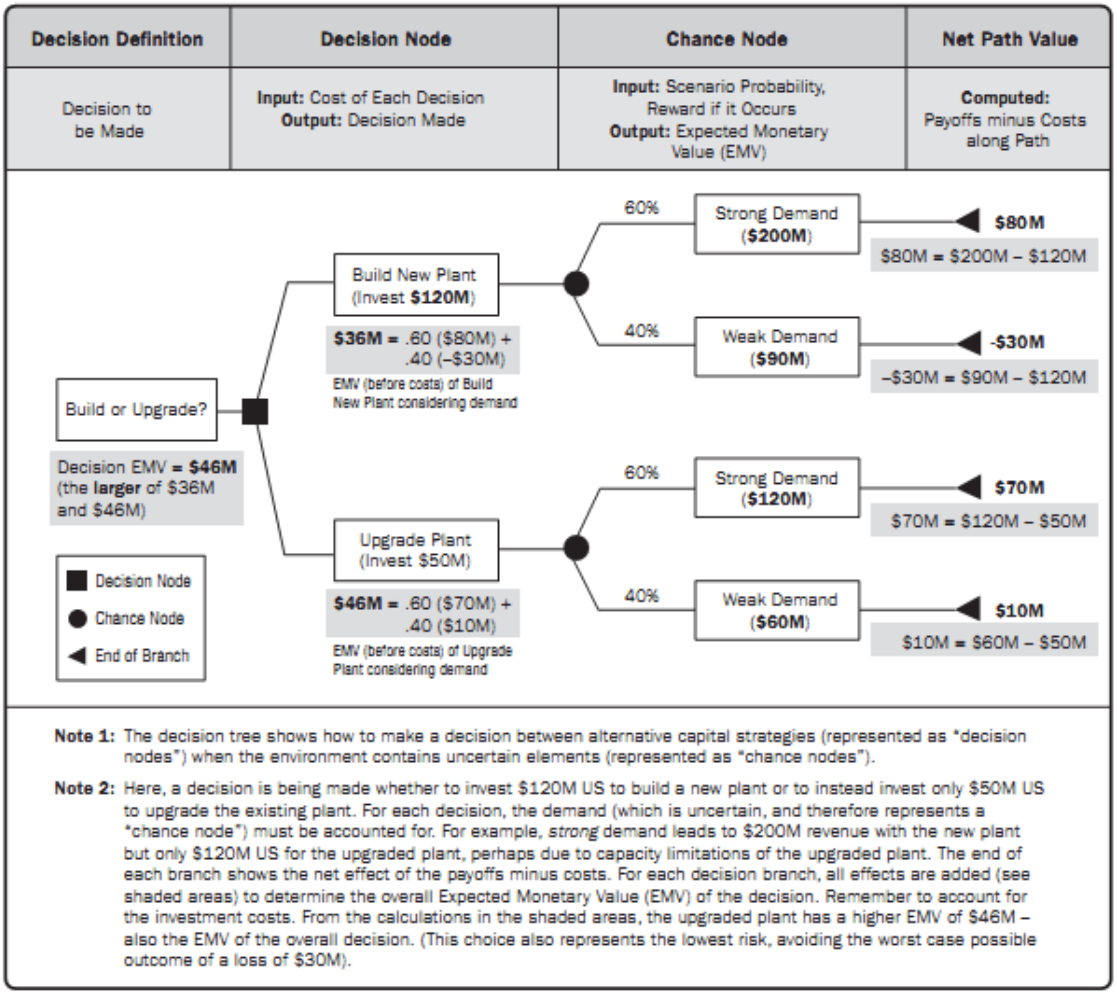

Figure 2.16 Decision tree diagram (PMI, 2013)

c) Expert judgment: as defined in 2.7.1.

2.7.5 RISK RESPONSE

The main purpose of risk response is to develop options and actions to maximize opportunities and minimize threats to the project objectives. Furthermore, during the planning of the risk response the chosen action must be appropriate to the risk as well as cost effectiveness to the project context.

> *Risk Responses is the process of developing options and actions to enhance opportunities and to reduce threats to project objectives. The benefit of this process is that it addresses risks by their priority, inserting resources and activities into the budget, schedule and project management plan as needed.* (PMI, 2013)

Risk response indicates what action should be taken towards the identified risks and threats. The response strategy and approach chosen depend on the kind of risks concerned. *"Risk analysis can be undertaken by any party to a construction project. There is, however, only one party that can undertake a comprehensive analysis of the risks, and instigate a reasoned allocation and mitigation strategy, and that is the employer."* (Davison, 2009)

Sometimes it is difficult to make decision if there is not enough information available. In these cases, it can be more suitable to delay the decision making until more information is available. *"The general guiding principle of risk response is that the parties to the project should seek a collaborative and, insofar as is possible, mutually beneficial distribution of risk."* (Raftery, 2003) The inputs, tools and techniques, and outputs of Risk response process are depicted in Figure 2.18.

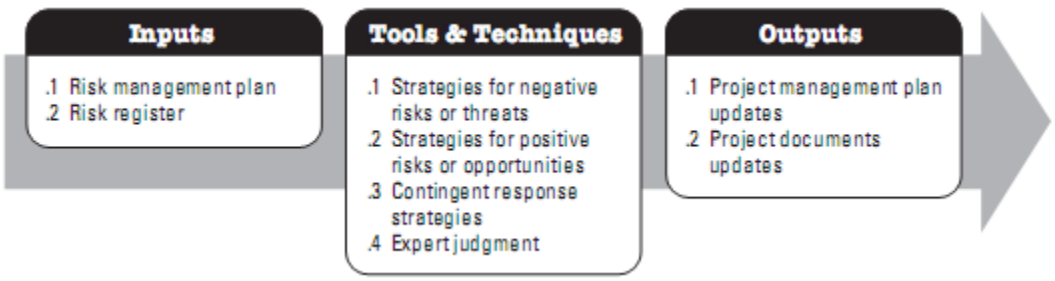

Figure 2.18 Risk responses: Inputs, tools & techniques, and outputs (PMI, 2013)

➢ Risk responses: tools and techniques

a) Strategies for negative risks or threats

- **Risk avoidance** *is a risk response strategy whereby the project team acts to eliminate the threat or protect the project from its impact.* (PMI, 2013) "*The best way to avoid all risk is not to proceed with the project. The benefits of the project must be judged to be worth the risks involved in undertaking it."* (Raftery, 2003)
- **Risk transference** *is a risk response strategy whereby the project team shifts the impact of a threat to a third party, together with ownership of the response.* (PMI, 2013) *It seems sensible to place the risk under the responsibility of the party who has the best possibility of controlling it.* (Raftery, 2003) "*Risk transfer helps to decide who is best placed to manage a risk. The choices lie between employer, consultants, contractor or insurers. Any decision about laying-off risks on to others must involve weighing up the frequency of occurrence against the level of premium being paid for the transfer."* (Hughes, 2000) "*Commonly used transferring techniques involves; insurance, warranties, guaranties, performance bonds, or contracting."* (Cretu et al., 2011). Construction risk allocation to participants is shown in table 2.6.

Table 2.6 Construction risk allocation to participants (Fisk, 2000)

Type of Risk	Contractor	Owner	Engineer	Comments
Site Access		•		
Subsurface Conditions		•		a
Quantity Variations	•	•		b
Weather	•			c
Acts of God		•		
Financial Failure	•	•	•	
Subcontractor Failure	•			
Accidents at Site	•			
Defective Work	•			
Management Incompetence	•	•	•	
Inflation	•	•		d
Economic Disasters		•		
Funding		•		
Materials and Equipment	•			
Labor Problems	•			
Owner-Furnished Equipment		•		
Delays in the Work	•	•	•	e
Inflation	•	•		d
Economic Disasters		•		
Funding		•		
Materials and Equipment	•			
Labor Problems	•			
Owner-Furnished Equipment		•		
Delays in the Work	•	•	•	e
Environmental Controls		•		
Codes and Regulations		•		
Safety at Site	•			
Public Disorder		•		
Union Strife	•			
Errors and Omissions			•	
Conflicts in Documents			•	
Defective Design			•	
Shop Drawings			•	

a—Can be transferred to the contractor; however, owner has obligation to undertake precontract exploration measures, and the designer has the responsibility to design for the conditions expected

b—Contractor can be expected to assume risk up to 15 to 25 percent. Where quantities are dependent upon unforseen subsurface conditions, owner must assume the risk.

c—Normal weather for the time and location only. Unusual inclement weather which delays the work is the owner's responsibility.

d—Sharing of escalation risk should be limited to 12 to 18 month span.

e—Usually the contractor's risk; however, owner could incur some liability.

- **Risk mitigation** *is a risk response strategy whereby the project team acts to reduce the probability of occurrence or impact of a risk.*
- **Risk acceptance** *is a risk response strategy whereby the project team decides to acknowledge the risk and not take any action unless the risk occurs.* (PMI, 2013)

b) Strategies for Positive risks or opportunities

- **Exploit** *strategy may be selected for risks with positive impacts where the organization wishes to ensure that the opportunity deinitely happens.*
- **Enhance** *strategy is used to increase the probability and/or the positive impacts of an opportunity.*
- **Sharing** *a positive risk involves allocating some or all of the ownership of the opportunity to a third party who is best able to capture the opportunity for the beneit of the project, e.g. joint ventures.*
- **Accepting** *an opportunity is being willing to take advantage of the opportunity if it arises, but not actively pursuing it.* (PMI, 2013)

c) Contingent response Strategies

It is appropriate for the project team to make a response plan that will only be executed under certain predefined conditions, if it is believed that there will be sufficient warning to implement the plan. (PMI, 2013)

d) **Expert Judgment：** as defined in 2.7.1.

2.7.6 RISK CONTROL

Risk control is the continuing process of reviewing the state of the risk once it has been identified, estimated, evaluated and responded to. "*Control Risks is the process of implementing risk response plans, tracking identified risks, monitoring residual risks, identifying new risks, and evaluating risk process effectiveness throughout the project."* (PMI, 2013) Risk control is a process of decision making for managing and/or reducing risk: its implementation, enforcement and re-evaluation from time to time, using the results of risk assessment as one input

This stage is the last of the risk management process; but can initiate the entire risk management process off again, if the risk under observation requires re-managing

"*Planned risk responses that are included in the risk register are executed during the life cycle of the project, but the project work should be continuously monitored for new, changing, and outdated risks."* (PMI, 2013) "*In some cases, changes in operations may redefine the risk, thus requiring different mitigation techniques."* (Leonard, 1995)

Re-managing could be for any number of reasons, such as a change of the nearby working area or a change of procedure or operation etc. These factors may re-define the risk, thus necessitating differing techniques to take account of the mitigating circumstances. "*Risk management should be a regular agenda item for project management meetings. The primary tool is the risk watch list. This is used to ensure all the important risks are examined."* (Cooper et al., 2005)

Leonard (1995) describes that monitoring must be continual, with the risks that are un-mitigated and designated as major requiring regular review. Benefits of the monitoring process include improved communications amongst departments and employees, increased disaster recovery planning, management skill development and more efficient budget planning. *"Monitoring must be continual; risks that are unmitigated are designate a review period, either annual or biennial. Situations designated "controlled risks" are also reviewed periodically to determine whether the mitigation methods are still effective."* (Leonard, 1995)

The inputs, tools and techniques, and outputs of Risk control process are depicted in Figure 2.19.

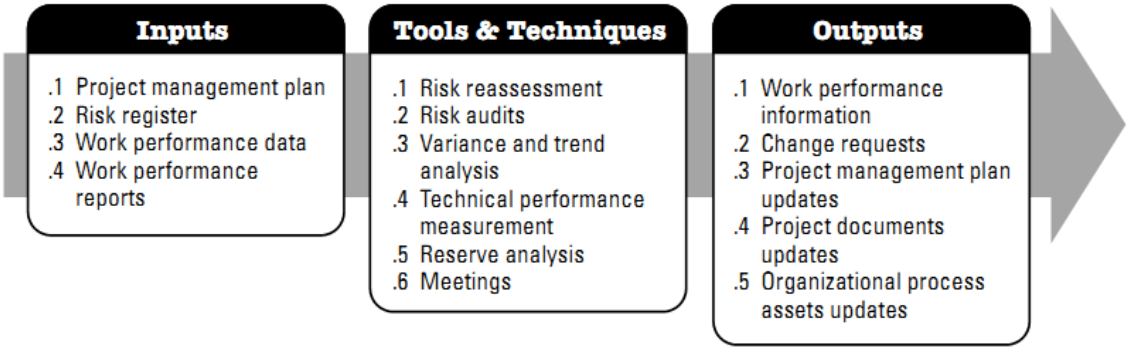

Figure 2.19 Risk Control: Inputs, tools & techniques, and outputs (PMI, 2013)

- **Risk Control: tools and techniques**

a) Risk reassessment

Control Risks often results in identification of new risks, reassessment of current risks, and the closing of risks that are outdated. Project risk reassessments should be regularly scheduled.

b) Risk Audits

Risk audits examine and document the effectiveness of risk responses in dealing with identified risks and their root causes, as well as the effectiveness of the risk management process.

c) Variance and trend Analysis

Many control processes employ variance analysis to compare the planned results to the actual results. Outcomes from these analyses may forecast potential deviation of the project at completion from cost and schedule targets.

d) Technical Performance Measurement

Technical performance measurement compares technical accomplishments during project execution to the schedule of technical achievement.

e) Reserve Analysis

Reserve analysis compares the amount of the contingency reserves remaining to the amount of risk remaining at any time in the project in order to determine if the remaining reserve is adequate.

f) Meetings

Project risk management should be an agenda item at periodic status meetings. The more often risk management is practiced, the easier it becomes. Frequent discussions about risk make it more likely that people will identify risks and opportunities. (PMI, 2013)

CHAPTER THREE

METHODOLOGY OF RESEARCH

In the previous chapters, detail concept about risk management in construction projects is discussed for full understanding of risk management. In this chapter, methods and techniques which are used to address the research objectives are discussed. Data collection procedure adopted for this research is described and information about target population and sample of the study is provided.

3.1 STUDY DESIGN

This thesis is non-intervention research type as it assesses the current risk management plan and compares it with standard risk management plan. It aims on showing the gap between the two that cause delay in project completion. The research follows a structure as shown in the figure.

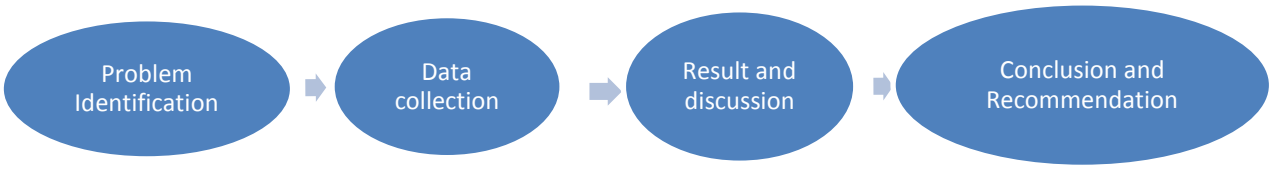

Figure 3.1 Outline of thesis

3.2 METHOD OF SAMPLING

The main concern of this study was to assess the practice of risk management in road projects under Ethiopian Road Authority, Jimma District. Therefore, out of the projects constructed during the past ten years, projects prone to delay have been analyzed for the case study. Data has also been gathered from stakeholders related with the aforementioned projects through questionnaire.

The sampling method used is incidental assignment non-probability sampling technique for the case study part as samples are taken from population because they are readily available. "*The term incidental or accidental applied to those samples that are taken because they are most frequently available*." (Singh, 2006)

On the other hand, purposive sampling technique is used for the questionnaire because samples are selected due to their importance to the particular study. "*The purposive sampling is selected by some arbitrary method because it is known to be representative of the total population, or it is known that it will produce well matched groups."* (Singh, 2006)

3.3 DATA COLLECTION

Two types of data collection techniques were used:

3.1.1 Data collection through questionnaire

The first data collection tool of this thesis to answer the research objectives is questionnaire. The structure of the questionnaire was designed generally to assess the practice of risk management by road construction participants. This was achieved by using literature review and the Project Management Institute's (PMI, 2013) guide to the Project Management Body of Knowledge (PMBOK). The aforementioned references were used as a checklist to assess the current practice of stakeholders concerning the input, tools and techniques and output of risk management process steps.

➢ Structure of the questionnaire

The questionnaire had an introductory letter and seven section described below.

- **Section one (Introduction):** respondents were asked to indicate their company name, work position, educational status, work experience in road project and their field of specialization.
- **Section two (Risk Management Plan):** general definition of "Risk" and "Risk Management" was given and respondents were asked about their current practice of risk management plan.
- **Section three (Risk Identification):** respondents were asked about their current practice concerning risk identification.
- **Section four (Risk Analysis):** respondents were asked about their current practice concerning qualitative and quantitative risk analysis.

- **Section five (Risk Response):** respondents were asked about their current practice concerning risk response.
- **Section six (Risk Control):** respondents were asked about their current practice concerning risk control.
- **Section seven (General):** respondents were asked to give recommendation on the idea of risk management. Respondents were also asked to provide their email address if they want to be addressed about the research findings.

➢ Respondents of the questionnaire

The questionnaires were distributed to consultants, contractors and engineers of the employer (Ethiopian Road Authority). According to the information gathered from ERA, Jimma District, ERA western region Addis Abeba, monthly progress reports and feasibility study documents; there are 7 contractors, 10 consultants and 1 employer (ERA) who participated in road projects under Jimma District which are completed in the past 10 years.

The researcher however was able to reach 14 companies including the employer at District and Head Office level. Some companies could not be reached by the researcher since some projects were completed few years ago and international companies do not have office in Ethiopia currently. In addition, some contractors and consultants are under restructuring and some have ceased to exist so the researcher could not reach them.

Questionnaires ranging from one up to three are collected from each company. From these, a total of twenty one questionnaires were distributed and collected from participants of contractors, consultants and engineers of the employer ERA.

Table 3.1 Respondent's profile for Questionnaires

Respondent's profile	**Number of respondents**
Contractor	8
Consultant	9
Employer	4
Total	**21**

Background information of respondents concerning educational status and work experience is summarized in Table 3.2.

Table 3.2 Summary of Educational status and Work Experience

Educational Status	**Number of Respondents / Work Experience in Road Projects**				**Total**
	< 1 year	**1-5 years**	**5-10 years**	**> 10 years**	
Master of Science	-	-	2	1	**3**
Bachelor of Science	2	4	9	3	**18**
Total	**2**	**4**	**11**	**4**	**21**

3.1.2 Data collection through case study

The second data collection tool of this thesis to answer the research objectives is case study. For this, documents like feasibility study, monthly reports and final reports of completed projects were referred to assess the practice of risk management in the road projects under Jimma District.

However, feasibility study of projects selected for case study was difficult to find because the projects are constructed in the past 10 years, and feasibility study was conducted 12-15 years back from now. Therefore, the researched faced difficulty to reach such data and was forced to conduct the case study using the available ones only. Similarly, in some projects, final progress reports are not yet complied and documented and the researcher could not reach them. Therefore only available reports are used for the case study.

3.4 STUDY VARIABLES

Key features of the study variables are:

a. Dependent variable
    - Risk management practice in road projects

b. Independent variable

- Analytical techniques
- Expert judgment
- Meetings
- Checklists
- Information gathering
- Risk cause and effect diagram
- Influence diagram
- Risk probability and impact matrix
- Risk urgency assessment
- Modeling and simulation
- Risk avoidance
- Risk transfer
- Risk mitigation
- Risk acceptance
- Risk audit
- Variance and trend analysis
- Technical performance measurement

CHAPTER FOUR
RESULT AND DISCUSSION

4.1 RISK MANAGEMENT PLAN IN ROAD PROJECTS

The first objective of this thesis was identification of risk management plan and practice among ERA projects. Out of the twenty one respondents; 9 respondents said their company uses a structured risk management plan while 12 respondents said they do not use structured risk management. On the other hand, all respondents have agreed that they do not have a separate risk management department to solely address the risk concern. As it can be seen in the questionnaire response and from information gathered through discussion with respondents during data collection, respondents have stated that they do not use a formally structured risk management plan.

Further analysis was made to assess practice of risk management plan in relation to inputs, tools and technique and outputs of risk management plan. The outcome of the survery is summarized in Tables 4.1, 4.2 and 4.3 below.

Table 4.1 Summary of Risk Management plan Input

Risk Management Plan Inputs	**Project management plan**	**Project Charter**	**Stakeholder register**	**Enterprise Environmental factors**	**Organization process assets**	**Average of reponses concerning Risk Management Plan Input**
Contractor's rating (%)	88	-	13	25	-	
Consultant's rating (%)	44	-	22	44	22	
Employer's rating (%)	100	-	-	25	-	
Weighted average	**71%**	**0%**	**14%**	**33%**	**10%**	**26%**

Table 4.2 Summary of Risk Management plan Tools and Technique

Risk Management Plan Tools and Techniques	**Analytical Techniques**	**Expert Judgement**	**Meeting**	**Average of reponses concerning Risk Management Plan Tools and Techniques**
Contractor's rating (%)	38	50	50	
Consultant's rating (%)	44	44	11	
Employer's rating (%)	50	25	50	
Weighted average	**43%**	**43%**	**33%**	**40%**

Table 4.3 Summary of Risk Management plan Outputs

Risk Management Plan Outputs	**Methodology of Risk Management**	**Roles and Responsibility of Risk Management team**	**Estimated Fund for Contingency and management reserve**	**Timing for Risk Management Process**	**Average of reponses concerning Risk Management Plan Outputs**
Contractor's rating (%)	50	25	0	0	
Consultant's rating (%)	67	22	0	11	
Employer's rating (%)	50	25	0	25	
Weighted average	**57%**	**24%**	**0%**	**10%**	**23%**

As it can be observed from the data analysis tables, respondents use 26% of Risk Mangement Plan inputs, 40% of Risk Mangement Plan Tools and Techniques and have 23% of Risk Mangemet Plan Output; which shows the low practice of risk management plan in road projects. This step should be continuously performed throughout the whole project in order to keep track of all potential risks as described in detail in the literature review.

4.2 RISK IDENTIFICATION IN ROAD PROJECTS

The second objective of this thesis was to assess the risk identification methodology being practiced in ERA projects. Therefore analysis was made to assess current practice in relation to inputs, tools and technique and outputs of risk identification. The outcome of the survery is summarized in Tables 4.4, 4.5 and 4.6 below.

Table 4.4 Summary of Risk Identification Input

Risk Identification Inputs	**Risk Mangement Plan**	**Cost Management Plan**	**Schedule Management Plan**	**Quality Management Plan**	**Human Resource Management Plan**	**Scope Baseline**	**Activity Cost Estimate**	**Activity Duration Estimate**	**Stakeholder Register**	**Project Documents**	**Procurement Documents**	**Enterprise Environmental Factors**	**Organization process assets**	**Average of reponses concerning Risk Identification Input**
Contractor's rating (%)	13	38	75	25	25	-	-	13	-	22	13	13	-	
Consultant's rating (%)	22	67	44	78	11	33	11	22	-	11	-	11	-	
Employer's rating (%)	50	50	50	50	-	-	25	-	-	25	25	-	-	
Weighted average	**24 %**	**52 %**	**57 %**	**52 %**	**14 %**	**14 %**	**10 %**	**14 %**	**0 %**	**19 %**	**10 %**	**10 %**	**0 %**	**21%**

Table 4.5 Summary of Risk Identification Tools and Technique

Risk Identification Tools and Technique	**Documentation Review**	**Information Gathering: Brainstorming**	**Information Gathering: Consensus of Experts**	**Information Gathering: Interviewing**	**Information Gathering: Root cause Analysis**	**Checklist Analysis**	**Assumption Analysis**	**Risk Cause and Effect Diagram**	**System or Process Flow Charts risk diagrams**	**Influence Diagrams**	**SWOT Analysis**	**Judgment of Experts**	**Average of reponses concerning Risk Identification Input**
Contractor's rating (%)	50	13	50	25	38	50	25	-	-	-	13	50	
Consultant's rating (%)	67	22	33	22	33	22	-	-	-	11	11	22	
Employer's rating (%)	50	25	25	-	-	25	-	25	-	-	-	25	
Weighted average	**67 %**	**19 %**	**38 %**	**19 %**	**29 %**	**38 %**	**10 %**	**5 %**	**0 %**	**5 %**	**10 %**	**33 %**	**23%**

Table 4.6 Summary of Risk Identification Outputs

Risk Identification Outputs	**Risk Register**	**Average of reponses concerning Risk Identification Outputs**
Contractor's rating (%)	13	
Consultant's rating (%)	56	
Employer's rating (%)	25	
Weighted average	**33%**	**33%**

As it can be observed from the data analysis tables, respondents use 21% of Risk Identification inputs, 23% of Risk Identification Tools and Techniques and have 33% of Risk Identification Output; which shows the low practice of risk identification in road projects. This step should be continuously performed throughout the whole project in order to keep track of all potential risks as described in detail in the literature review.

4.3 RISK ANALYSIS IN ROAD PROJECTS

The third objective of this thesis was to assess qualitative and quantitative risk analysis methodology being practiced in ERA projects. Therefore analysis was made to assess current practice in relation to inputs, tools and technique and outputs of qualitative and quantitative risk analysis. The outcome of the survery is summarized in Tables 4.7, 4.8, 4.9 and 4.10 below.

Table 4.7 Summary of Qualitative and Quantitative Risk Analysis Input

Qualitative and Quantitative Risk Analysis Inputs	**Risk Mangement Plan**	**Scope Baseline**	**Risk Register**	**Enterprise Environmental Factors**	**Organization process assets**	**Average of reponses concerning Qualitative and Quantitative Risk Analysis Input**
Contractor's rating (%)	25	25	25	13	13	
Consultant's rating (%)	-	22	33	44	22	
Employer's rating (%)	25	25	50	-	25	
Weighted average	**14%**	**24%**	**33%**	**24%**	**19%**	**23%**

Table 4.8 Summary of Qualitative Risk Analysis Tools and Technique

Qualitative Risk Analysis Tools and Technique	**Risk probability and impact assesement**	**probability and impact matrix**	**Risk data quality assessment**	**Risk Catagorization**	**Risk urgency assessment**	**Expert Judgement**	**Average of reponses concerning Qualitative Risk Analysis Tools and Technique**
Contractor's rating (%)	25	-	13	38	-	63	
Consultant's rating (%)	-	22	11	44	-	56	
Employer's rating (%)	25	-	50	25	-	50	
Weighted average	**14%**	**10%**	**19%**	**38%**	**0%**	**57%**	**23%**

Table 4.9 Summary of Quantitative Risk Analysis Tools and Technique

Quantitative Risk Analysis Tools and Technique	**Interview to quantify probability and impact of risk**	**Representation Techniques**	**Analysis: Sensitivity analysis**	**Analysis: Expected monetary value**	**Modeling and Simulation**	**Expert Judgement**	**Average of reponses conserning Quantitative Risk Analysis Tools and Technique**
Contractor's rating (%)	13	13	-	13	-	75	
Consultant's rating (%)	22	11	-	11	-	78	
Employer's rating (%)	25	50	-	25	-	50	
Weighted average	**14%**	**19%**	**0%**	**14%**	**0%**	**71%**	**20%**

Table 4.10 Summary of Risk Analysis Output

Risk Analysis Outputs	**Project documents update**	**Average of reponses conserning Risk Analysis Outputs**
Contractor's rating (%)	38	
Consultant's rating (%)	56	
Employer's rating (%)	50	
Weighted average	**48%**	**48%**

As it can be observed from the data analysis tables, respondents use 23% of Qualitative and Quantitative risk analysis inputs, 23% of Qualitative risk analysis Tools and Techniques, 20% of Quantitative risk analysis Tools and Techniques and have 48% of Risk Analysis Output; which shows the low practice of qualitative and quantitative risk analysis in road projects. This step should be continuously performed throughout the whole project in order to keep track of all potential risks as described in detail in the literature review.

4.4 RISK RESPONSE IN ROAD PROJECTS

The fourth objective of this thesis was to assess Risk Response methodology being practiced in ERA projects. Therefore analysis was made to assess current practice in relation to inputs, tools and technique and outputs of Risk Response. The outcome of the survey is summarized in Tables 4.11, 4.12, 4.13 and 4.14 below.

As it can be observed from the data analysis tables, respondents use 41% of Risk Response inputs, 36% of Risk Response Tools and Techniques for negative risks, 23% of Risk Response Tools and Techniques for positive risks and have 62% of Risk Response Output; which shows the low practice of risk response methods for positive and negative risk in road projects. This step should be continuously performed throughout the whole project in order to keep track of all potential risks as described in detail in the literature review.

Table 4.11 Summary of Risk Response Input

Risk Response Inputs	**Risk Mangement Plan**	**Risk Register**	**Average of reponses concerning Risk Response Input**
Contractor's rating (%)	13	63	
Consultant's rating (%)	22	56	
Employer's rating (%)	50	50	
Weighted average	**24%**	**57%**	**41%**

Table 4.12 Summary of Response Tools and Technique for Negative Risk

Response Tools and Technique for Negative Risk	**Risk Avoidance**	**Risk Transfer**	**Risk Mitigation**	**Risk Acceptance**	**Contingent response**	**Expert Judgement**	**Average of reponses concerning Response for Negative Risk**
Contractor's rating (%)	13	50	38	-	25	63	
Consultant's rating (%)	12	22	78	-	33	56	
Employer's rating (%)	75	25	75	-	50	50	
Weighted average	**24%**	**33%**	**67%**	**0%**	**33%**	**57%**	**36%**

Table 4.13 Summary of Response Tools and Technique for Positive Risk

Response Tools and Technique for Positive Risk	**Expliot**	**Enhance**	**Share**	**Accept**	**Average of reponses concerning Response for Positive Risk**
Contractor's rating (%)	13	38	13	38	
Consultant's rating (%)	-	22	11	44	
Employer's rating (%)	-	25	75	-	
Weighted average	**5%**	**29%**	**24%**	**33%**	**23%**

Table 4.14 Summary of Risk Analysis Output

Risk Response Outputs	**Project documents update**	**Average of reponses concerning Risk Response Outputs**
Contractor's rating (%)	50	
Consultant's rating (%)	78	
Employer's rating (%)	50	
Weighted average	**62%**	**62%**

4.5 RISK CONTROL IN ROAD PROJECTS

The fifth objective of this thesis was to evaluate risk monitoring and control mechanism being used in ERA road projects. Therefore analysis was made to assess current practice in relation to inputs, tools and technique and outputs of Risk Control. The outcome of the survery is summarized in Tables 4.15, 4.16 and 4.17 below.

As it can be observed from the data analysis tables, respondents use 29% of Risk Control inputs, 25% of Risk Control Tools and Techniques and have 73% of Risk Control Output; which shows the low practice of risk control method in road projects. This step should be continuously performed throughout the whole project in order to keep track of all potential risks as described in detail in the literature review.

Table 4.15 Summary of Risk Control Input

Risk Control Inputs	**Risk Mangement Plan**	**Risk Register**	**Work Performance Data**	**Work Performance Report**	**Average of reponses concerning Risk Control Input**
Contractor's rating (%)	13	38	13	38	
Consultant's rating (%)	11	22	44	44	
Employer's rating (%)	25	25	25	50	
Weighted average	**14%**	**29%**	**29%**	**43%**	**29%**

Table 4.16 Summary of Risk Control Tools and Technique

Risk Control Tools and Technique	**Risk Reassessment**	**Risk Audits**	**Variance and trend analysis**	**Technical Performance measurement**	**Reserve Analysis**	**Meeting**	**Average of reponses concerning Risk Control Tools and Technique**
Contractor's rating (%)	25	13	-	25	-	50	
Consultant's rating (%)	22	-	33	33	22	67	
Employer's rating (%)	-	25	25	25	-	25	
Weighted average	**19%**	**10%**	**19%**	**29%**	**19**	**52**	**25%**

Table 4.17 Summary of Risk Control Outputs

Risk Control Output	**Project Documents Update**	**Work performance information**	**change request**	**Organizational process assets update**	**Average of reponses concerning Risk Control Output**
Contractor's rating (%)	50	100	100	38	
Consultant's rating (%)	67	78	78	33	
Employer's rating (%)	100	100	100	75	
Weighted average	**67%**	**90%**	**90%**	**43%**	**73%**

4.6 GENERAL COMMENTS GATHERED FROM RESPONDENTS

Repondents have made a number of valuable comments concerning the importance of risk management for road projects. Their suggestion is listed below.

- Risk management is useful in managing both physical and financial activities to control project failures.
- Risk management plan is not accurately used on site so recommendation is made to bring the paperwork to site and be practiced well.
- Risk management is important tool to minimize risk and it is required to implement the tool in every organization.
- Significant number of risk is associated with road infrastructure development. Risk management should be practiced in different phase especially during design and implementation phase; risk should be analyzed and mitigated well.
- Companies use Quality Manual of ERA to evaluate overall quality of service and do not have separate system to analyze risk.
- Identification of possible risk areas are conducted through meeting with experts of contractors, consultants and other stakeholders.
- ERA has launched performance assessment of consultants which is under implementation in which design and supervision consultant staffs will be responsible for their responsible position.
- Risk management should be implemented in all stakeholders: contractor, consultants and employer in order to achieve project time and cost objectives.
- If risk management does not get attention in the construction industry; projects will keep suffering from those various risk events. Therefore, it should be considered.
- There is no organized risk management procedure in companies but it is important and should be implemented. However, there is no efficient expert to give training in this area so this needs attention.

4.7 CASE STUDY OF DELAYED PROJECTS

From the report found from Ethiopian Road Authority, Jimma District, there are Ten (10) projects that were constructed in the past 10 years as shown in Table 1.2. however, feasibilbility study of two projects (Jimma-Bonga-Mizan and Wacha-Maji) was accessible to the researcher. On the other hand, final completion report of four projects (Dembi- Bedele, Metu- Gore, Gore- Bure- Gambela and Wacha- Maji) was accessible.

However, both the feasibility study and completion report of respective projects have similarity to each other as observed from detail review of reports and discussion with ERA engineers. Therefore, as a representative sample, Wacha-Maji project is selected for case study as it is the only project available to the researcher among all; with completed information like EIA, SIA and final completion report documents.

➢ Wacha-Maji road project

The project constists of the upgrading of the existing gravel surfaced road by some realignment improvements to the horizontal curve and the vertical profile to accommodate the design speed of 60km/hour and to meet road safety requirments and to a 7-meter carriage way width. The surfacing work is gravel wearing course with double surface tratment at intermittent sections of the road length on steep grades of mountainous terrains and also in town sections. The contract includes clearing and grubbing activity, bed preparation, embankment construction, capping layer construction, gravel wearing course, sub-base course laying, surface treatment and the construction of major and minor drainage structres in accordance to the quality requirement of the signed contract document.

The overall assesment of the projects concerning risk management is summarized in Table 4.18 below. As shown in the table, risk management plan is not being practiced having a formal structure but in the documents, some components of risk management plan are being practiced.

Table 4.18 Risk Management practice for Wacha-Maji Project

Stages of Risk Management	**Method Used**	**Assessment of the Project**
Planning Risk Management	EIA and SIA	There is no structured Risk Management Plan document used for the project. (EIA and SIA studies). However risk management should be studied as part of project management plan.
Identifying Risks	Risk Register	Incoming and outgoing corespondences made during project duration are recorded for future reference. (Section 7.7, Completion report) But there is no document containing register of risks anticipated to occur during construction.
Performing Qualitative Risk Analysis	Work Breakdown Structure (WBS)	Techniques employed in carrying out activities is shown using WBS (Section 5.2, Completion report) but there is no Risk Breakdown Structure (RBS).
Performing Quantitative Risk Analysis	Quantitative analysis	Quantitative analysis is undertaken for project feasibility concerning traffic forecast using Sensitivity analysis, Economic Internal Rate of Return (EIRR), Net Present Value (NPV) and benefit to cost ratio (B/C). (Section 6.3, EIA report). But such analysis should be implemented for all types of risk and thier potential impact on the project.
Planning Risk Response	Risk Transfer	The contrator has provided valid insurance for Contractor's and Engineer's vehicles, Contractor's plant and equipment, Insurance of employee, Insurance of works and Third party insurance in all stages of the project duration. (Section 4.2 Completion report)
	Risk Mitigation	Positive and Negative impact to the project are presented in (Section 10.5, Completion report). But except risk mitigation, other response methodologies are not introduced.
Controlling Risk	Meetings	Meetings were held to review claims and issues raised in the project. (Section 7.5 Completion report)
	Technical Performance Measurement	Quality assurance system to ensure works are implemented according with specified standard and design. (Section 8.1, Completion report) but other risk monitoring techniques like risk audit, reassessment and variance analysis should also be practiced.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The main objective of this research was to assess the risk management techniques being used currently in road projects and compare this technique with standard risk management plan to show the gap between the two that is causing failure in achieving project objectives. During the assessment, the following findings were found.

- Stakeholders are using some components of risk management but not all. Risks are being managed every day in the industry, but not in such a structured way as the literature describes.
- Questionnaire response revealed that percentage usage of tools and techniques of risk management in comparison with literature are: Risk management plan (40%), Risk Identification (23%), Qualitative risk analysis (23%), Quantitative risk analysis (20%), Positive Risk response (23%), Negative Risk response (36%) and Risk control (25%).
- Both data collection tools: Questionnaire and Case study proved that risk management is not practiced in road projects having its own structure. But risks are studied indirectly using techniques like EIA, SIA and Quality management system for risk identification and assessment; insurance for risk response; and meeting as well as checklist for risk control.
- Social and Environmental impact assessment are done to assess impact of the road construction project on the project area. And risks that may occur during the construction phase are not planned for, as well as their impact on project objectives of time, cost and quality. Therefore Risk management is important to detect risks with the biggest impact on project deliverables and eliminate or mitigate by taking appropriate action.
- Respondents have understood and stressed the importance of risk management for the construction industry and suggested its implementation in the near future.

The risk management process ultimately improves the risk environment; in turn, brings advantages like increased profits, less time loss incidents and better quality.

5.2 RECOMMENDATION

For the road construction industry, it is recommended to prepare risk management manual that would be developed including basic theoretical information as well as ready-to-use guidance for each risk management process. In this regard, risk management plan template is attached on Annex-1 of this thesis. The researcher believes that it is useful to give incite of how to start dealing with risk management.

Construction related risks could be managed if Risk management, in terms of inputs, methodology and outputs will be properly defined in the project management plan and practiced as well. The following are detailed recommendations in respect to research objectives:

- For the flow of information in projects, tools and techniques like analytical techniques, expert judgment and meeting should be undertaken to prepare detailed risk management plan and its components.
- Detailed information gathering methods should be employed for risk identification. Risk register document should be prepared prior to the start of each project, reviewed during the construction phase and become available as a reference for other projects.
- Further analysis should be done to measure risk through qualitative and quantitative risk assessment methods like probability and impact matrix, modeling and simulation, EMV analysis and sensitivity analysis.
- Risk response mechanisms for positive and negative risks should be implemented. Risk should be allocated properly to construction participants.
- Risk control and monitoring should be continual process throughout the project life cycle in order to re-evaluate residual risk and determine whether mitigation methods are still effective.

Interested participants of this study will be forwarded the findings of this research through the email address they provided on the questionnaire. Therefore it is recommended for them to implement risk management in their respective company.

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ANNEX-1 Risk Management plan Template

PMdocs
Project Management Docs

PROJECT RISK MANAGEMENT PLAN TEMPLATE

RISK MANAGEMENT PLAN
<PROJECT NAME>

COMPANY NAME
STREET ADDRESS
CITY, STATE ZIP CODE

DATE

TABLE OF CONTENTS

INTORDUCTION

This section explains why risks exist and highlights the purpose and importance of the risk management plan. It provides a general description of why risk management is essential to effectively managing a project and describes what is needed before risk management can begin.

As organizations begin new projects they begin operating in an area of uncertainty that comes along with developing new and unique products or services. By doing so, these organizations take chances which results in risk playing a significant part in any project. The purpose of the risk management plan is to establish the framework in which the project team will identify risks and develop strategies to mitigate or avoid those risks. However, before risks can be identified and managed, there are preliminary project elements which must be completed. These elements are outlined in the risk management approach.

This project is considered a medium risk project as it has an overall risk score of 24 on a scale from 0 to 100. The project risk score is the average of the risk scores of the most significant risks to this project. A risk score below 16 is low risk project, a score between 16 and 45 is a medium risk project and a score above 45 is a high risk project.

Before risk management begins it is imperative that a foundation is established for providing structured project information, thus, the following project elements were completed and defined prior to developing this Risk Management Plan:

- Define work scope, schedule, resources, and cost elements
  - Develop project WBS/WBS dictionary
  - Develop master schedule and detailed schedules
  - Estimate project cost and finalize budget
  - Identify required and available resources
  - Establish performance measurement metrics
- Define minimum and maximum baseline thresholds
  - Schedule
  - Resources
  - Cost
- Baseline reporting requirements
  - Format
  - Frequency of distribution
  - Distribution list
- Define Risk Management Roles and Responsibilities
  - Project Manager chairs the risk assessment meetings
  - Project team participates in risk assessment meetings and members serve as meeting recorder and timekeeper
  - Key stakeholders participate in risk assessment meetings
  - Project Sponsor may participate in risk assessment meetings

TOP THREE RISKS

It is important to explicitly state the top three risks to the project in the Risk Management Plan. This will make management aware of the top risks for the project and the nature of the risks.

The top three high probability and high impact risks to this project are:

Delay in Server Equipment
Due to a manufacturer's production backlog, the servers are not available for large scale application testing causing a delay in the project schedule. The project manager will mitigate this risk by using servers from the backup data center if needed.

Fiber Optics Connection Not Completed
Due to construction delays in installing the fiber optic cable between the data center and the headquarters facilities users will not have a high speed connection between their site and the datacenter resulting in slow responses from the application making it unusable. The Project Manager will implement a site to site broadband Ethernet radio network between the data center and headquarters facility.

Network Operations Center (NOC) Not Appropriately Staffed
Due to lead times associated with hiring and training additional staff, the NOC does not have the necessary staff to monitor the additional bandwidth associated with the project resulting in a delay to the project schedule. The project manager will mitigate this risk by working with the NOC to create an alternate work schedule to compensate for the staffing shortage until additional staff hiring and training is complete.

RISK MANAGEMENT APPROACH

This section provides a general description for the approach taken to identify and manage the risks associated with the project. It should be a short paragraph or two summarizing the approach to risk management on this project.

The approach we have taken to manage risks for this project included a methodical process by which the project team identified, scored, and ranked the various risks. The most likely and highest impact risks were added to the project schedule to ensure that the assigned risk managers take the necessary steps to implement the mitigation response at the appropriate time during the schedule. Risk managers will provide status updates on their assigned risks in the bi-weekly project team meetings, but only when the meetings include their risk's planned timeframe. Upon the completion of the project, during the closing process, the project manager will analyze each risk as well as the risk management process. Based on this analysis, the project manager will identify any

improvements that can be made to the risk management process for future projects. These improvements will be captured as part of the lessons learned knowledge base.

RISK IDENTIFICATION

This section explains the process by which the risks associated with this project were identified. It should describe the method(s) for how the project team identified risks, the format in which risks are recorded, and the forum in which this process was conducted. Typical methods of identifying risks are expert interview, review historical information from similar projects and conducting a risk assessment meeting with the project team and key stakeholders.

For this project, risk identification was conducted in the initial project risk assessment meeting. The method used by the project team to identify risks was the Crawford Slip method. The project manager chaired the risk assessment meeting and distributed notepads to each member of the team and allowed 10 minutes for all team members to record as many risks as possible.

Expert Interview
Two Expert Interviews were held for this project. The interviews revealed several risks which were then mitigated by making changes to the project plan. The remaining risks are included in the Risk Register.

Risk Assessment Meeting
A risk assessment meeting was held with key team members and stakeholders. The risks identified during this meeting were added to the project plan and Risk Register.

Historical Review of Similar Projects
The project team reviewed the history of similar projects in order to determine the most common risks and the strategies used to mitigate those risks.

RISK QUALIFICATION AND PRIORITIZATION

Once risks are identified it is important to determine the probability and impact of each risk in order to allow the project manager to prioritize the risk avoidance and mitigation strategy. Risks which are more likely to occur and have a significant impact on the project will be the highest priority risks while those which are more unlikely or have a low impact will be a much lower priority. This is usually done with a probability – impact matrix. This section explains risks were qualified and prioritized for this project. For more information on how to qualify and prioritize risks refer to our ***Risk Assessment Meeting Guide.***

In order to determine the severity of the risks identified by the team, a probability and impact factor was assigned to each risk. This process allowed the project manager to

prioritize risks based upon the effect they may have on the project. The project manager utilized a probability-impact matrix to facilitate the team in moving each risk to the appropriate place on the chart.

Once the risks were assigned a probability and impact and placed in the appropriate position on the chart, the recorder captured the finished product and the project manager moved the process on to the next step: risk mitigation/avoidance planning.

RISK MONITORING

This section should discuss how the risks in the project will be actively monitored. One effective way to monitor project risks is to add those risks with the highest scores to the project schedule with an assigned risk manager. This allows the project manager to see when these risks need to be monitored more closely and when to expect the risk manager to provide status updates at the bi-weekly project team meetings. The key to risk monitoring is to ensure that it is continuous throughout the life of the project and includes the identification of trigger conditions for each risk and thorough documentation of the process.

The most likely and greatest impact risks have been added to the project plan to ensure that they are monitored during the time the project is exposed to each risk. At the appropriate time in the project schedule a Risk Manager is assigned to each risk. During the bi-weekly project team meeting the Risk Manager for each risk will discuss the status of that risk; however, only risks which fall in the current time period will be discussed. Risk monitoring will be a continuous process throughout the life of this project. As risks approach on the project schedule the project manager will ensure that the appropriate risk manager provides the necessary status updates which include the risk status, identification of trigger conditions, and the documentation of the results of the risk response.

RISK MITIGATION AND AVOIDANCE

Once risks have been qualified, the team must determine how to address those risks which have the greatest potential probability and impact on the project. This section explains the considerations which must be made and the options available to the project manager in managing these risks.

The project manager has led the project team in developing responses to each identified risk. As more risks are identified, they will be qualified and the team will develop avoidance and mitigation strategies. These risks will also be added to the Risk Register and the project plan to ensure they are monitored at the appropriate times and are responded to accordingly.

The risks for this project will be managed and controlled within the constraints of time, scope, and cost. All identified risks will be evaluated in order to determine how they

affect this triple constraint. The project manager, with the assistance of the project team, will determine the best way to respond to each risk to ensure compliance with these

cases it may be necessary to allow flexibility to one of the project's constraints. Only one of the constraints for this project allows for flexibility as a last resort. If necessary, funding may be added to the project to allow for more resources in order to meet the time (schedule) and scope constraints. Time and scope are firm constraints and allow for no flexibility. Again, the cost constraint is flexible only in extreme cases where no other risk avoidance or mitigation strategy will work.

RISK REGISTER

Every project must maintain a risk register in order to track risks and associated mitigation strategies. This section describes the risk register criteria as well as where the risk register is maintained and how these risks are tracked in the project schedule.

The Risk Register for this project is a log of all identified risks, their probability and impact to the project, the category they belong to, mitigation strategy, and when the risk will occur. The register was created through the initial project risk management meeting led by the project manager. During this meeting, the project team identified and categorized each risk. Additionally, the team assigned each risk a score based on the probability of it occurring and the impact it could potentially have. The Risk Register also contains the mitigation strategy for each risk as well as when the risk is likely to occur.

Based on the identified risks and timeframes in the risk register, each risk has been added to the project plan. At the appropriate time in the plan—prior to when the risk is most likely to occur—the project manager will assign a risk manager to ensure adherence to the agreed upon mitigation strategy. The each risk manager will provide the status of their assigned risk at the bi-weekly project team meeting for their risk's planned timeframe.

The Risk Register will be maintained as an appendix to this Risk Management Plan.

SPONSOR ACCEPTANCE

Approved by the Project Sponsor:

_____ Date: _____

<Project Sponsor>
<Project Sponsor Title>

This free Project Risk Management Plan Template is brought to you by

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ANNEX-2 Questionnaire

Questionnaire

This research is being conducted as partial fulfilment of Master's Degree in Construction Engineering and Management with the title:

ASSESSMENT OF RISK MANAGEMENT IN ROAD PROJECTS UNDER ETHIOPIAN ROAD AUTHORITY: CASE STUDY ON JIMMA DISTRICT.

The purpose of this questionnaire is to gather information from selected stakeholders in order to assess the risk management techniques being used currently in road projects and compare this technique with standard risk management plan to show the gap between the two that is leading projects to time overrun.

The results of this survey will be kept confidential and used for academic purpose only. Respondent's name and organization's name will be kept anonymous. However, the outcome of the research can be made available to you if you desire so. The respondents' participation is voluntary.

Your participation is highly valuable for the outcome of this research. I appreciate your positive consideration in responding to this questionnaire and assisting me in my research efforts. If you have any questions please call on +251912050190 or email at meaza.ketaw@yahoo.com

Thank you for your Cooperation!

Meazadingil Shewanketaw
(Student, Msc. in Construction Engineering and Management)
Jimma Institute of Technology, Civil Engineering department
Jimma University

Section-1 Introduction

1.1 Name of company you are working in ……
1.2 Position……
1.3 Educational status
Bsc.☐ Msc.☐ PhD☐ Others……
1.4 Work experience in Road construction
< 1 year ☐ 1 - 5 years ☐ 5 - 10 years ☐ >10 years ☐
1.5 Field of specialization……..

Section-2 Risk management plan

Risk is defined as: *"hazard, danger, chance of loss, failure or injury; the degree of probability of loss; a person, thing or factor likely to cause loss or danger."*
(Chambers dictionary)

Risk Management *is one of the 10 pillars of knowledge area building project management which are: Integration management, Scope management, Time management, Cost management, Quality management, Human resource management, Communication management, Risk management, Procurement management and Stakeholder management.*
(PMBOK, 2013)

Risk Management *includes the process of conducting risk managment planning, identification, analysis, response planning and controllong risk on a project. The objectives of project risk management are to increase the likelihood and impact of positive events and decrease the likelihood and impact of negative events in the project.*
(PMBOK, 2013)

*****Please tick in the boxes shown below about your current practice of risk management**

2.1 As one of ERA road project stakeholders, does your company use a **structured risk management plan**?
Yes ☐ No ☐
2.2 Does your company have a separated **risk management** department?
Yes ☐ No ☐
2.3 Which of the following **risk management plan** inputs do you use?
☐ Project management plan (document that defines the basis of all project work)
☐ Project charter (document that formally authorize existence of a Project)
☐ Stakeholder register (identification and classification of project Stakeholders)
☐ Enterprise environmental factors (condition that influence project program)
☐ Organizational process assets (processes & policies specific to an organization)
2.4 Which of the following **risk management plan** methods do you use?
☐ Analytical techniques (evaluate & analyze outcome based on possible variations)
☐ Expert judgment (individuals with specialized knowledge on the subject area)
☐ Meetings to develop the risk management plan
2.5 Which of the following **risk management plan** outputs do you have?
☐ Methodology for the approaches, tools, and data sources of risk management
☐ Roles and responsibilities of risk management team members

☐ Estimate funds needed for application of contingency and management reserves
☐ Timing when and how often the risk management processes will be performed

2.6 If you use a different approach for risk management planning, please describe it below.

……..
……..
…….
…….

Section-3 Risk Identification

3.1 Which of the following **risk identification** inputs do you use?

☐ Risk management plan
☐ Cost management plan
☐ Schedule management plan
☐ Quality management plan
☐ Human resource management plan
☐ Scope baseline (project major deliverables, assumptions and constraints & WBS)
☐ Activity cost estimates
☐ Activity duration estimates
☐ Stakeholder register (identification and classification of project Stakeholders)
☐ Project documents (project charter, project schedule, checklist)
☐ Procurement documents (if the project requires external procurement of resource)
☐ Enterprise environmental factors (condition that influence project program)
☐ Organizational process assets (processes & policies specific to an organization)

3.2 Which of the following **risk identification** methods do you use?

☐ Documentation reviews
☐ Information gathering through brainstorming,
☐ Information gathering through consensus of experts
☐ Information gathering through interviewing
☐ Information gathering through root cause analysis
☐ Checklist analysis through knowledge accumulated from previous projects
☐ Assumptions analysis (risks to the project from inaccuracy of assumptions)
☐ Risk cause and effect diagrams
☐ System or process flow charts risk diagrams
☐ Influence diagrams; graphical representation of variables and outcomes
☐ SWOT analysis; examine project strengths, weaknesses, opportunities, and threats
☐ Judgment of experts with relevant experience with similar projects

3.3 Do you have risk register document resulting from **risk identification** process?

Yes ☐ No ☐

3.4 If you use a different approach for **risk identification**, please describe it below.

……..
……..
…….
…….

Section-4 Risk Analysis

4.1 Which of the following **risk analysis** inputs do you use?

☐ Risk management plan
☐ Scope baseline (project major deliverables, assumptions and constraints & WBS)
☐ Risk register (information used to assess and prioritize risks)

- ☐ Enterprise environmental factors (condition that influence project program)
- ☐ Organizational process assets (processes & policies specific to an organization)

4.2 Which of the following **qualitative risk analysis** methods do you use?

- ☐ Risk probability and impact assessment
- ☐ Probability and impact matrix
- ☐ Risk data quality assessment (evaluate usefulness of data for risk management)
- ☐ Risk categorization (by sources of risk, area of project affected or project phase)
- ☐ Risk urgency assessment (Risks requiring near-term response)
- ☐ Expert judgment (having experience with similar and recent projects)

4.3 Which of the following **quantitative risk analysis** methods do you use?

- ☐ Interviewing based on experience to quantify probability and impact of risks
- ☐ Representation techniques (e.g. probability distributions of duration and cost)
- ☐ Analysis and modeling through sensitivity analysis of risks with potential impact
- ☐ Analysis and modeling through expected monetary value analysis
- ☐ Modeling & simulation of uncertainties into their potential impact on objectives
- ☐ Expert judgment (having experience with similar and recent projects)

4.4 Do you make project documents updates based on the **risk analysis** methods?

Yes ☐ No ☐

4.5 If you use a different approach for **risk analysis**, please describe it below.

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Section-5 Risk Response

5.1 Which of the following **risk response** inputs do you use?

- ☐ Risk management plan
- ☐ Risk register (information used to assess and prioritize risks)

5.2 Which of the following negative risks or **threats response** methods do you use?

- ☐ Risk avoidance (eliminate the threat or protect the project from its impact)
- ☐ Risk transfer (shift the impact of a threat to a third party by insurance, warranty)
- ☐ Risk mitigation (reduce the probability of occurrence or impact of a risk)
- ☐ Risk acceptance (acknowledge the risk and not take action unless the risk occur)

5.3 Which of the following positive risks or **opportunities response** methods do you use?

- ☐ Exploit (where the organization ensure that the opportunity definitely happens)
- ☐ Enhance (increase the probability and/or the positive impacts)
- ☐ Share (allocating some or all of the ownership of the opportunity to a third party)
- ☐ Accept (take advantage of the opportunity if it arises, but not actively pursuing it)

5.4 Which of the following **risks response** methods do you use?

- ☐ Contingent response strategies (designed for use only if certain events occur)
- ☐ Expert judgment (having experience with similar and recent projects)

5.5 Do you make project documents updates and project management plan updates based on the **risk response** methods?

Yes ☐ No ☐

5.6 If you use a different approach for **risk response**, please describe it below.

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Section-6 Risk Control

6.1 Which of the following **risk control** inputs do you use?

- ☐ Risk management plan
- ☐ Risk register (information used to assess and prioritize risks)
- ☐ Work performance data (Deliverable status, Schedule progress, Costs incurred)
- ☐ Work performance reports (variance analysis, earned value data, and forecasting)

6.2 Which of the following **risk control** methods do you use?

- ☐ Risk reassessment (regularly scheduled)
- ☐ Risk audits (examine and document the effectiveness of risk responses & RMP)
- ☐ Variance and trend analysis (compare the planned results to the actual results)
- ☐ Technical performance measurement (compares accomplishments to schedule)
- ☐ Reserve analysis (amount of contingency risk reserve remaining to the project)
- ☐ Meetings (about project risk management at periodic status meetings)

6.3 Do you make project documents updates and project management plan updates based on the **risk control** methods?

Yes ☐ No ☐

6.4 Do you use work performance information to **monitor and control** project work?

Yes ☐ No ☐

6.5 Do you make change requests recommending corrective or preventive action to the project management plan?

Yes ☐ No ☐

6.6 Do you make Organizational process assets updates based on the **risk control** methods?

Yes ☐ No ☐

6.7 If you use a different approach for **risk control**, please describe it below.

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Section-7 General

7.1 If you would like to expand on idea of **risk management** and recommend its importance for road projects, please describe it here.

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7.2 If you want to be addressed about findings of this research, please provide your email address here……

I would like to thank you very much for taking time to respond this questionnaire and helping me progress with my Msc. I wish you every success for the future.