RISKS AND MITIGATIONS ASSOCIATED WITH INFRASTRUCTURE DEVELOPMENT PROJECTS IN SOUTH AFRICA

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By

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Declaration

I, Frans Phetole Kudumela, Student number 920414806 hereby declare that the minor dissertation titled “Risks and mitigations associated with infrastructure development projects in South Africa” submitted in partial fulfillment of the Degree Magister Ingeneriae: Engineering Management, Faculty of Engineering and the Built Environment at the University of Johannesburg, apart from the help recognized, is my own original work and has not been submitted to another university or institution of higher education for a degree.

Abstract

Infrastructure development describes a group of activities that contribute towards the positive outcome of socio-economic conditions for communities. The two commonly known types of infrastructure are economic infrastructure and social infrastructure. Economic infrastructure promotes economic activities through the provision of physical assets such as power stations (electricity), telecommunication networks, roads, highways, railways, airports etc. Social infrastructure contributes to the welfare of communities by promoting education, healthcare and cultural norms of the population. Though infrastructure plays an important role in the livelihood of communities, there have been instances whereby infrastructure development projects are overshadowed by risks that impede their successful implementation.

Some infrastructure development projects in South Africa showed evidence of been negatively affected by risks. Thus the purpose of this research study is to identify infrastructure development risks and mitigations in South Africa. A questionnaire survey was used to collect data from professionals involved in the implementation of infrastructure projects. The questionnaire contained a list of risks identified from literature, and respondents were asked to identify risks that they have encountered while implementing infrastructure projects and provide mitigations that were implemented.

The results of the study revealed that infrastructure development risks encountered in South Africa are similar to risks experienced in other parts of Africa and the rest of the world. Many professionals in the industry associate with performance risks and inadequate skills capacity risks. Political risks and corruption have also been identified by a large number of the participants, followed by commercial and lack of funding risks. Financial risk and economic risks were identified by a small number of participants, which indicates that such risks are seldom experienced on infrastructure development projects in South Africa. Risk mitigations were identified for each of the identified risks by the research participants.

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List of Abbreviations

BBBEE ..... Broad-Based Black Economic Empowerment
COSATU ..... Congress of South African Trade Unions
CSIR ..... Council for Scientific and Industrial Research
DBSA ..... Development Bank of Southern Africa
FIFA ..... Fèdèration Internationalè dè Football Association
GDP ..... Gross Domestic Product
GFIP ..... Gauteng Improvement Freeway Improvement Project
IIP ..... Infrastructure Investment Programme
IMESA ..... The Institution of Municipal Engineering of Southern Africa
MDG ..... Millennium Development Goals
NDP ..... National Development Plan
OUTA ..... Opposition to Urban Tolling Alliance
PPP ..... Public-Private Partnership
R&D ..... Research and Development
RSA ..... Republic of South Africa
SA ..... South African
SANRAL ..... South African National Roads Agency Limited
TIF ..... Tax Increment Financing
USA ..... United States of America

1. Chapter 1: Introduction

This chapter aims to present a brief history of South Africa, definition of infrastructure, the problem statement, research aims and objectives, research questions, and research benefits.

1.1 South African history

The Republic of South Africa (RSA) is located at the southern tip of the African continent, and held its first democratic elections in April 1994, after enduring decades of struggle under the oppressive rule of the colonial and apartheid regime. During the apartheid era, local government entities were separated and allocated based on racial profiling. The fragmentation and separation of racial groups was aimed at enforcing apartheid policies that restricted economic activities, land ownership and access to basic services in African townships [**1**]. Some of the services that the African townships were deprived of include sanitation, access to clean water, electricity, telecommunications, refuse collection, healthcare, education, and housing.

Today RSA consists of a diverse inclusive population of at least 54 million people of different races, nationalities and cultures [**2**]. In South Africa there are nine provinces, which are governed by the national, provincial and local spheres of government to deliver services to the population at large [**3**]. The South African government post 1994 is responsible for enforcing the constitution in building a democratic country with basic human rights, without discrimination based on race, religion, gender, and nationality [**4**]. In this quest for building a democratic country, the government is faced with the challenge of removing the negative effects caused by the policies of the colonial and apartheid government prior to April 1994 [**5**]. Though there are challenges, progress has been made with respect to the provision of social and economic infrastructure.

It is clear from this discussion that South Africa has experienced hardships, and the country is now in a state of attempting to improve access to basic services through the provision of the necessary infrastructure. The next section defines the concept of infrastructure and its importance for the wellbeing of communities around the world.

1.2 Defining infrastructure

Infrastructure development describes a group of activities that contribute towards the positive outcome of socio-economic conditions for communities, and two distinctions of infrastructure relate to social and economic infrastructure [**6**]. The development bank of Southern Africa (DBSA) [**7**] describes social infrastructure as related to the provision of basic human services such as healthcare, water supply, sanitation, education, information and welfare. Economic infrastructure also known as physical infrastructure is associated with the provision of energy and power, transportation, and communication networks [**6**]. Both these spheres of infrastructure contribute to the well being of communities around the world. Increase in infrastructure development has been directly linked ideally to an increase in the gross domestic product (GDP) [**8**]. The availability and quality of infrastructure influence the level of development and poverty reduction in communities [**7**].

Infrastructure has been defined as physical assets that facilitate the improvement of social and economic conditions in communities. Infrastructure includes physical assets such as schools, hospitals, housing, roads, power stations, telephone lines, water pump stations, water purification plants, farm stables, landfill sites, satellites, network masts, pipeline, sewer treatment plants etc. Since infrastructure assets are of great importance, they need to be provided without any impediments. The next section discusses the problem area with regards to risks or impediments that affect the development of infrastructure in South Africa.

1.3 Problem area

Large infrastructure development projects capture the attention of the public in great numbers. Whether such projects are implemented by government alone or through public private partnerships, the public is still interested in the outcome of such projects. Thus any negative impact on the projects is easily detected in the public domain. In South Africa there are such cases, whereby projects seem to be affected by negative factors. Such projects include the new Eskom's Medupi power station construction project, SANRAL's Gauteng freeway improvement project (GFIP) and the 2010 FIFA World cup stadiums. Though these projects are hampered by

some negative factors they are meant to have a positive contribution towards infrastructure development and the livelihood of those living in South Africa.

Eskom's Medupi power station in Lephalale Limpopo province created more than 14 005 skilled and unskilled jobs, more than 995 houses were built, water and electricity infrastructure was also upgraded, and the value of property in the area increased two fold [**9**]. During the preparations to host the 2010 FIFA World Cup, it was estimated that the South African government together with the public sector will create more than 160 000 direct and indirect jobs, and see at least € 2.7 billion generated in terms of economic activities [**10**].

The Gauteng Freeway Improvement project was initiated to address high traffic volumes on Gauteng freeways, the high traffic volumes usually resulted in congestion leading to more time spent in traffic, loss of production time at work, driver fatigue, less family time etc. [**11**]. Jerome [**12**] states that government institutions which continuously invest in the development of infrastructure will see a positive growth in economic and social development. Such infrastructure also aid in the reduction and elimination of poverty in developing countries.

During construction of the 2010 FIFA World cup stadiums and related infrastructure, construction costs were initially estimated at R2.3 billion, and were later escalated to R39.3 billion, which was to be paid by the government using public funds [**13**]. The Eskom Medupi power station construction project commenced in 2007, with the first unit expected to be online by the end of 2013 [**14**]. The completion date for the project has since changed and the first unit was expected to go online in December 2014. The original cost for the construction of the Medupi power station was estimated at around R50 billion, and it is envisaged that the construction costs will eventually amount to over R150 billion [**14**] .

From this discussion it can be deduced that infrastructure development projects in South Africa experience impediments to their successful implementation. The next section discusses the problem statement to try and find measures of controlling factors that impede the successful delivery of infrastructure development projects in South Africa.

1.4 Problem statement

Well developed infrastructure is important to enable nations to prosper both socially and economically [**15**]. Though this is the case, infrastructure development projects have been found to be overshadowed by challenges that impede their successful delivery. McKinsey and Company [**16**], highlighted that infrastructure development projects are prone to exceed budgets, delayed completion, lack of funding, and skills. Clements and Gido [**17**], refer to factors that may prevail which will impede the accomplishment of a positive outcome on a project as risk. Clements and Gido [**17**], also states that it is important to note that risk is inherent in every project, thus it is necessary for project stakeholders to perform risk management through proper risk identification, risk assessment, risk response planning, and risk monitoring. In a development report by the World Bank [**18**], it is stated that if risk management is well implemented on infrastructure development projects, the project success rate increases, while decreasing negative outcomes.

It is evident that infrastructure development projects in South Africa are also overshadowed by risk factors that impede their successful delivery. Thus in order to control the risk factors, it is important to initially identify the risks. Once the risks have been identified, potential mitigations may be identified. The statement of the problem is as follows:

"If knowledge is available about infrastructure development project risks and mitigations it can be used for risk management on South African infrastructure development projects".

The next section presents research objectives to aid in addressing the research problem.

1.5 Research objectives

This research study aims to identify risks associated with infrastructure development projects in South Africa. Knowing the risks associated with infrastructure development projects in South Africa will aid in identifying possible risk mitigations, and this will generate useful knowledge for practitioners when managing project risks. The next section presents research questions, which will aid in achieving the research objectives.

1.6 Research questions

The problem statement discussed in section 1.4 prompt one to ask the following questions about infrastructure development projects:

- What are the risks associated with infrastructure development projects?
- What are the mitigations that can be implemented to the identified risks, to aid in decreasing undesired outcomes and increase project success?

The next section discusses benefits of conducting this research with regards to infrastructure development risks and mitigations in South Africa.

1.7 Research benefits

The world is changing, and opportunities are increasingly presenting themselves to developing countries around the world; with these opportunities there is also the possibility of old risks and new risks resurfacing [**18**]. Risk is inherent in every project, and for countries to take advantage of these opportunities, there is a need to ascertain project success through the control of risks [**19**].This research will provide information relating to infrastructure development risks and mitigations in South Africa. Such information can be used by both the public and private sectors when developing risk management plans for infrastructure development projects. The next section presents the research process adopted to address the research problem.

1.8 Research process

The first step in the research design involved conducting a literature review study by collecting and studying data to understand the concept of project risk and techniques that are utilized to identify project risks. Data was also collected and studied to identify existing infrastructure development risks and mitigations. The second step involved the researcher conducting a questionnaire survey to gather knowledge about infrastructure development project risks in South Africa as experienced by industry practitioners. The information gathered from

practitioners pertained to risk categories, risk impacts, risk occurrence frequency and risk mitigations as experienced on real-life projects in South Africa. In order to analyze the collected data, both qualitative and quantitative methods were utilized. Qualitative methods aid in analyzing descriptive data, whilst quantitative methods aid in analyzing numeric data derived by means of counting responses and making inferences. The next section presents the layout adopted for this document.

1.9 Report layout

The layout of this research study is divided into six different chapters as follows:

- Chapter 2: Literature Review

This chapter presents the literature review study aimed at investigating already existing findings about infrastructure development project risks. The literature review study explores the concept of project risk, and identifies risks and mitigations that are associated with infrastructure development projects as reported by researchers.

- Chapter 3: Research Methodology

This chapter investigates various research techniques to aid in developing a research design which will inform the process of sampling, data collection, data presentation and analysis. A well developed research design ensures that relevant data is collected to address the research problem [**20**].

- Chapter 4: Research Results

This chapter presents the collected data results, data analysis and interpretation of results to aid in answering the research questions. This chapter also presents project risks and mitigations associated with infrastructure development projects in South Africa as identified by industry practitioners.

- Chapter 5: Conclusions and recommendations

This chapter presents a discussion of the research results and concludes the study, and based on the conclusions, this chapter also presents recommendations for future research.

1.10 Chapter conclusion

South Africa has experienced shortage of basic infrastructure services in the past, and it is in the process of building the necessary infrastructure to aid in social and economic development. Infrastructure involves physical assets that ascertain that populations around the world have access to education, healthcare, information, entertainment, clean water, sanitation, electricity, transportation, telecommunications etc.

In South Africa there are infrastructure development projects which are affected by impediments to their successful delivery. In order to understand these impediments the following questions need to be answered:

- What are the risks associated with infrastructure development projects?
- What are the mitigations that can be implemented to the identified risks, to aid in decreasing undesired outcomes and increase project success?

The next chapter presents the literature review study which focuses on concepts associated with the subject of project risk, and identifies infrastructure development projects' risks and possible mitigations.

2. Chapter 2: Literature Review

The purpose of this chapter is to present aspects of risk management concepts, and infrastructure development risks that have been identified and assessed by researchers. Sources of information in this literature review are mainly peer reviewed published journals, academic textbooks, internet sources, newspapers, and company websites. The information that is summarized in this chapter will enable an easy overview and understanding of project risk concepts, risk identification concepts, and risks associated with infrastructure development projects. The information collected through the literature review will also allow for a more robust and well rounded research methodology, data collection method, presentation and analysis of research results to aid in answering the research questions presented in section 1.6.

2.1 The concept of project risk

This section presents the concepts that are associated with the subject of project risks. Topics covered in this section include defining project risk, risk management and risk identification. This section will aid in understanding how to conduct risk identification on projects.

2.1.1 Defining project risk

Meredith and Mantel [**21**], state that even when a project has the resources, technical skills, knowledge and all that is required for its accomplishment, uncertainty about accomplishing the project as planned still remains. Hillson and Simon [**22**] define risk as an uncertainty that may occur resulting in either a negative or positive outcome on the objectives of a project. Clements and Gido [**23**], refer to factors that may prevail which will impede the successful accomplishment of a positive outcome as risk. Kim Heldman [**24**] simply defines risk as an uncertainty, and states that not all risks are bad, some may present threats and some may present opportunities. Patrick Lam [**19**] acknowledges that there is inherent risk in every opportunity, but that does not stop infrastructure development projects from taking place. The construction industry highly suffers from poor project performance due to project risks [**25**]. McKinsey and Company [**16**],

states that infrastructure development projects are easily susceptible to exceeding budgets, delays, lack of funding and skills shortage. Though this is the case, the solution is not to reject opportunities to avoid risks, but to plan and anticipate risks. Well implemented risk management practices will allow project stakeholders to take advantage of the opportunities that are brought about by development projects [**18**].

This section has defined risk as uncertain factors that may prevail and impede on the successful accomplishment of a specific task; and may be controlled through the implementation of risk management practices. In order to understand the concept of project risk management, the next sections discusses project risk management to aid in controlling project risk and ensure project success.

2.1.2 Defining project risk management

On most construction projects risk is increased due to the large investment nature of projects; long durations; increased number of resources; stakeholders; unstable economic and political environment, sometimes leading to increased risk complexity on the project [**26**]. A.C Cagliano et al. [**27**], states that on today's projects there is more attention dedicated to managing factors that affect changes in project scope, quality, duration, and cost versus production. Carbone and Tippett [**28**] state that many projects exceed budgets, experience delays and poor performance due to failure to manage project risk. Risk management is the process of dealing with uncertainties [**21**]. Risk management may also be defined as a systematic process of identifying, analyzing, and responding to project risk [**24**]. Risk management can increase and build the capacity to improve project benefits and reduce project losses [**18**].

Risk management is central during the planning phase of a project, and its scope and complexity increases as the project progresses into the implementation phase, and decreases towards project termination [**29**]. As such project risk management is an iterative process that occurs throughout every phase of the project. Hillson [**30**] identified phases involved in the risk management process as planning, risk identification, risk analysis, risk response, and risk monitoring and control. The risk management planning phase determines the goals, methodology, and the required resources to conduct adequate risk management activities [**31**]. The risk identification phase determines factors that cause project risks [**31**]. Risk analysis

determines the probability that certain risks may occur and their impact on the project scope, quality, duration, and cost [**31**]. Risk response focuses on applicable methodologies for decreasing negative risk impacts, and increase positive impacts [**30**]. Risk monitoring and control involves an ongoing process of identifying and controlling new risk, and the monitoring of the already identified risks, and applying the already developed risk response processes [**32**].

From this section it is clear that risk management is a process of identifying, analyzing, and responding to project risk. Since this research is focused on project risk identification and risk response the next section will present the concept of risk identification as one of the phases in the risk management process.

2.1.3 Risk identification

Risk identification is the most important step in project risk management, such that unidentified risks can cause major problems to the success of a project [**33**]. All other phases in the risk management process rely on the identification of risks; as such processes of risk analysis, risk response, risk monitoring and control may not occur without knowing the potential project risks [**33**]. Project risk identification is described as the first step of project risk management and entails listing potential factors that may result in an undesired outcome on the project [**19**]. Risk identification can also be defined as involving the identification and documentation of risks that may have an impact on project objectives [**24**]. Other authors define risk identification as the systematic and continuous process of identifying, classifying and assessing initial risks that may impact a project [**34**]. Table 1 shows a summary of some of the available risk identification techniques.

Table 1: Risk identification techniques

Risk management techniques	Description
Brainstorming [**27**]; [**35**] [**36**]	Involves a group session, were participants discuss and identify as many risks as possible. This technique requires strong leadership during the brainstorming sessions. Some organizations may require their risk management staff to be trained and certified to conduct risk brainstorming sessions [**37**].
Risk questionnaire and risk surveys [**37**]; [**35**]	Risk questionnaires involve a number of questions that participants must answer to address risks in a particular area of interest. In some cases to avoid lengthy rigorous questionnaires, a survey may be used to collect specific data from respondents. In both techniques the data is later reduced to make conclusions [**37**].
Flowchart method [**37**]; [**35**]	Involves a sequential graphic representation of a process in order to identify weaknesses in the process. This method can also be used to

	identify potential risks in a system, but cannot provide the impact and severity of such risks [**37**].
SWOT analysis [**27**];	Involves the identification of strengths, weaknesses, opportunities and threats in an organization. This technique is aimed at taking advantage of company strengths and opportunities, and addresses the weaknesses and threats. SWOT analysis is utilized by organizations when developing company strategies [**37**].
Checklist [**34**] [**35**] [**36**]	Consists of a set of items with an option marked "yes" or "no", and may be used in an interview [**36**].
Interview/ Expert judgement [**35**] [**36**]	Involves structured, semi-structured, formal or informal interviews conducted with a group of experienced project stakeholders to identify project risks [**35**] [**36**].
Delphi technique [**36**]	Requires expert opinion on particular subject matter, and this technique requires hand written responses from the experts who may be sited in different locations during the process. In many cases it has been found that a well prepared questionnaire is deemed the best method to collect data for analysis from the experts [**36**].
Literature [**35**]	Involves the study of past projects to extract information about project risks [**19**].
Cause and effect diagram [**27**]	Is used to graphically present problems and identify possible causes of the problems. This technique depicts the relationship between causes and effects/problems [**21**].
Preliminary hazard analysis (PHA) [**27**]	Involves a process of identifying and listing hazards that may affect a system in the early stages of conceptual design [**38**].
Fault tree analysis (FTA) [**27**]	Is a reliability design technique used to evaluate system failures and effects to aid in developing mitigations [**38**].
Decision tree analysis [**27**]	Is a reliability design analysis technique and involves mapping out situations and the sequence of risks that follow each decision concerned with a particular situation [**39**].
Failure mode and effects criticality analysis (FMECA) [**27**]	This technique is widely used in reliability design analysis and involves the consideration of each mode of failure on components of a system to establish the full effects of the failure mode on the entire system [**39**].

From Table 1 it can be derived that risk identification can be conducted using techniques such as brainstorming, risk surveys and questionnaires, checklists, interviews, literature reviews, flowchart method, SWOT analysis, cause and effect diagrams, preliminary hazard analysis and fault tree analysis. Deng et al. [**40**] utilised a questionnaire survey to gather data for the analysis of fraud risk in public construction projects in China. In a research paper to evaluate the risk factors impacting construction projects in Ghana, Chileshe and Yirenkyi-Fianko [**41**] utilised a questionnaire survey for data collection. When identifying techniques utilized by Brazilian construction to identify risks, Garrido et al. [**42**] utilized a questionnaire survey to collect data. Other risk identification techniques may be utilized in commerce and systems engineering [**43**] [**39**].Risk identification techniques have been identified in this section, the next section presents various techniques available for risk response.

2.1.4 Risk response

This section explores available knowledge on project risk response options to aid in controlling project risks. Miao Fan et al [**44**] states that project risk response forms an important phase in project risk management. Hillson [**30**] established that project risk response focuses on applicable methodologies for decreasing negative risk impacts, and increase positive impacts. Zhi-Ping Fan et al [**45**] defined project risk response as the process of formulating and implementing strategies to control project risks. Kim Heldman [**24**] states that project risk response involves careful selection of suitable actions to implement in order to reduce threats and embrace opportunities identified during the risk analysis process. Vanita Bhoola et al [**46**] identified four available options in project risk response as avoidance, transference, mitigation, and acceptance. Kim Heldman [**24**] defines three project risk response strategies to deal with project impediments as avoid, transfer, and mitigate. In their research paper based on 302 project managers Vanita Bhoola et al [**46**] established that risk mitigation was considered as an appropriate risk response technique to meet project objectives.

Risk avoidance is a risk response strategy that involves planning the project to avoid or eliminate identified risks [**31**]. Other authors state that risk avoidance involves insulating a project from risk impact [**46**]. Risk transfer involves transferring part or the entire risk and its consequences to a third party for management [**31**], [**46**]. Risk mitigation involves reducing the probability of a risk and its impact on a project [**24**], [**31**]. Risk acceptance may involve appreciating that a risk will occur and implementing suitable contingencies to control its impact, or doing nothing about a risk except monitoring its impact on a project [**46**].

Since the concept of project risk has been defined trough the literature study, it is clear that project risk is managed by implementing proper project risk management techniques. Risk management involves risk planning, risk identification, risk analysis, risk response, risk monitoring and control. This section has established that risk can be controlled through four strategies including risk avoidance, risk transference, risk mitigation and risk acceptance. This research aims to identify possible risk mitigations for identified infrastructure project risks. The next section of the literature study is aimed at exploring existing knowledge to aid in identifying risks and mitigations associated with infrastructure development projects.

2.2 Infrastructure project risks

McKinsey and Company [**16**] found that infrastructure development projects are prone to exceed budgets, delayed completion, lack of funding and skills capacity. In a research paper, Craciun [**47**] classified infrastructure project risks into commercial risks, financial risks and political risks. Sanjaya De Zoysa and Russell [**33**] presented a research paper identifying infrastructure project risks such as financial, economic, environmental, technical and political risks. Wilson and Begley [**48**] published a research paper identifying risks associated with energy development projects as political risks and economic risks. In a research paper Van Der Waldt [**49**] relates infrastructure project challenges in South African municipalities as due to corruption, inadequate skills, political challenges and financial challenges. Emuze and Smallwood [**50**] identified performance risks as related to skills shortage, poor productivity, accidents, time overruns, rework, cost overruns and corruption. In South Africa, gender and race are important for job creation in industries such as mining, construction and infrastructure development to aid in an inclusive economy [**51**], as such it is important for the public sector to facilitate training of both skilled and unskilled entrants into these industries to improve performance [**50**] [**51**].

From this discussion one realizes that infrastructure development project risks exist in different categories and name tags. This section of the literature study aims to explore already existing knowledge on risks associated with infrastructure development projects. It is important to note that in South Africa infrastructure development projects are mainly implemented by the national, provincial and local spheres of government (public entities) [**52**]. Chileshe and Yirenkyi [**41**] also state that the government of Ghana is the main custodian of infrastructure development projects. In a research paper by Carlile [**53**] it was found that the public sector in the form of government is responsible for implementing infrastructure development projects. Carlile [**53**] further states that in many cases public entities don't always have the capacity to implement the projects, thus such capacity is provided by the private sector. Hall and Sandelands [**54**] acknowledged private sector contribution in the construction of physical infrastructure assets related to mining, industrial, energy, power, and transport in South Africa. Van Der Waldt [**49**] deduced that the private sector in the form of the construction sector plays an important role in the provision of physical infrastructure and job creation in South Africa, whilst Kenny [**55**] emphasizes that the construction sector is also closely intertwined with government institutions.

From this discussion it is clear that risks exits and if not controlled by both the public sector and private sector may negatively affect projects. Risks that are discussed in the next sections are associated with skills capacity, lack of funding, corruption, financial risks, economic risks, political risks and construction performance risks.

2.2.1 Skills capacity

Fang and Aboushhiwa [**56**] recognize the importance of engineers with regards to their contribution in the planning and implementation of infrastructure development projects. Van der Waldt [**49**] states that proper and adequate project management techniques are necessary to aid in successful infrastructure project implementation and public service delivery across all municipalities in South Africa. Emuze and Smallwood [**57**] presented a research paper on the importance of skills development in government institutions to aid in successful infrastructure development projects in South Africa. Ricaurte et al. [**58**] states that civil engineers need to play an important role as master planners of infrastructure development projects. Odusami [**59**] mentions infrastructure development skills requirements such as technical skills, planning skills, human skills, conceptual skills, leadership skills, team building skills, conflict resolution skills and organizational skills. Wium [**60**] acknowledges that skills required for implementing infrastructure projects include construction management, public-private partnerships, financial management, projects management and design management. From this discussion it is clear that the implementation of infrastructure development projects requires a set of specific skills for successful delivery.

Van der Waldt [**49**] has found that in many cases infrastructure development projects have been found to be hampered by poor planning. Fang and Aboushhiwa [**56**] state that the shortage of skills in the engineering sectors impedes on the achievement of set aims including Eskom and Transnet expansion, private sector development, and the United Nations Millennium Development Goals. In a research paper by Emuze and Smallwood [**57**], it was found that in South African municipalities inadequate skills that hamper the successful delivery of infrastructure projects included lack of technical expertise, project management, construction management and financial management. In 2011 the South African Institution of Civil Engineering (SAICE) published a document titled “SAICE Infrastructure Report Card for South Africa”, in the report card SAICE [**61**] states that constraints in engineering skills results in slow

progress being made in developing infrastructure. It is clear that South Africa is experiencing some degree of inadequate skills capacities to implement infrastructure development projects successfully to boost economic growth and social cohesion.

Some researchers that have identified inadequate skills capacity as a risk for implementing infrastructure development projects have also presented possible mitigations as follows:

- Public entities need to work together with consulting engineers [**57**];
- Public entities need to employ engineering candidates who will be given full authority to make decisions and not be subordinates to political appointees [**57**];
- Public entities to implement workplace training contracts for graduates [**56**];
- Pair young graduates with experienced engineers to facilitate knowledge transfer [**56**] [**57**];
- Promote knowledge in contracts and tender documentation [**56**]; and
- Promote knowledge in design and managing of private sector consultants [**56**].

From this section it is clear that infrastructure development projects are affected by inadequate skills capacity. The lack of skills capacity is further exacerbated by inadequate number of graduates, high number of drop outs, poor workplace training and lack of understanding the importance of engineers by government officials [**57**]. The next section discusses lack of funding and financial risk factors that may impede infrastructure development projects.

2.2.2 Lack of funding and financial risks

Infrastructure projects are normally headed by government, though in some cases it has been found that government institutions often lack the funds to implement infrastructure development projects [**62**]. Vassallo [**63**] states that in the past government institutions used public budgets to fund infrastructure development projects, however recently public budgets are struggling to satisfy constant investments in infrastructure. Leavitt et al. [**64**] found that in many cities the gap between infrastructure needs and infrastructure funding continues to widen.

In many countries lack of infrastructure project funding has resulted in government institutions inviting private sector entities to enter into contractual agreements for the development and operation of capital intensive projects [**65**] [**63**] [**64**] [**47**] [**66**]. Wilson and Begley [**48**] states that when there is lack of project funds government institutions turn to multilateral organizations, non

banking organizations, and capital or equity markets for project funding. Due to lack funding, the Indonesian government called for private investments for infrastructure development projects [**67**]. In South Africa funding for the Medupi power station as an investment loan project was sourced from the South African government, African development bank (AfDB), Export Credit Agencies (ECA), and the World Bank [**68**]. Funding for the Gauteng freeway improvement project was mainly sourced through borrowing from capital markets by the issuing of bonds and the utilization of toll income [**69**]. These types of relationships between the public sector and private sector for project funding are known as public private partnerships (PPP) [**65**].

Project financial risks are characterized by changes in interest rates, cash flow problems, and credit ratings [**41**]. Financial risks may result in project financial failure and delays in payments to suppliers and other affected parties [**70**]. The South African minister of Public Enterprises [**71**] stated that the effects of interest rates, foreign exchange rates, and inflation contributed to the increase in the budgeted project funding for the construction of the Medupi power station project. Xenidis and Angelides [**72**] cited sources of project financial risks as bankruptcy, high bidding costs, high design costs, high construction costs, unfavourable economy of the host country, currency risks, cost overruns and lack of creditworthiness.

Some researchers that have identified lack of funding and financial risks as risks experienced in implementing infrastructure development projects have also presented possible mitigations as follows:

- Dividing large infrastructure investment projects into smaller projects to aid development in stages as money becomes available [**47**];
- Government institutions are encouraged to offer greater support to investors through the provision or issuing of guarantees and other forms of support [**47**];
- Government institutions may partner with the private sector through Public Private Partnerships to fund and development infrastructure [**65**];
- Organizations may enter into buying forward contracts with suppliers [**73**];and
- Organizations are encouraged to develop mechanisms for minimizing foreign exchange exposure [**73**].

This section has highlighted lack of funding as a risk that can impede the implementation of infrastructure development projects, and presented methods that the public sector institutions can implement in order to source project funding. The next section discusses political risk factors that may impede infrastructure development projects.

2.2.3 Political/ governance

In the research paper about municipal infrastructure project challenges in South Africa, Van der Waldt [**49**] states that municipalities developed better infrastructure in regions with stable political relations as compared to regions characterized by political instability. Ling and Hoang [**74**] states that government politics may affect the development of infrastructure through project selection, budget planning, building codes, policies and legislations related to licenses and permits. Deng et al. [**40**] found that government officials were prone to be bribed to select projects and approve project funding in favour of family businesses.

Political risks or governance challenges have been identified as impediments to infrastructure development projects [**49**] [**48**] [**33**]. In their research study into project risks, Ling and Hoang [**74**] found that political risks are due to changes in the business environment or project environment and are caused by political changes. Craciun [**47**] define political risks as risks that are caused by government actions and may attribute a force majeure. Kapila and Hendrickson [**73**] define political risks as the possibility that political decisions will cause drastic changes to a country's business environment and in turn impact negatively on businesses. Political risks are associated with policy changes, law and regulations changes, and import restrictions [**73**]. Ling and Hoang [**74**] differentiated between two groups of political risks as macropolitical risks and micropolitical risks. Table 2 shows forms of political risks [**74**] [**73**].

Table 2: Forms of political risks

Macropolitical risks	Micropolitical risks
Revolutions	Elective expropriations
Civil wars	Discriminatory taxes
Nationwide strikes	Import restrictions directed towards a specific firm
Protests	
Riots	
Mass expropriations	

Political risks have been said to attribute a force majeure and are difficult to anticipate and control [**47**]. Possible mitigations to guard against political risks include [**75**]:

- Project stakeholders securing political risk guarantees (PRG); and
- Project stakeholders sourcing political risk insurance (PRI).

Political risks have the potential to negatively affect the implementation of infrastructure projects, as such it is important for project stakeholders to guard against political risks. The next section discusses risks associated with corruption when implementing infrastructure development projects.

2.2.4 Corruption

Infrastructure development involves the construction of physical assets such as roads, water supply networks, sanitation, power stations, houses, schools, hospitals, police stations, prisons, court houses etc [**6**]. Kenny [**55**] states that typical construction projects in developing countries comprise of multiple stakeholders including the government as the client, consulting engineers, main contractor, suppliers and sub-contractors. Bowen et al. [**76**] states that government officials, contractors and sub contractors are recognized as the main parties involved in corruption activities when implementing infrastructure projects. Deng et al. [**40**] defines corruption as related to government officials and public sector abusing their office powers to their own advantage. Grobler and Joubert [**77**] define corruption as the exploitation of public office to ensure self enrichment or gain.

Bowen et al. [**76**] differentiates forms of corruption on infrastructure projects in South Africa as conflict of interest, tender rigging or collusion, bribes and fronting. Sohail and Cavill [**78**] states that corruption involves bribery, embezzlement, kickbacks and fraud. Yun Le et al [**79**] identified twelve forms of corruption as related to bribery, fraud, nepotism, front companies, negligence, extortion, dishonesty, collusion, bid rigging, conflict of interest, kickbacks and embezzlement. Bribery refers to offering or receiving anything of value to influence a decision to the benefit of parties involved [**80**] [**81**]. Fraud involves provision of fabricated information to mislead decision makers [**78**] [**76**]. Collusion involves an agreement between two or more parties to commit fraudulent activities [**82**] [**83**]. Bid rigging involves the tenderee structuring bidding documents to favour particular tenderer, some form of bid rigging include over pricing, bid cutting, and hidden fees [**76**]. Embezzlement involves misappropriating project funds for personal use or benefit [**74**] [**78**]. Bowen et al. [**76**] defines kickbacks as related to economic incentives used to gain favour from decision makers. From these definitions it is clear that corruption involves favours, deceit and theft.

Kenny [**55**] states that corruption on infrastructure development projects can result in poor quality construction, poor project selection, cost overruns, and health and safety problems. Chileshe and Yirenkyi-Fianko [**41**] emphasizes that corruption can be used to circumvent regulations, cover poor workmanship, cover inadequate health and safety practices and to steal construction materials and resources. Some researchers that have identified corruption as a risk when implementing infrastructure development projects have also presented the following possible mitigations:

- Organizations are encouraged to commit to anti corruption programmes [**55**] [**78**] [**40**];
- Consulting firms are encouraged to adopt guidelines stipulated by International Federation of Consulting Engineers to combat corruption [**55**] [**78**];
- Construction firms in South Africa must foster to abide by professional ethics as endorsed by professionals associations in the industry [**76**] [**78**] [**40**];
- Public sector officials must be presented with guidelines stipulating ethical conduct [**76**] [**78**];
- Organizations to foster greater transparency procedures [**76**] [**78**].

It is clear that corruption can impact infrastructure development projects. Forms of corruption that have been identified include bribery, fraud, nepotism, front companies, negligence, extortion, dishonesty, collusion, bid rigging, conflict of interest, kickbacks and embezzlement. Thus it is important for project stake holders to be aware of risks associated with corruption and in turn be able to mitigate such risks. The next section discusses economic risks.

2.2.5 Economic risks

In a research paper by Baydoun [**84**] on risk management of large scale infrastructure projects, economic risks were explained as related to variations in economic indicators which may impact a project. Blank and Tarquin [**85**] states that economics involve cash flows, time occurrence of cash flows, interest rates for time value of money and the measures of economic worth. Wilson and Begley [**48**] identified foreign exchange rates as one of the most critical forms of economic risks that can affect infrastructure projects. Craciun [**47**] describes economic risks as risks associated with changes in interest rates and exchange rates, and are very difficult to control. Kapila and Hendrickson [**73**] define economic risk as the probability that economic events may occur resulting in changes to a country's business environment and may affect businesses.

Kapila and Hendrickson [**73**] further state that inflation is one of the major problems arising from economic risk and may result in a decrease in the value of cash flows as a country's currency depreciates on the exchange rates market. In South Africa foreign exchange rates have been linked to a increase in cost for the construction of the Medupi Power station project [**71**]. In Indonesia economic risks have resulted in an unstable economic environment with interest rates increasing from 19 to 60 % between 1997 and 1998, this trend has resulted in a decrease in the value of the currency [**67**].

Bowen and Edwards [**86**] describe economic risks as associated with price of materials and labour, price of equipment, inflation, exchange rates and fiscal policies. Manelele and Muya [**87**] identified economic risks as associated with factors affecting the purchase of materials. Yin and Hoang [**74**] state that economic risks on infrastructure development projects include fluctuation in foreign exchange rates, interest rates, import and export restrictions, restriction on the repatriation of funds, labour and material costs or prices. Yin and Hoang [**74**] further explained that economic risks can easily translates into financial impacts on a project.

From this discussion it is clear that economic risks may have a negative impact on infrastructure development projects. Such impacts may be induced by changes in foreign exchange rates, interest rates and inflation, which in turn may affect the purchasing power of local currency, thus resulting in organizations paying more for materials, labour, equipment and other goods [**41**].

Some researchers that have identified economic risks as possible impediments when implementing infrastructure development projects have also presented possible mitigations as follows:

- Educate project stakeholders about economic risks [**47**] [**41**] [**74**];
- Ensuring that project stakeholders may be prepared to anticipate and be ready to confront economic risks [**47**] [**41**] [**74**];
- Organizations may enter into buying forward contracts with suppliers [**73**];
- Organizations may reduce economic exposure [**73**] [**74**];
- Price products in stable foreign currency [**74**]; and
- Allow adequate contingencies in the budget [**74**].

It is clear that economic risks can impact infrastructure development projects. Thus it is important for project stakeholders to be aware of risks associated with economic risks and in

turn be able to mitigate such risks. The next section presents risks that impact the construction of infrastructure projects.

2.2.6 Construction performance risks

Though the construction industry plays an important in the development of infrastructure, the industry is overshadowed by performance impediments. Emuze and Smallwood [**50**] identified construction performance risks on South African projects as related to the following:

- Poor productivity;
- Accidents (Health and Safety)
- Time overruns;
- Rework;
- Cost overruns;
- Poorly defined scope;
- Contractual disputes; and
- Design creep.

Construction risks affecting infrastructure projects in Thailand where identified by Ghosh and Jintanapakanont [**88**] as the following:

- Unclear scope of work;
- Construction delay;
- Disputes;
- Contractual issues;
- Subcontractor underperformance;
- Time overruns; and
- Environmental

Other risks affecting construction performance were identified by El-Sayegh [**89**] in the United Arab Emirates as related to the following:

- Design changes;
- Unrealistic construction schedule;
- Shortages in materials and labour supply; and

- Inflation resulting in increased prices

Jarkas and Haupt [**90**] investigated construction risks in Qatar, and they identified the following risks:

- Slow decision-making process by client;
- Delay in payment process by client;
- Frequent change orders by client;
- Errors and omissions in design drawings;
- Unavailability or shortage in specified materials;
- Contractor's financial difficulties;
- Clarity of drawings and technical specifications;
- Shortage in technical staff and skilled labour;
- Late delivery of materials; and
- Delay in consultant's response to requests for information

The next section presents a discussion based on commercial risk factors that impact infrastructure development projects.

2.2.7 Commercial risks

In a world development report by the World Bank [**6**] commercial risks are defined as those that relate to production cost and those caused by uncertainties in the demand for services. Matsukawa and Habeck [**75**] define commercial risks in the context of export transactions as bankruptcy or insolvency of the borrower or the buyer, failure to make payment by the buyer, failure or refusal to accept goods or services by the buyer, termination of purchase contracts etc. Craciun [**47**] define commercial risks as project risks that are related to the effect the project has on the surrounding market in which the project is implemented such as the environment, customers, raw material suppliers, communities, and local authorities. Manelele and Muya [**91**] identified risks associated with the project environment as:

- Community contribution, which is influenced by logistical problems, lack of cooperation, and adverse weather conditions;
- Skilled labour, which is characterized by unavailability of skilled labour in the locality and incompetent labour;

- Material procurement, which is characterized by unavailability of non-local materials in local shops, lengthy tender processes, and high-transportation costs.

Yescombe [**92**] define commercial risks as project risks inherent in the project market. Yescombe [**92**] further distinguishes commercial risk factors as construction risks, operating risks, environmental risks, and force majeure risks. Possible mitigations for controlling commercial risks include [**6**] [**47**] [**41**] [**75**]:

- Project stakeholders sourcing risk insurance;
- Educating project stakeholders about commercial risks; and
- Conducting detailed background checks on the proposed project site location; for accessibility, availability of materials, community liaisons and the structures within the offices of local authorities.

It is clear from this discussion that commercial risks are risks inherent in the project environment and may include factors relating to community concerns, local authorities (politics), force majeure and procurement of project resources. Thus it is important for project stakeholders to guard against commercial risks by implementing the necessary risk mitigations. The next section presents a summary of infrastructure development project risks and mitigations from the literature study.

2.3 Summary of infrastructure development risks and mitigations

Infrastructure development risks have been identified in the previous sections of the literature review study, as such this section aims to compile a list of suggested risk mitigations for the identified risks as stated by different researchers in the literature study. Infrastructure development risks have been identified in public entities and private entities, thus it can be deduced that risks are prevalent in both public entities and private entities involved in infrastructure development projects. The risks identified in public entities also exist in private entities, and vies versa, though the degree of impact and occurrence may vary. Table 3 presents a summarized list of identified risks in the literature with suggested mitigations.

Table 3: Summary of Infrastructure development risks and suggested mitigations

Risk Category	Risk mitigation
Lack of funding [**63**], [**64**]	This type of risk may affect both public and private organizations. The risks associated with lack of funding may be mitigated by the public-sector partnering with the private sector through public-private partnerships [**66**], such as concessions [**63**], tax increments [**64**], to fund infrastructure development projects.
Inadequate skills capacity [**57**], [**41**]; [**49**]	This type of risk is concerned with the lack of formal training in technical and management skills (project management, construction management, financial management etc.), which are required for the implementation of infrastructure projects. The proposed mitigation for this type of risk is to enhance best practice by employing and training technically skilled personnel and highly skilled project managers for the execution of projects [**56**] [**50**].
Corruption [**55**], [**41**]	This type of risk involves both private and public sector organizations. Corruption involves activities associated with stealing from project resources, bribing to force matters to ones advantage without following procedure, selection of projects that favour specific contractors by public entities and structuring bids to favour certain contractors. Some companies bribe to obtain project contracts, and increase profits, while lowering construction cost at the expense of the quality of the finished product. The suggested approach to mitigate the impact of corruption activities in construction include, financial and physical auditing of project stakeholders; increase public participation; limit the approval powers of individuals, transparency should be encouraged throughout the entire project life cycle, and monitoring of compliance to regulations [**55**], [**41**].
Financial [**41**]	Financial risks are associated with interest rates, cash flows and credit ratings. These factors may result in delays in payment, which may result in cash flow problems that will cause a ripple effect resulting in an undesired outcome on the project. The suggested mitigation for financial risks is ensuring that project stakeholders are aware of the importance of risk management, to aid in the development of contingencies for these risks [**41**].
Economic [**47**], [**41**]	Economic risks include factors impacting on material availability; labour sourcing; machinery rentals; inflation; pricing of goods and materials; fiscal policies; and exchange rates. The authors suggest that this type of risk may be mitigated through education, and ensuring that project stakeholders may be able to anticipate and be ready to confront risks that impact projects [**47**], [**41**].
Commercial [**47**], [**41**]	This type of risks is induced by factors that affect the environment in which the project is being implemented; some of these factors may include possible supply of raw materials, community concerns, and local authorities. This type of risk may be kept under control by conducting detailed background checks on the proposed project site location, for accessibility, availability of materials, community liaisons and the structures within the offices of local authorities [**47**], [**41**].
Political [**47**], [**41**]	Political risks involve factors that affect countries, and they may be induced by government decisions, social unrests or war. Political risks cannot be controlled as they present a force majeure condition, but can be built into contingencies during risk management planning [**47**], [**41**]; • Project stakeholders securing political risk guarantees (PRG) [**75**]; and • Project stakeholders sourcing political risk insurance (PRI) [**75**].
Performance risks [**50**], [**55**]	This type of risks involve poor project definition, inadequate design input, rework due to poor quality, occupational health and safety, and disputes. These risks may be mitigated by sourcing personnel with high levels of technical expertise, maintain strong relationship with manufactures and suppliers, and promoting the development of skills in-house, and retaining highly skilled personnel [**50**], [**55**].

Table 3 presents risks associated with infrastructure development projects as identified in the literature review study. Possible mitigations are also presented for the identified risks. From Table 3, it is clear that infrastructure development project risks exist and that possible mitigation are available for controlling such risks. Some of the risks that cannot be controlled are those associated with political factors. The next section presents the chapter conclusion.

2.4 Chapter conclusion

This section explored the concepts of project risk, risk management and risk identification, to aid in selecting appropriate techniques when identifying project risks and mitigations. Further parts of this section identified risks that are associated with infrastructure development projects, and in some cases possible mitigations were also identified.

It is clear that infrastructure development projects are affected by risks that impede their successful delivery. In order to control such risks it is important to first identify potential project risks and propose mitigations for the identified risks.

Infrastructure development projects are affected by a variety of risks, with different impacts on the project, e.g. inadequate skills capacity may result in poor project scoping and specifications, thus resulting in ambiguous project requirements or goals, which my lead to project delays and cost overruns due to rework. The risks identified in this section can be used by project stakeholders when developing project risk management plans, to aid in controlling risks.

The literature review study has provided different risks and mitigations associated with infrastructure development projects. The next chapter will discuss the research methodology to be implemented in order to establish the South African perspective with regards to infrastructure development risks and mitigations.

3. Research methodology

This chapter aims to present the research methodology to be adopted in this research study. Particular attention is focused on the research method, data sampling, data collection, data analysis, and questionnaire layout design.

3.1 Introduction

This section details the research methodology to be employed for this research dissertation. R. Cooper and S. Schindler [**20**] distinguished between two research methods being qualitative and quantitative. R. Cooper and S. Schindler [**20**] state that qualitative research methodology involves the pursuit of thorough in-depth understanding of problems, with views from different perspectives. In a quantitative research approach, there is a set of predetermined responses that the research participants or subjects must choose from, and this doesn't offer participants the freedom to think "outside the box" with regard to their own unique existence. Martha Starr [**93**] presented a research paper into the application of qualitative and mixed-methods research with regards to the advantages, how and why they are utilized. Mixed-methods research is an approach that utilizes both qualitative and quantitative research principles. Martha Starr further defines qualitative research as concerned with data that is expressed in words and analyzed in a particular way, whilst quantitative research is concerned with the collection of numerical data that is analyzed through statistical and econometric theory and principles. Qualitative research allows research participants the freedom to interrogate the subject of interest in the research and give responses based on how they really feel and relate to the problem to be solved. Qualitative research methodology further encourages respondents to answer questions in their own words, and also allows the interviewer to ask for clarity on certain responses, thus encouraging debate that will yield more insight into the phenomenon of interest. Martha Starr [**93**] distinguishes between the following types of qualitative research:

In-depth interviews

In-depth interviews involve the researcher having one-on-one real time discussions with research respondents, and may follow a set of predetermined questions. Such discussions may be tape recorded or hand written on paper; in either way it is important to preserve all records for further analysis and consultation.

Focus groups

Focus groups involves group discussions led by a facilitator with all the necessary information to direct certain types of discussions to aid in getting relevant data to answer research questions. It is important to plan focus groups, because responses from different ethnic groups may differ, it is best to separate groups of different ethnicity to facilitate uniform data collection for ease of analyses.

Case studies and site visits

Case studies are concerned with the utilization of a small number of cases which may be related to countries, individuals and companies to perform an in depth analysis into a given research question or hypothesis to aid in answering such questions or proving a hypothesis.

Turner and Danks [**94**] state that case study research is usually used by managers and practitioners to make sense of real life problems, thus making case study research an effective technique for identifying opportunities for improving policies, processes and procedures within organizations.

According to Martha Starr, economists seem to doubt the reliability of qualitative research findings, due the notion that the perspective of the researcher may affect the research results. This implies that researchers may have different views on the same phenomena of interest, thus affecting the reliability of research findings from one researcher to the next. Though this is the case, [**93**] states that well-done qualitative research utilizes different practices to prove or answer certain research question, with the aim of increasing the reliability of findings. Factors that make qualitative research to be reliable over quantitative research include the fact that qualitative research improves its reliability by (a) fully explaining and documenting followed procedures, such that the study methodology is transparent (b) stating research limitations and future research opportunities (c) conducting research in teams, thus prompting debate.

Another form of research methodology is the use of surveys in the form of questionnaires. Such surveys are sent out to carefully selected research participants or respondents and returned to the researcher for analysis.

Reitz and Anderson [**95**] presented a research paper aimed at comparing survey methods or techniques that are used in studies of the nurse workforce. Reitz and Anderson define a survey as a sampling or a limited collection of data and information that is utilized to estimate the characteristics of the complete sample collection. In many cases a survey involves a questionnaire that is sent out to carefully selected respondents and returned to the researcher or research team for analysis. K. Kelley et al. [**96**] state that a survey involves the selection of a large population of people of interest in a research study, and collecting data from a small sample of individuals within the population. The collected data is then used to make inferences about certain aspects of the population at large. Surveys may be sent out to respondents via email, post, and internet.

Different research methods have been discussed and differentiated ranging from qualitative research to quantitative research methods. Qualitative research allows research participants the freedom to interrogate the subject of interest and give responses based on how they have experienced the problem to be solved [**93**]. Quantitative research involves a set of predetermined responses that the research participants or subjects must choose from, and it doesn't offer participants the freedom to think outside the box [**20**].

The next section discussed the research design, to aid in data collection, sample population size, data presentation and analysis.

3.2 Research design

This section presents the research design, which focuses on the adopted research methodology, data collection technique, sample population size, data presentation and data analysis.

3.2.1 Selected research method

This research study will adopt qualitative and quantitative research methodology with the aid of a questionnaire survey. Qualitative research methodology will aid in collecting and analyzing descriptive data, whilst quantitative research methodology will aid in analyzing numeric data derived by means of counting responses and making inferences. The survey is chosen due to its ability to generate data based on real life problems and solutions in a descriptive format [**96**]. The survey will be in a form of an internet survey questionnaire, which will be sent out via email to professionals with expertise in civil, electrical, mechanical engineering, construction management, and project management. The reason for adopting an internet survey questionnaire is because it is more cost effective to implement, and questionnaires can be sent out and sent back much quicker, thus saving time [**95**].

3.2.2 Sample and sampling

Due to the nature of the research study, the sampling method adopted is judgemental or purposive sampling. Judgemental sampling is a non-parametric sampling method whereby researchers utilise their own personal experience and knowledge to select a subgroup of experienced individuals within a population as a representative sample [**97**]. Non-parametric methods do not require the researcher to make assumptions relating to the population distribution, thus also referred to as distribution free methods [**98**] [**99**]. The sample population benchmarked to be respondents in this research study hail from the private sector and public sector. There are a total of 23 identified professionals to serve as respondents in this research, based on their roles and expertise with regards to infrastructure development projects. The targeted participants will aid in covering most of the industries that are involved to a greater extent in infrastructure development projects, and will also facilitate expert judgment from the professionals, thus making the collected data more reliable. The participants will be contacted by telephone informing them of the research study and asked to participate in the questionnaire survey. A follow through email will then be sent to the participants with the questionnaire attached in Microsoft word format. The targeted 23 South African professionals will aid in identifying project risks and mitigations.

Respondents have been identified from the following organizations:

- Sasol; is a company that specializes in energy and chemical production. For their expansion efforts Sasol gets involved in the implementation of infrastructure projects to boost their production capacity [**100**].
- Murray & Roberts; is a construction company in South Africa with over 110 years of existence operating locally and internationally, and has been involved in major infrastructure development projects both for the private sector and the public sector [**101**].
- WBHO; is a construction company in South Africa that operate locally and internationally, and has been involved in major infrastructure development projects both for the private sector and the public sector [**102**].
- Hatch Goba; is a multidisciplinary professional services organization that specializes in IT, engineering, consulting, and construction management in the mining, metallurgical, energy and infrastructure development sectors [**103**].
- Transnet; is a state owned company that operates freight rail, ports, and pipelines in South Africa, and gets involved in major infrastructure development projects when there is a need to expand operations [**104**].
- SANRAL; is a state owned company that finances, improves, manages, and maintains the national road network in South Africa, and gets involved in the development of major road infrastructure projects [**105**].
- Randwater; is a state owned company that supplies water to a number of Provinces in South Africa, and gets involved in the development of major water storage, supply and distribution infrastructure projects [**106**].
- Eskom; is a state owned company that generates, transmits, and distributes electricity power to industrial, commercial, residential, mining, and agricultural customers in South Africa and parts of Africa as whole. Eskom is also involved in the development of major power generation infrastructure projects.

The respondents benchmarked for this research are involved in the following roles in their respective workplace:

- Civil, electrical, mechanical and structural engineers; these individuals are qualified professionals in their areas of specialty practicing in feasibility studies, design and construction of transportation infrastructure, water infrastructure, power generation infrastructure, mining infrastructure, and buildings. These professionals have knowledge of

risks encountered while working on infrastructure development projects, and how such risks were mitigated.

- Site agent/construction managers; these professionals are involved in the daily activities of a construction site for development projects related to infrastructure. They are responsible for activities such as monitoring the project schedule, cost, and scope. On infrastructure development projects these individuals have encountered project delays, cost overruns, quality issues, resource shortages, political interference etc. Thus they will be able to provide useful data in this research to allow for a more robust report.
- Project managers; they assume the overall responsibility of a project from conceptual, initiation, scheduling, design, construction and monitoring and control. Project managers are responsible for making sure that every phase of a project is successful, as such these individuals encounter risks along the project life cycle, and such will be able to provide insight into mitigations that were adopted to control some of the risks.

The participants in this research study have been selected based on their potential expert knowledge with regards to infrastructure development project risks and mitigations. This approach will aid in generating reliable answers to the research questions. The next section presents the data collection process to be adopted in this research study.

3.2.3 Data collection

For the purpose of this research, data collection will be by means of an internet questionnaire sent to respondents via email. The questionnaire is selected due to its ability to generate qualitative and descriptive data that can be used to make inferences about the research phenomena [**96**]. Questionnaires also have low implementation costs; respondents can be reached anywhere in the world; can be completed and returned at a quick pace; respondents can answer questions at their own time; enable respondents to answer questions on sensitive issues; respondents can change answers at will and quality of data is improved due to a limited number of missing respondents [**95**].

The data to be collected using the questionnaires should be able to answer the following research questions as stated in Section 1.6:

- What are the risks associated with infrastructure development projects?

- What are the mitigations that can be implemented to the identified risks, to aid in decreasing undesired outcomes and increase project success?

The literature review study has answered both questions, though on a global level. Thus to justify the South African perspective of infrastructure development risks and mitigations, the process that will be implemented for data collection is as follows:

- A list of the risks identified in the literature study (refer to section 2.2) will be provided with the questionnaire;
- Mitigations will not be provided, to allow for unbiased responses for the mitigations;
- From the questionnaire's list of risks, respondents will be asked to select risks that they have encountered while working on infrastructure development projects in South Africa;
- Respondents will also be allowed to add infrastructure development risks, which are not in the provided list that forms part of the questionnaire;
- Once the risks have been selected, respondents will be asked to provide mitigations that were implemented in order to control such risks;
- Respondents will also be asked to state the impact of the selected risks on project cost (C), time (T) and scope (S).
- Rating of occurrence frequency will also be allocated in the questionnaire on a scale of high (H), medium (M) and low (L). The sample of the questionnaire is shown in Appendix A. The next section presents the data analysis process to be adopted in this research study.

3.2.4 Data presentation and analysis

This sections aims to present the process to be adopted in the analysis of the collected data to aid in answering the research questions, and explaining what can be learned from the data and what to tell others about the collected data.

In the field of research, data analysis involves the systematic process of organizing, categorizing and summarizing collected data in order to generate theoretical concepts and conclusions for understanding the research problem [**107**]. The analysis of qualitative data requires researchers to study collected data carefully, search for themes and emergence of patterns, look for relationships that may exist amongst the collected data and finally present the findings in report write up [**107**].

Qualitative data analysis techniques identified in literature include ethnographic analysis, narrative analysis, phenomenological analysis, constant comparative analysis, hermeneutic/ interpretive analysis, narrative/ performance analysis, discourse analysis, grounded theory analysis, content/ text analysis and cross cultural analysis [**108**] [**109**] [**110**].

For the purpose of this research study, qualitative text analysis will be adopted for analyzing the collected data. With guidelines from Udo Kuckartz [**111**], the following steps will be followed in the data analysis process:

- Data will be categorized based on the risk categories, as presented in Table 3 of the literature review study, i.e. mitigations from collected data will be listed based on the applicable risk category. As such all the risk mitigations provided by respondents for a particular risk category will be listed under that particular category, and if possible the mitigations will be summarized to derive similar themes.

- Once the risks and possible mitigations have been listed, the next step will be to work through the data by reading, studying, interpreting the written text word for word and line by line. This process will aid in understanding the data, and establishing the number of responses associated with each risk category, determine themes, similarities and variations amongst the collected data.

- While working through the data, summaries and themes will be compiled, highlighting important information from the data in relation to the research questions.

- The themes will then be utilized to code the data, in order to categories data with similar themes. This practice will aid in counting and generation of graphs to aid in data interpretation.

- In order to enhance the understanding of the risk categories that the respondents associate with, the risks categories will also be rated based on a degree of occurrence frequency, and impact. The degree of occurrence frequency rating scale will be measured as high (H), medium (M) and low (L). The impact of the risks will be evaluated based on project cost, time and scope. This exercise will aid in developing statements concerning the impact of risk factors on project cost, time, and scope, and measure the likelihood of occurrence of such risks on infrastructure development projects.

3.2.5 Questionnaire layout

The questionnaire will be designed using Microsoft word, and will be sent out to respondents via email as an attachment. In order to identify and correct any flaws in the questionnaire design, a pilot survey will be conducted, and thereafter the questionnaire will be revised and sent out to the respondents. A sample of the questionnaire is presented is Appendix A.

3.2.6 Chapter conclusion

This section explored different research methods to aid in developing an appropriate research design for the purpose of this research study. Data collection will be by means of a questionnaire survey sent out to participants currently involved in implementing infrastructure development projects in South Africa. The method of data analysis for this study will be by means of qualitative text analysis. The next section presents the research results and research conclusion.

4 Research results

This section aims to present the research results and conclusion derived from the collected data.

4.1 The respondents

The respondents involved in this research study were profiled based on position, qualifications and years of experience as shown in Table 4. A total of 23 practicing professionals agreed to participate in the research study since they are involved in implementing infrastructure projects in South Africa. From Table 4, 21 of the participants qualified in various fields of engineering, and one respondent qualified in construction management. The years of experience range from at least 4 to 34 years. This data serves to illustrate that the collected data was provided by qualified professionals involved in the implementation of infrastructure development projects in South Africa as discussed in Section 3.2.2. Morano et al. [**36**] states that during risk identification process, it is important to seek expert judgment from experienced professionals. The next section presents the risks identified by the respondents.

Table 4: Respondents profiles

Position	Qualifications	Experience (Years)
1 Construction Manager	B. Eng Civil	7
2 Site Manager	B. Eng Civil	5
3 Roads Engineer	B. Eng (Hons) Transportation	10
4 Manager-Roads	B. Eng Civil	34
5 Construction Manager	N. Diploma Civil	13
6 Civil Engineer	B. Eng Civil	5
7 Geometric Designer	B. Tech Transportation	13
8 Engineering Manager	Bsc. Eng & MBA	25
9 Project Engineer	Bsc. Mechanical Engineering	8
10 Project Manager	B. Tech	11
11 Transportation Engineer	B. Eng Civil	5
12 Site Engineer	B. Eng Civil	4
13 Civil Engineer	Bsc. Civil Engineering	14
14 Project Manager	Bsc. Mechanical Engineering & MBA	10
15 Maintenance Manager	B. Eng Civil	4
16 Programme Manager	B. Tech Water Engineering	11
17 Contract Administrator	B. Tech Construction Management	5
18 Structural Engineer	Bsc. Civil Engineering	5
19 Structural Engineer	B. Eng Civil	5
20 Programme Manager	B. Tech Chemical Engineering	19
21 Site Agent	N. Diploma Civil	11

4.2 Identified risks in South Africa

A total of 23 questionnaires were sent out by email to professionals involved to a great extent in the implementation of infrastructure development projects in South Africa as shown in Table 4. Out of the 23 administered questionnaires only 21 were completed and returned by the respondents. The returned questionnaires represented 91% of the total sample, which was deemed sufficient enough to proceed with the analysis. Oke and Ogunsemi [**112**] state that for survey results to be considered of significance, it is important to achieve a return rate of at least 20-30%. The two missing questionnaires were not returned due to the busy work schedules of the potential respondents.

A total of eight risk categories from the literature review study were presented in the questionnaire for respondents to identify risks that they have encountered while implementing infrastructure development projects in South Africa. Table 5, shows a list of identified risks and the percentage of respondents that identified the listed risks based on the 21 completed and returned questionnaires. The number in the responses column presents the total number of respondents that identified the particular risk category i.e each risk category had a chance to be identified by all 21 respondents, less or none. For example lack of funding was identified by only 14 of the 21 respondents, which represents 67% of the total sample, the other 33% did not identify lack of funding as a risk they have experienced while implementing infrastructure development projects in South Africa. The same principle was applied to the rest of the risk categories as shown in Table 5. The next section discusses Table 5 in detail to make sense of the collected data.

Table 5: Identified risks in South Africa

Risk category	Responses (N=21)	Percentage (%)
Inadequate skills capacity	19	90
Performance	19	90
Corruption	15	71
Political	14	67
Lack of funding	14	67
Commercial	13	62
Economic	12	57
Financial	11	52

Inadequate skills capacity

From Table 5, it can be seen that 90% of the respondents experienced inadequate skills capacity when implementing infrastructure development projects in South Africa. Inadequate skills capacity is concerned with the lack of formal training in technical and management skills such as project management, construction management, financial management, contract managements, engineering, construction methods etc., which are essential when implementing infrastructure development projects [**49**] [**59**] [**60**].

Performance risks

From Table 5 it can seen 90% of the respondents identified performance risk as the risk that they have experienced while implementing infrastructure development projects in South Africa. Performance risks are associated with factors such as poor productivity, rework, disputes, construction delay, design changes, delay in consultant's response to requests for information, late delivery of materials, accidents, poorly defined scope, unrealistic construction schedule, contractor's financial difficulties etc. [**50**] [**89**] [**88**] [**90**].

Corruption

Another type of a risk category impacting on infrastructure development projects was identified by 71% of the respondents in Table 5 was corruption. Kenny [**55**] states that corruption on infrastructure development projects can result in poor quality construction, poor project selection, cost overruns, and health and safety problems. Chileshe and Yirenkyi-Fianko [**41**] emphasizes that corruption can be used to circumvent regulations, cover poor workmanship, cover inadequate health and safety practices and to steal construction materials and resources. Yun Le et al [**79**] identified twelve forms of corruption as related to bribery, fraud, nepotism, front companies, negligence, extortion, dishonesty, collusion, bid rigging, conflict of interest, kickbacks and embezzlement.

Political risks

In South Africa it has been found that municipalities developed better infrastructure in regions with stable political relations as compared to regions characterized by political instability [**49**]. From Table 5 it can seen that 67% of the respondents identified political risks as a risk category that they have experienced while implementing infrastructure development projects in South Africa. Ling and Hoang [**74**] states that government politics may affect the development of

infrastructure through project selection, budget planning, building codes, policies and legislations related to licenses and permits. Deng et al. [**40**] found that government officials were prone to be bribed to select projects and approve project funding in favour of family businesses. Political risks or governance challenges have been identified as impediments to infrastructure development projects [**49**] [**48**] [**33**]. In their research study into project risks, Ling and Hoang [**74**] found that political risks are due to changes in the business environment or project environment and are caused by political changes. Craciun [**47**] define political risks as risks that are caused by government actions and may attribute a force majeure.

Lack of funding

Lack of funding risk involves the shortage of the required funds to finance a project. From Table 5 it can be seen that 67% of the research respondents identified lack of funding as a risk that they have experienced while implementing infrastructure development projects in South Africa. Infrastructure development projects are normally headed by government, though in some cases it has been found that government institutions often lack the funds to implement infrastructure development projects [**62**]. Vassallo [**63**] states that in the past government institutions used public budgets to fund infrastructure development projects, however recently public budgets are struggling to satisfy constant investments in infrastructure. Leavitt et al. [**64**] found that in many cities the gap between infrastructure needs and infrastructure funding continues to widen. In South Africa funding for the Medupi power station as an investment loan project was sourced from the South African government, African development bank (AfDB), Export Credit Agencies (ECA), and the World Bank [**68**].

Commercial risks

Craciun [**47**] define commercial risks as project risks that are related to the effect the project has on the surrounding market in which the project is implemented such as the environment, customers, raw material suppliers, communities, and local authorities. Yescombe [**92**] define commercial risks as projects risks inherent in the project market. From Table 5 it can be seen that 62% of the respondents identified commercial risks as a risk category that they have encountered while implementing infrastructure development projects in South Africa.

Economic risks

Another risk factor affecting infrastructure development projects in South Africa has been identified by 57% of the respondents as economic risks as shown in Table 5. Craciun [**47**] describes economic risks as risks associated with changes in interest rates and exchange rates, and are very difficult to control. Kapila and Hendrickson [**73**] define economic risks as the probability that economic events may occur resulting in changes to a country's business environment and may affect businesses. Kapila and Hendrickson [**73**] further state that inflation is one of the major problems arising from economic risks and may result in a decrease in the value of cash flows as a country's currency depreciates on the exchange market. Bowen and Edwards [**86**] describe economic risks as associated with the price of materials and labour, price of equipment, inflation, exchange rates and fiscal policies. In South Africa foreign exchange rates have been linked to a increase in cost for the construction of the Medupi Power station project [**71**].

Financial risks

When project funding is available for infrastructure development projects, another risk factor that comes into play is financial risks. Project financial risks are characterized by changes in interest rates, cash flow problems, and credit ratings [**41**]. Financial risks may result in project financial failure and delays in payments to suppliers and other affected parties [**70**]. From Table 5, 52% of the respondents identified financial risk as a risk category that they have experienced while implementing infrastructure development projects in South Africa.

It is clear from this discussion of findings that infrastructure development projects in South Africa are affected by risk factors such as inadequate skills capacity, construction performance risks, corruption, political risks, lack of funding, commercial risks, economic risks and financial risks. In order to establish the impact of the identified risks on infrastructure development projects, respondents were asked to state whether the identified risk factors impacted on project cost, time, and scope. In this regard respondents were given the freedom of stating one or a combination of project objectives (cost, time and scope) impacted by the identified risk factors. The next section presents a discussion of risk impact findings.

4.3 Identified risks impact in South Africa

Risk impacts on three main objectives of a project associated with cost, time and scope [**24**]. Thus in order to understand the impact of the identified risks on infrastructure development projects respondents were asked to state whether the identified risks impacted on cost, time, scope or a combination. Table 6 shows the percentage of respondents that reported on project risk impact as experienced on South African projects.

Table 6: Risk impact

Legend: T-Time; C-Cost; S-Scope

	Frequency (%)							
Impact	Inadequate skills capacity	Performance	Corruption	Political	Lack of funding	Commercial	Economic	Financial
T	23	9	5	10	5	10	0	0
C	5	24	28	10	10	9	19	5
S	5	5	0	0	5	0	0	0
T+C+S	14	33	19	10	24	19	10	19
C+T	33	19	14	37	18	19	19	23
C+S	5	0	0	0	5	0	9	5
T+S	5	0	5	0	0	5	0	0
Total	**90**	**90**	**71**	**67**	**67**	**62**	**57**	**52**

Inadequate skills capacity

The impact of inadequate skills capacity is on all three project objectives associated with cost, time and scope. From Table 6 it can be seen that 33% of the respondents experienced that inadequate skills capacity impacted on a combination of project cost and time, only 23% reported that inadequate skills capacity impacted on time, whilst 14% of the respondents experienced that inadequate skills capacity impacted on a combination of project cost, time, and scope. Inadequate skills capacity is reported to be associated with lack of formal training in technical and management skills [**49**] [**59**] [**60**], as such if projects are designed, constructed and managed without the necessary knowledge and experience it is realistic that project cost, time and scope will be negatively affected.

Performance risks

Performance risks affecting infrastructure projects have been reported by 33% of the respondents as impacting on a combination of project time, cost and scope as shown in Table 6. Only 24% of the respondents experienced that performance risks impacted on project cost

only, whilst 19% of the respondents reported that performance risks impacted on a combination of project cost and time. Performance risks are concerned with the execution of the project through construction, and in many cases it has been reported that performance risks are associated with poor productivity, rework, disputes, construction delay, design changes, delay in consultant's response to requests for information, late delivery of materials, accidents, poorly defined scope, unrealistic construction schedule, contractor's financial difficulties etc. [**50**] [**89**] [**88**] [**90**]. The identified factors associated with performance risks have the potential to impact project cost, time and scope.

Corruption

From Table 6 it can be seen that 28% of the respondents experienced that corruption impacts on project cost. This may be due to fact that corruption involves activities that are aimed at personal enrichment. Only 19 % of the respondents experienced that corruption impacted on a combination of project cost, time and scope; whilst 14% of the respondents reported that corruption impacted on a combination of project cost and time. Yun Le et al [**79**] identified twelve forms of corruption as related to bribery, fraud, nepotism, front companies, negligence, extortion, dishonesty, collusion, bid rigging, conflict of interest, kickbacks and embezzlement.

Political risks

The impact of political risks on infrastructure development projects in South Africa has been identified by 37% of the respondents as a combination of project cost and time. Some 30% of the respondents were split evenly in reporting that the impact of political risks was on project cost, time and scope as shown in Table 6. This may be due to the control that politics have on the developmental mandate of a country. Ling and Hoang [**74**] states that government politics may affect the development of infrastructure through project selection, budget planning, building codes, policies and legislations related to licenses and permits.

Lack of funding

Lack of funding for infrastructure development projects has been identified by 24% of the research respondents as impacting on a combination of project cost, time and scope as shown in Table 6. This may be due to the fact that when there is no funding, project cash flow is affected, and projects may be delayed or projects may be reduced in size for affordability.

Commercial risks

Table 6 also shows that 19% of the respondents experienced that commercial risks impacted on a combination of project cost, time and scope, another 19% reported that commercial risks impacted on a combination of project cost and time. It is clear that commercial risks impacts on project cost, time and scope. This may be related to instances where there is lack of raw materials and the project may be delayed or the materials may have to be sourced from far-away locations thus increasing the cost of sourcing such materials. Manelele and Muya [**87**] reported that commercial risks are associated with material procurement, which is characterized by unavailability of non-local materials in local shops, lengthy tender processes, and high-transportation costs.

Economic risks

Economic risks have been identified by 19% of the respondents as impacting on project cost, and another 19% of the respondents reported that economic risks impact on a combination of project cost and time. Only 10% of the respondents identified economic risks as impacting on a combination of project cost, time and scope as shown in Table 6. Edwards [**86**] describe economic risks as associated with the price of materials and labour, price of equipment, inflation, exchange rates and fiscal policies. Depending on the economic conditions of a country, economic risks have the potential to impact on project cost, time, and scope.

Financial risks

From Table 6 it can be seen that 23% of the respondents experienced that financial risk impacted on a combination of project cost and time, while 19% of the respondents reported that financial risk impacted on a combination of project cost, time and scope. The South African minister of Public Enterprises [**71**] stated that the effects of interest rates, foreign exchange rates, and inflation contributed to the increase in the budgeted project funding for the construction of the Medupi power station project. Xenidis and Angelides [**72**] cited sources of project financial risks as bankruptcy, high bidding costs, high design costs, high construction costs, unfavourable economy of the host country, currency risks, cost overruns and lack of creditworthiness.

From this discussion, it is clear that the identified infrastructure development risks have impacted on project cost, time and scope. The next section discusses the occurrence frequency of the identified risks impacting on infrastructure development project cost, time and scope.

4.4 Identified risk occurrence frequency in South Africa

Kim Heldman [**24**] states that risk impacts need to be identified hand in hand with the occurrence frequency to aid in proper prioritization when controlling project risks. In this case respondents were asked to state the occurrence frequency of the identified risks on a scale of low, medium, and high. Table 7 shows the percentage of respondents that reported on the risk occurrence frequency.

Table 7: Risk occurrence frequency

	Frequency (%)							
Rating	Inadequate skills capacity	Performance	Corruption	Political	Lack of funding	Commercial	Economic	Financial
Low	14	0	19	19	9	6	5	14
Medium	43	43	19	19	29	28	33	19
High	33	47	33	29	29	28	19	19
Total	**90**	**90**	**71**	**67**	**67**	**62**	**57**	**52**

From Table 7 it can be seen that the occurrence frequency of encountering inadequate skills capacity ranges from low, medium to high, with 43% of the respondents having reported a medium occurrence frequency. A total of 33% of the respondents experienced that inadequate skills capacity risk had a high occurrence frequency on infrastructure development projects in South Africa. The occurrence frequency of performance risks on infrastructure development projects was rated medium by 43% of the respondents and high by 47% of the respondents as shown in Table 7.

The occurrence frequency of corruption ranges from low, medium and high. From Table 7 it can be seen that 33% of the respondents reported the occurrence frequency of corruption as been high on infrastructure development projects. The occurrence frequency of political risks has been reported by 29% of the respondents as high, whilst 38% was split evenly between low and medium as shown in Table 7.

The occurrence frequency of lack of funding has been identified by 29% of the respondents as medium, and another 29% of the respondents reported the occurrence frequency of lack of funding as high, as indicated in Table 7. The occurrence frequency of commercial risks has been identified by 28% of the respondents as medium, and another 28% reported an occurrence frequency of high as shown in Table 7. The occurrence frequency of economic risks

has been identified by 33% of the respondents as medium, whilst 19% experienced that economic risks had a high occurrence frequency. It is evident that financial risk affects infrastructure development projects in South Africa, and 14% of the respondents reported that the occurrence frequency of financial risks is low, whilst 19% reported medium and another 19% reported high occurrence frequency.

It is clear from this discussion that the identified infrastructure development risks have different occurrence frequencies ranging from low, medium and high. In summation the next section presents a summary of the identified risks, risk impact and occurrence frequency.

4.5 Summary of the identified risk categories, impact and occurrence frequency

In order to present a summary of the research findings with regards to risk impact, and risk occurrence frequency, it was considered well enough to present data with the highest affirmative response **[**91**] [**113**]**.

Table 8: Summary of risk categories, impact and occurrence frequency

Risk category	Impact	Occurrence frequency
Inadequate skills capacity	• Cost • Time	• Medium
Performance	• Cost • Time • Scope	• High
Corruption	• Cost	• High
Political	• Cost • Time	• High
Lack of funding	• Cost • Time • Scope	• Medium • High
Commercial	• Cost • Time • Scope	• Medium • High
Economic	• Cost • Time	• Medium
Financial	• Cost • Time	• Medium • High

The research findings presented in Table 5, 6 and 7 allows one to state the identified risks, possible impact on infrastructure development projects, and likely occurrence frequency, but does not provide one with the possible measures that can be implemented to control the identified risks. In order to answer the second research question, respondents were asked to share possible mitigations that they have implemented in practice to control the risks they have identified from the list provided with the questionnaire. The next section presents the identified risk mitigations that can be implemented to control the identified risks.

4.6 Identified risk mitigations

Infrastructure development risks, risk impacts, and occurrence frequencies were identified by the respondents as discussed in Section 4.2, and answered the first research question. In order to answer the second research question, respondents were asked to state the type of mitigations that they implemented to control the identified risks. For this purpose the collected data from respondents comprised of several mitigations for each of the identified risks. In order to generate meaningful results, the free text data was organized, studied, coded and themes were generated as explained in Section 3.2.4 of the research design. Table 9 shows the results that were achieved through qualitative text analysis. It is important to note that by means of text analysis, the collected data was reduced to have common meaning e.g for inadequate skills capacity mitigations; themes were developed as shown in the brackets.

Table 9: Risk mitigations

Risk category	Collected mitigations (Actual data)	Final mitigations (Derived)
Inadequate skills capacity	• The appointment service providers must be given a mandate by the client to "mentor" an emerging service provider on the project duration **(training and mentoring)**. • Provide in-serves training at regular intervals. Lack of senior mentorship, therefore require balances skills levels in labour force **(training and mentoring)**. • Formal training programmes and mentorships contracts between trainees and experienced professionals **(training and mentoring)**. • Identify skills gap, outsource where necessary. Initiate skills retention scheme which promotes and is dependent on completion on target **(outsource work)**. • Government departments rely on private sector (Agents/Consultants) to carried duties **(outsource work)**. • Contractor had to recruit more resources (welders from Thailand) outside the country. Recruit experienced	• Appointment of service providers that can mentor emerging service providers and junior staff. • Outsource work to qualified organizations.

	management personnel **(outsource work)**.	
Performance	• The implementation of quality control procedures and documents (i.e. Inspection procedures, checklists and non-conformance reports) mitigate risks and ensure that any unsatisfactory work by the professional team or the contractor is recorded and rectified. • Design development to go through a formal development process (short cuts = risk!). Design to be performed by competent design office. Provision for correct levels of site quality management to implement the work, QS services. • More independent audits introduced to evaluate the quality and how the projects were handled. Part of internal quality Control system is to have peer review on projects. • Weekly integration and planning meetings with the contractor to address all access dates. Organised shared access in the areas, if and where possible, to complete all outstanding work. Redefine Completion Dates for Sub Sections (New baseline required) . • Adequate planning that involves all parties/ input from a variety of different fields of expertise. Set fair and achievable deadlines. Ensure that individuals are followed up on and managed. Ensure excellent communication channels so that all understand the risks, deadlines, etc. • Contractor to recruit more resources. Introducing night shift work from the contractor, as and when required (S.C 8.6 Rate of Progress under FIDIC contract). Daily progress meetings with the contractors, to expedite progress. Track progress against a Contractor schedule (updated on a weekly basis) and contractor management under Sub Clause 8.6. Daily site walk downs and inspections. Incentive bonus schemes. Recognition for good progress. Compile and manage an adequate integrated program for the works.	• Develop and implement quality control procedures and independent audits. • Agreement of project scope, time and budget between service providers, clients and all affected parties.
Corruption	• Ensure state entities follow tendering procedures. Submitted prices and documents can be made public to allow others to scrutinize. Educate individuals of kinds of corrupt actions. • Procurement policies, evaluation guidelines and declaration of interest can assist to mitigate this risk but more it is an individual decision not to corruption the sourcing process • A procurement policy whereby at least 3 quotations are acquired prior to issuing an order should be in place. • Audits of service providers. Compliance with Anti-corruption. In depth tender adjudication. • Ensure suitable resources are assigned, and auditable processes are followed for bidding, contract award, and contract management. • Requires strict external audits, transparent procurement policies, strict prosecution with when exposed.	• Forster compliance with procurement procedures and policies. • Conduct strict independent audits.
Political	• Technical groups need to lead the development and politicians must get information from Technical group. • Infrastructure must be driven by sound engineering decisions based supply on demand and not political gain. • Keep the political people individuals away from the technical structures/organisations. • Formed a task team to work with local community. The task team looked at how local businesses (taxis, accommodation establishments etc) can benefit. A committee formed to	• Technical professionals to implement projects without interference from politicians. • Enhance community liaison.

	facilitate employment of local youths (unskilled jobs reserved for locals to be employed via the committee. • Political influence is always a major problem in nowadays implementation of projects. I found that having an influential community liaison officer (CLO) can be very beneficial. Also, ensuring that company policies are correctly followed in every procedure can really help in covering the company during social unrests or war.	
Lack of funding	• Reduce low priority scope to ensure completion of essential project, thereafter once the project is adding commercial value, use those funds to fund the remainder of the scope. • Scope of the project gets reduced; hence bring frustration to the community being serviced. Small portion must be done than nothing at all. • Projects must be prioritized based impact if not executed. • Prioritising high risk projects and ranking them based legislative requirements.	• Reduction of project scope until funds are available. • Prioritize projects based on organizational requirements.
Commercial	• The project client or client's representative must allow for and provide a Community Liaison Officer (CLO) who will address any community or labour related issues during a project. • Technical group must work with Local authorities from the beginning and update them timeously. • Proper environmental impact assessments and close communication on the expectations of the affected communities can safe on time and costs with a pre-determined scope of works to suite the socio-economic and environmental aspects. • Local product/Material is utilised in agreement with local authority to minimize cost of importing commercial from a long distance. • Source labour from the surrounding communities. Engage the community leaders throughout the project. • This type of risk is mitigated by ensuring that local suppliers are considered in procurement of goods. However, if the locals are not able to supply, then it is critical that the contractor forms a relationship between the local suppliers and the outside suppliers that can provide the service. This allows the local suppliers to act as middle man and they are also able to benefit from the project.	• Communicate project plans with local communities and update them timeously. • Labor and materials to be sourced from local communities.
Economic	• A competent contractor should be able to provide for certain economic risks when tendering for a project. The contractor, client or client's representative must understand the contractual agreements (i.e JBCC, GCC, FIDIC etc.) in order to protect themselves from certain economic risk. • Measures to be into contract to deal with issues as far as possible. Normally the risk will remain with Contractor unless specified separately for a specific reason. • This risk category maybe difficult to mitigate at project level, however escalations and flexible scope or application of re-measurable contracts can be incorporated or considered in the contract. • Research to be done before implementation for material availability. • Proper planning and risk mitigation strategies to be in place, to cater for external drivers impacting on the project.	• Parties to be competent in contractual agreements to guard against economic risks. • Planning of design and construction methods to aid in assessing material availability.

	Financial modelling to analyse impact of economic factors, sensitivity analyses. • Confirmation of sourcing plans and labour availability during tender stages.	
Financial	• The client needs to ensure that their internal finance department is capable of fulfilling their duties. • When the skills capacity of the project managers are raised and proper pre feasibility studies and budget estimates are done, the financial risk will lower automatically. • Ensure scope is clearly defined. Understand impact of environment / environmental issues have been properly assessed. • Contractual requirements to be considered to manage exchange rates, interest rates, escalation, etc • This risk category maybe difficult to mitigate at project level, however escalations and flexible scope or application of re-measurable contracts can be incorporated or considered in the contract. • Well-structured Enterprise development plan will assist in minimising this risk especial when dealing with the BEE contractors.	• Employ skilled personnel to deal with finances. • Structure contractual requirements to aid in managing changes in rates.

From Table 8 it can be derived that inadequate skills capacity risk has been identified to impact more on a combination of project cost and time. The identified research mitigations in Table 9 will aid in controlling the identified risk impact by providing the necessary technical and management knowledge from experienced teams to implement projects. Emuze and Smallwood [**50**] associate inadequate skills capacity with poor productivity, accidents, time overruns, rework and cost overruns on projects. Thus if inadequate skills capacity risk factors are not controlled projects may be delayed, and project cost may increase.

Performance risks have been identified to impact on project cost, time and scope as shown in Table 8. Performance risks are associated with factors such as poor productivity, rework, disputes, construction delay, design changes, delay in consultant's response to requests for information, late delivery of materials, accidents, poorly defined scope, unrealistic construction schedule, contractor's financial difficulties etc. [**50**] [**89**] [**88**] [**90**]. The identified mitigations by respondents seek to control risk impact on project cost, time, and scope by implementing agreements with project stakeholders and implementation of quality control measures as shown in Table 9.

Respondents have identified corruption to impact more on project cost as shown in Table 8. Grobler and Joubert [**77**] define corruption as the exploitation of public office to ensure self enrichment or gain. Yun Le et al [**79**] identified twelve forms of corruption as related to bribery, fraud, nepotism, front companies, negligence, extortion, dishonesty, collusion, bid rigging,

conflict of interest, kickbacks and embezzlement. The identified mitigations by respondents will aid in limiting corrupt activities within organizations implementing infrastructure development projects through strict regulations as shown in Table 9.

Political risks have been identified by respondents as impacting on project cost and time as shown in Table 8. Ling and Hoang [**74**] states that government politics may affect the development of infrastructure through project selection, budget planning, building codes, policies and legislations related to licenses and permits. Craciun [**47**] define political risks as risks that are caused by government actions and may attribute a force majeure. The identified mitigations provided by respondents are aimed at implementing the project according to scope, which may aid in controlling project cost and time. Though these mitigations can be implemented, political risks have been found to present a force majeure on infrastructure development projects. Since the public sector is responsible to a great extent for initiating and funding infrastructure development projects, it might be difficult to implement infrastructure development projects without political interference.

Lack of funding has been identified to impact on project cost, time and scope as shown in Table 8. This is true in that available funds or lack thereof may determine whether a project is implemented or not, and if implemented the scope of the project will have to meet the available budget. Thus the mitigations identified by the respondents have the potential to aid in controlling projects with limited funds.

Craciun [**47**] define commercial risks as project risks that are related to the effect the project has on the surrounding market in which the project is implemented such as the environment, customers, raw material suppliers, communities, and local authorities. From Table 8 it can be derived that commercial risks impact on project cost, time and scope. The identified mitigations can aid in controlling project cost by sourcing materials locally and promoting liaison with the community will aid in avoiding protest/resistance from the community which may result in delays, thus impacting on both project cost and time. Liaisons with the community were a project is to be implemented may result in a scope change due to the adoption of new designs to take advantage of local raw materials, equipment and labour.

Economic risk factors have been reported by respondents as impacting on project cost and time. Edwards [**86**] describe economic risks as associated with the price of materials and labour, price of equipment, inflation, exchange rates and fiscal policies. Mitigations identified by respondents may aid in controlling economic risks through planning of designs and

constructions methods to guard against the use of materials, equipment and labour prone to the adverse effects of economic activities. This in turn will aid in controlling project cost and time.

Project financial risks are characterized by changes in interest rates, cash flow problems, and credit ratings [**41**]. Financial risks may result in project financial failure and delays in payments to suppliers and other affected parties [**70**]. Project financial risk factors have been identified to impact on project cost and time. The employment of skilled professionals in finance will aid in controlling the effects of interest rates, exchange rates, and credit ratings. This in turn will aid in controlling the project cost. Early payment of contractors and suppliers will aid in reducing cash flow problems that may result in project delays due to the late purchase of materials and equipment required for implementing the project.

Table 9 has presented potential mitigations that can be implemented to control risks associated with infrastructure development projects in South Africa and a discussion that followed has demonstrated how the identified risk mitigations can aid in controlling each of the identified risk impacts. The next section compares mitigations identified from the literature study with the research findings.

4.7 Comparison of literature study and research findings mitigations

This section aims to present a comparison of risk mitigations identified from literature with risk mitigations identified through this research study as shown in Table 10.

Table 10: Comparison of risk mitigations

Risk category	Literature	Research findings
Inadequate skills capacity	• Public entities need to work together with consulting engineers [**57**]; • Public entities need to employ engineering candidates who will be given full authority to make decisions and not be subordinates to political appointees [**57**]; • Public entities to implement workplace training contracts for graduates [**56**]; • Pair young graduates with experienced engineers to facilitate knowledge transfer [**56**] [**57**]; • Promote knowledge in contracts and tender documentation [**56**]; and • Promote knowledge in design and managing of	• Appointment of service providers that can mentor emerging service providers and junior staff. • Outsource work to qualified organizations.

	private sector consultants.	
Performance	• These risks may be mitigated by sourcing personnel with high levels of technical expertise, maintain strong relationship with manufactures and suppliers, and promoting the development of skills in-house, and retaining highly skilled personnel [**50**], [**55**].	• Develop and implement quality control procedures and independent audits. • Agreement of project scope, time and budget between service providers, clients and all affected parties.
Corruption	• Organizations are encouraged to commit to anti corruption programmes [**55**] [**78**] [**40**]; • Consulting firms are encouraged to adopt guidelines stipulated by International Federation of Consulting Engineers to combat corruption [**55**] [**78**]; • Construction firms in South Africa must foster to abide by professional ethics as endorsed by professionals associations in the industry [**76**] [**78**] [**40**]; • Public sector officials must be presented with guidelines stipulating ethical conduct [**76**] [**78**]; and • Organizations to foster greater transparency procedures [**76**] [**78**].	• Forster compliance with procurement procedures and policies. • Conduct strict independent audits.
Political	• Political risks cannot be controlled as they present a force majeure condition, but can be built into contingencies during risk management planning [**47**], [**41**]; • Project stakeholders securing political risk guarantees (PRG) [**75**]; and • Project stakeholders sourcing political risk insurance (PRI) [**75**].	• Technical professionals to implement projects without interference from politicians. • Enhance community liaison.
Lack of funding	• The public-sector partnering with the private sector through public-private partnerships [**66**], such as concessions [**63**], tax increments [**64**], to fund infrastructure development projects; • Dividing large infrastructure investment projects into smaller projects to aid development in stages as money becomes available [**47**]; • Government institutions are encouraged to offer greater support to investors through the provision or issuing of guarantees and other forms of support [**47**]; and • Government institutions may partner with the private sector through Public Private Partnerships to fund and development infrastructure [**65**].	• Reduction of project scope until funds are available. • Prioritize projects based on organizational requirements.
Commercial	• This type of risk may be kept under control by conducting detailed background checks on the proposed project site location, for accessibility, availability of materials, community liaisons and the structures within the offices of local authorities [**47**], [**41**]; • Project stakeholders sourcing risk insurance [**6**] [**47**] [**41**] [**75**]:; • Educating project stakeholders about commercial risks [**6**] [**47**] [**41**] [**75**]:; and • Conducting detailed background checks on the proposed project site location; for accessibility, availability of materials, community liaisons and the structures within the offices of local authorities [**6**] [**47**] [**41**] [**75**].	• Communicate project plans with local communities and update them timeously. • Labor and materials to be sourced from local communities.
Economic	• Educate project stake holders about economic risks [**47**] [**41**] [**74**]; • Ensuring that project stake holders may be	• Parties to be competent in contractual agreements to guard against economic risks. • Planning of design and construction methods to aid

	prepared to anticipate and be ready to confront economic risks [**47**] [**41**] [**74**]; • Organizations may enter into buying forward contracts with suppliers [**73**]; • Organizations may reduce economic exposure [**73**] [**74**]; • Price products in stable foreign currency [**74**]; and • Allow adequate contingencies in the budget [**74**]	in assessing material availability.
Financial	• Ensuring that project stakeholders are aware of the importance of risk management, to aid in the development of contingencies for these risks [**41**]; • Organizations may enter into buying forward contracts with suppliers [**73**];and • Organizations are encouraged to develop mechanisms for minimizing foreign exchange exposure [**73**].	• Employ skilled personnel to deal with finances. • Structure contractual requirements to aid in managing changes in rates.

The following can be derived from Table 10:

- Inadequate skills capacity risk mitigations identified by research respondents are similar to mitigations identified from the literature study as shown in Table 10;
- Risk mitigations identified by research respondents for controlling performance risks are similar to those identified from the literature study;
- The mitigations identified by research respondents for controlling performance risks are similar to mitigations identified from the literature study;
- The mitigations identified by respondents for controlling political risks are different to mitigations identified from the literature study;
- Risk mitigations identified by respondents for controlling lack of funding risk are similar to mitigations identified from the literature study, though research findings indicate that respondents did not identify alternative means of sourcing funding for infrastructure development projects. This may be due to situations were limited funds are available for project implementation;
- Commercial risk mitigations identified from the literature study are similar to mitigations identified by research respondents, though from the research findings sourcing of risk insurance was not mentioned by respondents;
- Economic risk and financial risk mitigations identified from both the literature study and research findings are different from one another as shown in Table 10.

The differences and similarities in the identified risk mitigations between research respondents and literature study may be due to the awareness to project risk. Davis [**114**] states that maturity to risk in organizations is related to the awareness that risk management is as important as

project scope, time, cost, quality. Hillson [**115**] identifies four levels of risk maturity models (RMM) for assessing corporate risk maturity as level 1: naïve, level 2: novice, level 3: normalised, and level 4: normal. The RMM levels are described as follows [**115**]:

- Level 1-Naïve, the risk organization with the naive status, does not see the need to conduct risk management on projects and does not have a risk management approach. The management processes respond to uncertainties as they occur and there is no effort to learn from past experiences and lessons;
- Level 2-Novice, the novice organization is aware of the importance and benefits associated with risk management, but do not have a well developed formal risk management process in place;
- Level 3-Normalized, at this level the organization is practicing risk management at all levels of the business and on most projects. The importance and benefits of risk management are well understood;
- Level 4-Natural, this organization has a high risk awareness culture, with a proactive approach to risk management in every aspect of the business. Information about risk is utilized to enhance business processes and aid in improved competitive advantage.

It is clear from this discussion that risk maturity may influence the knowledge of project risk within an organization. As such what organization A knows about project risk may be similar or different to the knowledge that organization B possesses about project risk. The next section presents the conclusion.

5 Conclusions and recommendations

5.1 Conclusions

Infrastructure development projects are implemented to contribute to the well being of communities. In many cases infrastructure development projects have been overshadowed by project risks. Infrastructure projects in South Africa seem to be affected by risks that impede their successful implementation. This trend can be observed on Eskom's Medupi Power Station project, 2010 FIFA World Cup Stadiums, and SANRALs Gauteng Freeway Improvement project and many more projects in South Africa.

This research aimed to identify project risks and mitigations associated with infrastructure development projects in South Africa. The results of the study will provide a source of knowledge for infrastructure development risks in South Africa as identified by professionals involved in project implementation.

From the research study the identified infrastructure development risks in South Africa include inadequate skills capacity; performance risks, corruption; political risks, lack of funding, commercial risks, economic risks and financial risks. A high percentage (90%) of the respondents experienced inadequate skills capacity and performance risks while implementing projects. This response rate means that most projects in South Africa are implemented without the necessary skill set; as such this impacts on project performance factors such as quality, adequate design input, project definition, health and safety etc. Corruption is also of great concern as identified by 71% of the respondents, based on this trend it can be deduced that critical project matters may be overlooked due to bribes and other corrupt activities on infrastructure projects. In the literature it has been established that corruption involves activities associated with stealing from project resources, bribing to force matters to ones advantage without following procedure, selection of projects that favour specific contractors by public entities and structuring bids to favour certain contractors. Some companies bribe to obtain project contracts, and increase profits, while lowering construction cost at the expense of the quality of the finished product. The identified risks were also found to impact on project duration, cost and scope with an occurring frequency of medium to high. Table 11 shows a summary of the identified risks, impact, occurrence frequency and mitigations.

Table 11: Identified risks, impact, occurrence frequency and mitigations

Risk category	Responses (%)	Impact	Occurrence frequency	Mitigations
Inadequate skills capacity	90	• Cost • Time	• Medium	• Appointment of service providers that can mentor emerging service providers and junior staff. • Outsource work to qualified organizations.
Performance	90	• Cost • Time • Scope	• High	• Develop and implement quality control procedures and independent audits. • Agreement of project scope, time and budget between service providers, clients and all affected parties.
Corruption	71	• Cost	• High	• Forster compliance with procurement procedures and policies. • Conduct strict independent audits.
Political	67	• Cost • Time	• High	• Technical professionals to implement projects without interference from politicians. • Enhance community liaison.
Lack of funding	67	• Cost • Time • Scope	• Medium • High	• Reduction of project scope until funds are available. • Prioritize projects based on organizational requirements.
Commercial	62	• Cost • Time • Scope	• Medium • High	• Communicate project plans with local communities and update them timeously. • Labor and materials to be sourced from local communities.
Economic	57	• Cost • Time	• Medium	• Parties to be competent in contractual agreements to guard against economic risks. • Planning of design and construction methods to aid in assessing material availability.
Financial	52	• Cost • Time	• Medium • High	• Employ skilled personnel to deal with finances. • Structure contractual requirements to aid in managing changes in rates.

This research study aimed to identify risks and mitigations associated with infrastructure development projects in South Africa. The risks identified in South Africa include lack of funding, inadequate skills capacity, corruption, financial, economic, commercial, political, and performance risks. Mitigations have also been identified for each of the risks. Based on this study and making use of Table 11 one can derive the following conclusions with regards to infrastructure development risks in South Africa:

- Inadequate skills capacity is experienced on most projects in South Africa with a great impact on project cost and duration/time, with an occurrence frequency rated medium;
- Due to the lack of skills one can conclude that project deliverables will be affected, thus performance risks are also experienced on most projects in South Africa, with impact on

project cost, time and scope. Performance risks have been identified to have an occurrence rating of high;

- Corruption impacts greatly on project cost, since it involves exchange of favors for money, and has an occurrence frequency of high;
- Lack of funding and commercial risks impacts more on project cost, time and scope with an occurrence frequency of medium to high;
- Economic risks impacts on project cost and time with an occurrence frequency of medium;
- Financial risks also impact on project cost and time with an occurrence frequency of medium to high.

5.2 Contributions

Risk is inherent in every project, and for countries to take advantage of these opportunities, there is a need to ascertain project success through the control of risks [**19**]. This research will serve as a benchmark for organizations formulating project risk management plans, by making available a list of risks associated with infrastructure development projects with associated mitigations. With the identified project risks and mitigations in this research, risk identification processes will be comprehensive and complete, without overlooking any possible risk factors, and avoid undesired project outcomes in South Africa. Organizations that will benefit the most from this research include construction firms, state owned companies, project funding organizations, consulting engineers, municipalities, and academics.

5.3 Research limitations and recommendations

Future research should provide participants or respondents with a questionnaire that does not state risks identified from literature. This will aid respondents in providing factors that they believe are risks when implementing infrastructure development projects, without the bias of selecting risks provided with the questionnaire.

Reference List

[1] Alison Todes, "New Directions in Spatial Planning? Linking Strategic Spatial Planning and Infrastructure Development.," *Journal of Planning Education and Research*, vol. 32, no. 4, pp. 400-414, Aug. 2012.

[2] Statistics South Africa, "Mid-year population estimates," Statistics South Africa Statistical release P0302 Statistical release P0302, 2014.

[3] (GCIS), Government Communication and Information System, *South Africa Yearbook 2012/13*, 20th ed., L. v. Niekerk, Ed. Pretoria, South Africa: GCIS, 2012.

[4] Government of South Africa, *Constitution of the Republic of South Africa*. Pretoria, South Africa: Government Printer, 1996.

[5] R. v. Niekerk, "Revisiting History: The Creation of Provinces and the Politics of Social Policy in a Democratic South Africa," *Social Policy & Administration*, vol. 46, no. 6, pp. 619-635, Dec. 2012.

[6] World Bank, *World Development Report 1994: Infrastructure for Development*, 1st ed., W. Bank, Ed. Washington, United States of America: Oxford University Press, Inc., 1994.

[7] The Presidency Republic of South Africa and Development Bank of Southern Africa, "The State of South Africa's Economic Infrastructure: Opportunities & Challenges ," Development Bank of Southern Africa, 2012.

[8] V. Snieska and I. Simkunaite, "Socio-Economic Impact of Infrastructure Investments," *Engineering Economics*, vol. 63, no. 3, pp. 16-25, 2009.

[9] Lise Pretorius, "Power Plant Development. Rewards for risk," 2012.

[10] Adam M. Goliger, "South African sports stadia-from the perspective of the 2010 FIFA World Cup," *Bautechnik*, vol. 82, no. 3, pp. 174-178, Mar. 2005.

[11] Siseko Njobeni, Sanchia Temkin, "In Brief-National Economy & Business," Business Day, 2008.

[12] A. Jerome, "Infrastructure, Economic Growth and Poverty Reduction in Africa," *Journal of Infrastructure Development*, vol. 3, no. 2, pp. 127-151, 2011.

[13] Eddie Cottle, Paulo Capela, and Andre Furlan Meirinho, "A Lesson from South Africa: Are Construction Cartels dramatically increasing Brazil's 2014 FIFA World Cup Infrastructure Costs?," Corporate Strategy and Industrial Develoment 153, 2013.

[14] H. Berry, "Medupi and industry left reeling," RiskSA managzine January 2014, 2014.

[15] Janine Thorne-Erasmus and Chris Heyman, "Infrastructure: a foundation for development-key points from the DBSA Development Report 1998," *Development of Southern Africa*, vol. 15, no. 4, pp. 661-667, Oct. 1998.

[16] McKinsey and Company, "A risk-management approach to a successful infrastructure project," McKinsey & Company Working Paper 52, 2013.

[17] James P Clements and Jack Gido., "Managing Risk," in *Effective Project Management*, A. v. Rosenberg, Ed. Canada, US: Thomson South Western, 2006, ch. 4, pp. 80-83.

[18] The World Bank, "Risk and Opportunity: Managing Risk for Development," The World Bank, Washington DC, World Development Report ISSN:0163-5085, 2013.

[19] Patrick T I Lam, "A sectoral review of risks associated with major infrastructure projects," *International Journal of Project Management*, vol. 17, no. 2, pp. 77-87, 1999.

[20] Donald R. Cooper and Pamela S. Schindler, *Business research methods*. Boston: McGraw-Hill, 2006.

[21] Jack R. Meredith and Samuel J. Mantel, Jr., *Project Management A Managerial Approach*, 7th ed. New York, United States of America: John Wiley & Sons, Inc, 2009.

[22] David Hillson and Peter Simon, *Practical Project Risk Management: The ATOM Methodology*, 2nd ed. Vienna, Austria: Management Concepts Press, 2007.

[23] James P Clements and Jack Gido., "Managing Risk," in *Effective Project Management*, A. v. Rosenberg, Ed. Canada, US: Thomson South Western, 2006, ch. 4, pp. 80-83.

[24] Kim Heldman, *Project Management Professional Exam Study Guide*, 5th ed., J. Flynn, Ed. Idianapolis, Indiana, America: Wiley Publishing, 2009.

[25] J.H.M. Tah, and V. Carr, "Towards a framework for project risk knowledge management in the construction supply chain," *Advances in Engineering Software*, vol. 32, no. (2001), pp. 835-846, Feb. 2001.

[26] Goufeng W., W. Min, and Z. Weiwei, "Study on the Existing Problems and Counter measures of Project Risk Management in China," in *Energy Procedia 13*, 2011, pp. 2726-2733.

[27] Anna Corinna Cagliano, Sabrina Grimaldi and Carlo Rafele, "Choosing project risk management techniques. A theoretical framework," *Journal of Risk Research*, vol. 18, no. 2, pp. 232-248, Jan. 2015.

[28] Thomas A. Carbone and Donald D. Tippett, "Project Risk Management Using the Project Risk FMEA," *Engineering Management Journal*, vol. 16, no. 4, pp. 28-35, 2004.

[29] Chris Chapman and Stephen Ward, *Project Risk Managment Processes, Techniques and Insights*, 2nd ed. New York, United States of America: Wiley, 2003.

[30] David Hillson, *Effective Opportunity Management for Projects. Exploiting Positive Risk*. New York, United States of America: Marcel Dekker, 2003.

[31] Kim Heldman, Claudia Baca, and Patti Jansen, *PMP Project management professional exam study guide delux edition*, 2nd ed. Canada, Canada: Wiley Inc., 2007.

[32] Jack R. Meredith and Samuel J. Mantel, Jr., *Project Management A Managerial Approach*, 8th ed. Singapore: John Wiley & Sons, 2012.

[33] Sanjaya De Zoysa and Alan D. Russell, "Knowledge-based risk identification in infrastructure projects," *Canadian Journal of Civil Engineering*, vol. 30, no. 1, pp. 511-522, Jan. 2003.

[34] D. Bajaj, J. Oluwoye and D. Lenard, "An analysis of contractors' approaches to risk identification in New South Wales, Australia," *Construction Management and Economics*, vol. 15, no. 1, pp. 363-369, Oct. 1997.

[35] Akintoye A., *Framework for risk assessment and management of private initiative projects*. Glasgow, United Kingdom: Glasgow University, 2001.

[36] Morano CAR, Martins CG, and Ferreira MLR, "Application of techniques for the identification of risk in the E & P ventures," *Engevista*, vol. 8, no. 2, pp. 120-133, 2006.

[37] Ana-Maria DINU, "Modern Methods of Risk Identification in Risk Management," *International Journal of Academic Research in Economics and Management Sciences*, vol. 1, no. 6, pp. 67-71, Nov. 2012.

[38] Lee T. Ostrom, Cheryl A. Wilhelmsen, *Risk Assessment: Tools, Techniques, and Their Applications*. John Wiley & Sons, 2012.

[39] Patric D.T. O'Connor and Andre Kleyner, *Practical Reliability Engineering* , 5th ed. West Sussex, United Kingdom: John Wiley & Sons, Ltd, 2012.

[40] Xiaomei Deng, Yuhong Wang, Qianqian Zhang, Judy Xiye Huang and Jingjing Cui, "Analysis of fraud risk in public construction projects in China," *Public Money and Management*, vol. 34, no. 1, pp. 51-58, Nov. 2013.

[41] Nicholas Chileshe and Adwoa Boadua Yirenkyi-Fianko, "An Evaluation of Risk Factors Impacting Construction Projects in Ghana," *Journal of Engineering Design And Technology*, vol. 10, no. 3, pp. 306-329, 2012.

[42] Martins Claudia Garrido, Morano Cassia Andrea Ruotolo, Ferreira Miguel Luiz Ribeiro and Haddad Assed Naked, "Risk identification techniques knowledge and application in the Brazilian construction," *Journal of Civil Engineering and Construction Technology*, vol. 2, no. 11, pp. 242-252, Nov. 2011.

[43] The Chartered Institute of Management Accountants (CIMA), *Strategic Analysis Tools*. United Kingdom, UK: CIMA, 2007.

[44] Miao Fan, Neng-Pai Lin, and Chwen Sheu, "Choosing a project risk-handling strategy: An analytical model," *International Journal of Production Economics*, vol. 112, no. 2, pp. 700-713, Jan. 2008.

[45] Zhi-Ping Fan, Yong-Hai Li and Yao Zhang, "Generating project risk response strategies based on CBR: A case study," *Expert Systems with Applications* , vol. 42, no. 2, pp. 2870-2883, Nov. 2015.

[46] Vanita Bhoola, S B Hiremath and Debasis Mallik, "An assessment of risk response strategies practiced in software projects," *Australasian Journal of Information Systems*, vol. 18, no. 3, pp. 161-191, Nov. 2014.

[47] M. Craciun, "A New Type of Risk in Infrastructure Projects," *Modern Economy*, vol. 2, no. 1, pp. 479-482, Sep. 2011.

[48] David W. Wilson and William E. Begley, "Strong Project Financing To Continue," Natural Gas (John Wiley & Sons,Inc/Business) Outlook-International Project Financing, 1997.

[49] Gerrit van der Waldt, "Infrastructure Project Challenges: The Case of Dr Kenneth Kaunda District Municipality," *Journal of Construction Project Management and Innovation*, vol. 4, no. 1, pp. 844-862, 2014.

[50] Fidelis Emuze, John Julian Smallwood, "Bridging public works project performance gaps in South Africa," *Management, Procurement and Law*, vol. 165, no. MP2, pp. 111-118, May 2012.

[51] Government of the Republic of South Africa, "The Status of Women in the South African Economy," Department of Women, Pretoria, Developmental Report, 2015.

[52] The Department of Provincial and Local Government of the Republic of South Africa (the dplg), *Municipal Infrastructure Roles and Responsiblities of National Sector Departments, Provincial Counterparts and Municipalities*. Pretoria, South Africa: the dplg, 2006.

[53] Carlile, J.L, "Private Funding of Public Highway projects," *Transport Planning and Road Panel*, vol. 105, no. 1, pp. 53-63, 1994.

[54] Jonathan Hall and Eric Sandelands, "Addressing South Africa's Engineering Skills Gaps," *Education and Training*, vol. 51, no. 3, pp. 215-219, 2009.

[55] Charles Kenny, "Construction, Corruption, and Developing Countries," World Bank Policy Research Working Paper 4271, 2007.

[56] Fang Fang and Rawad Ayad Aboushhiwa, "Strategies to address skills shortages in South African civil engineering," *Management, procurement and law*, vol. 165, no. MP2, pp. 103-109, May 2012.

[57] Smallwood and Emuze, "Criticality of Intelligent Clients in the Infratsructure Sector," *Municipal Engineer*, vol. 164, no. ME4, pp. 251-257, Dec. 2011.

[58] Jorge L. Ricaurte, Carlos A. Arboleda, and Feniosky Pena-Mora, "Civil Engineers in Public-Private Partnerships and as Master Planners for Infrastructure Development," *Leadership and Management in Engineering*, vol. 8, no. 4, pp. 276-286, Oct. 2008.

[59] K.T. Odusami, "Perceptions of Construction Professionals Concerning Important Skills of Effective Project Leaders," *Journal of Management in Engineering*, vol. 18, no. 2, pp. 61-67, Apr. 2002.

[60] Jan A. Wium, "Briefing: Murray & Roberts chair at Stelenbosch University," *Management, Procurement and Law*, vol. 165, no. MP2, pp. 81-83, Jun. 2012.

[61] The South African Institution of Civil Engineering (SAICE), *Infrastructure Report Card for South Africa*, 1st ed., SAICE, Ed. Johannesburg, South Africa: SAICE, 2011.

[62] Michael A. Pagano, "Financing Infrastructure in the 21st Century City," *Public Works Management & Policy*, vol. 13, no. 1, pp. 22-38, Jul. 2008.

[63] J. M. Vassallo, "Short-Term Infrastructure Concessions Conceptual Approach and Recent Applications in Spain," *Public Works Management & Policy*, vol. 8, no. 4, pp. 261-270, Apr. 2004.

[64] William M. Leavitt, John C. Morris, John R. Lombard, "Developing Infrastructure Through the Use of Tax Increment Financing," *Public Works & Management and Policy*, vol. 13, no. 2, pp. 92-99, Oct. 2008.

[65] Darrin Grimsey and Mervyn K. Lewis, "Evaluating the risks of public private partnerships for infrastructure projects," *International Journal of Project Management*, vol. 20, no. 2002, pp. 107-118, May 2000.

[66] Brown Kathleen, "Are Public-Private Transactions the Future of Infrastructure Finance," *Public Works Management & Policy*, vol. 12, no. 1, pp. 320-324, Jul. 2007.

[67] Andreas Wibowo and Bernd Kochendorfer, "Financial Risk Analysis of Project Fiance in Indonesian Toll Roads," *Journal of Construction Engineering and Management*, vol. 131, no. 9, pp. 963-972, Sep. 2005.

[68] African Development Bank, "Medupi Power Project Appraisal Report," African Development Bank, Appraisal Report, 2009.

[69] Nazir Ali, Stewart Wilson and Alex van Niekerk, "Benefits of freeway investment through innovative procurement," *Institution of Civil Engineers*, vol. 165, no. MP1, pp. 13-18, Feb. 2011.

[70] Agyakwa-Baah, A and Chileshe, N, "Construction professionals perception of risk assessment and mangement practices: does length of service in construction industry matter," in *Procs 26th Annual ARCOM Conference, Association of Researchers in Construction Management, 6-8 September*, Leeds, UK, 2010, pp. 1219-1228.

[71] Linda Ensor, "Medupi likely to cost R35bn more than first estimated," Business Day, 2014.

[72] Yiannis Xenidis and Demos Angelides, "The financial risks in build-operate-transfer projects," *Construction Management and Economics*, vol. 23, no. 4, pp. 431-441, May 2005.

[73] Kapila, P. and Hendrickson, C., "Exchange rate risk management in International Construction Ventures," *Journal of Management in Engineering*, vol. 17, no. 4, pp. 186-191, Oct. 2001.

[74] Florence Yean Yng Ling and Vivian To Phuong Hoang, "Political, economic,and legal risks faced in international projects: Case study of Vietnam," *Journal of Professional Issues in Engineering Education and Practice*, vol. 136, no. 3, pp. 156-164, Jul. 2010.

[75] Tomoko Matsukawa and Odo Habeck, *Review of Risk Mitigation Instruments for Infrastructure Financing and Recent Trends and Developments*, 4th ed. Washington DC, United States of America: World Bank, 2007.

[76] Bowen P., Edwards P. and Cattell K., "Corruption in the South African Construction Industry: A Mixed Methods Study," in *Smith S.D (Ed) Proceedings 28th Annual ARCOM Conference*, Edinburgh, UK, 2012, pp. 521-531.

[77] E. Grobler and S.J. Joubert, "Corruption in the public sector: the elusive crime," *Acta Criminologica*, vol. 17, no. 1, pp. 90-102, 2004.

[78] M. Sohail and S. Cavill, "Accountability to Prevent Corruption in Construction Projects," *Journal of Construction Engineering and Management*, vol. 134, no. 9, pp. 729-738, Sep. 2008.

[79] Yun Le, Ming Shan, Albert P.C. Chan and Yi Hu, "Overview of Corruption Research in Construction," *Journal of Management Engineering*, vol. 30, no. 4, pp. 1-7, Jul. 2014.

[80] Ameh, O. and Odusami, K., "Professionals' Ambivalence toward Ethics in the Nigerian Construction Industry," *Journal of Professional Issues in Engineering Education and Practice*, vol. 136, no. 1, pp. 9-16, Jan. 2010.

[81] Surya Sudheer Meduri and Thillai Rajan Annamalai, "Unit Costs of Public and PPP Road Projects: Evidence from India," *Journal of Construction Engineering and Management*, vol. 139, no. 1, pp. 35-43, Jan. 2013.

[82] Ranon Chotibhongs and David Arditi, "Detection of Collusive Behavior," *Journal of Construction Engineering and Management*, vol. 138, no. 11, pp. 1251-1258, Nov. 2012.

[83] Tabish, S. Z. S. and Jha, Kumar Neeraj, "Analyses and evaluation of irregularities in public procurement in India," *Construction Management and Economics*, vol. 29, no. 3, pp. 261-274, Mar. 2011.

[84] Mohammad Baydoun, "Risk management of large=scale development projects in developing countries: Case from MDI's projects," *International Journal of Technology Management and Sustainable Development*, vol. 9, no. 3, pp. 237-249, 2010.

[85] Leland Blank and Anthony Tarquin, "Foundations of Engineering Economy," in *Engineering Economy*. New York, United States of America: Mc Graw Hill, 2012, ch. 1, pp. 2-37.

[86] P.J. Edwards and P.A. Bowen, "Risk and risk management in construction: a review and future directions for research," *Engineering, Construction and Architectural Management*, vol. 5, no. 4, pp. 339-349, 1998.

[87] I. Manelele and M. Muya, "Risk identification on community-based construction projects in Zambia," *Journal of Engineering, Design and Technology*, vol. 6, no. 2, pp. 145-161, 2008.

[88] Ghosh, S. and Jintanapakanont, J., "Identifying and assessing the critical risk factors in an underground rail project in Thailand: a factor analysis approach," *International Journal of Project Management*, vol. 22, no. 8, pp. 633-643, 2004.

[89] El-Sayegh, "Risk assessment and allocation in the UAE construction industry," *International Journal of Project Management*, vol. 26, no. 4, pp. 431-438, 2008.

[90] Abdulaziz M. Jarkas and Theodore C. Haupt, "Major construction risk factors considered by general contractors in Qatar," *Journal of Engineering, Design and Technology*, vol. 13, no. 1, pp. 165-194, May 2015.

[91] I. Manelele and M. Muya, "Risk identification on community-based construction projects in Zambia," *Journal of Engineering, Design and Technology*, vol. 6, no. 2, pp. 145-161, Jan. 2008.

[92] E.R. Yescombe, "Commercial Risks," in *Principles of Project Finance*. Tokyo, Japan: Elsevier Inc, 2014, ch. 9, pp. 197-256.

[93] Martha A. Starr, "Qualitative and mixed-methods research in economics: surprising growth, promising future.," *Journal of economic surveys*, vol. 28, no. 2, pp. 238-264, 2014.

[94] John R. Turner and Shelby Danks, "Case research: a valuable learning tool for performance improvement

professionals," *Performance Improvement*, vol. 53, no. 4, pp. 24-31, 2014.

[95] Reitz OE and Anderson MA, "A comparison of survey methods in studies of the nurse workforce," *Nurse Researcher*, vol. 20, no. 4, pp. 22-27, 2013.

[96] Kate Kelley, Belinda Clark Vivienne and John Sitzia, "Good practice in the conduct and reporting of survey research," *International Journal for Quality in Health Care*, vol. 15, no. 3, pp. 261-266, 2003.

[97] Delbert C. Miller and Neil J. Salkind, "Sampling," in *Handbook of Research Design and Social Measurement (6th Edition)*, D. C. M. a. N. J. Salkind, Ed. California, United States of America: Sage Publications, 2002, ch. 2, pp. 52-57.

[98] Duncan Cramer and Dennis Howitt, "The Sage Dictionary of Statistics," in *The Sage Dictionary of Statistics*. London, England: Sage Publications Ltd., 2004, pp. 113-114.

[99] Ian Scott and Debbie Mazhindu, *Statistics for Health Care Professionals*. London, England: Sage Publications Ltd., 2005.

[100] Sasol. (2015, Mar.) www.sasol.co.za. [Online]. http://www.sasol.co.za/about-sasol/company-profile/historical-milestones

[101] Murray & Roberts. (2015, Mar.) www.murrob.com. [Online]. http://www.murrob.com/au_overview.asp

[102] WBHO. (2015, Mar.) www.wbho.co.za. [Online]. http://www.wbho.co.za/about-us/

[103] Hatch. (2015, Mar.) www.hatch.ca. [Online]. http://www.hatch.ca/About_Us/default.htm

[104] Transnet. (2015, Mar.) www.transnet.net. [Online]. http://www.transnet.net/AboutUs/Overview.aspx

[105] SANRAL. (2015, Mar.) www.nra.co.za. [Online]. http://www.nra.co.za/live/content.php?Session_ID=65dff59deaae6ed3a973e35e6818f848&Category_ID=20

[106] Rand Water. (2015, Mar.) www.randwater.co.za. [Online]. http://www.randwater.co.za/AboutUs/Pages/Default.aspx

[107] Barba B Kwaulich, "Data analysis techniques in qualitative research," *Journal of research in education*, vol. 14, no. 1, pp. 96-113, 2004.

[108] Bernard, H.R., *Social research methods: Qualitative and quantitative approaches*. CA: Sage Publications, 2000.

[109] Merriam S.B., *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass, 1998.

[110] Isabelle Walsh, Judith A Holton, Lotte Bailyn, Walter Fernandez, Natalia Levina, and Barney Glaser, "What Grounded Theory Is...A Critically Reflective Conversation Among Scholars," *Organizational Research Methods*, pp. 1-19, 2015.

[111] Udo Kuckartz, *Qualitative Text Analysis: A Guide to Methods, Practice and Using Software*, SAGE, Ed. London, UK: SAGE Publication Ltd., 2014.

[112] Oke, A.E. and Ogunsemi D.R., "Competences of quantity surveyors as value managers in a developing economy," in *The construction and Building Research Conference of the Royal Institutions of Chattered Surveyor* , 10-11 September 2009, pp. 23-38.

[113] L.Y. Shen, George W.C. Wu, and Catherine S.K. Ng, "Risk assessment for construction joint ventures in China," *Journal of Construction Engineering and Management*, vol. 127, no. 1, pp. 76-81, Feb. 2001.

[114] Hullet Davis T., "Key Characteristics of a Mature Risk Management Process," in *Fourth European Project Management Conference*, London, England, 2001.

[115] David A. Hillson, "Towards a Risk Maturity Model," *The International Journal of Project and Project Risk Management*, vol. 1, no. 1, pp. 35-45, Sep. 1997.

APPENDIX A

Questionnaire: Infrastructure Development Risks and Mitigations

This research is for my Masters in Engineering Management Mini Dissertation at the University of Johannesburg, South Africa.

Infrastructure plays an important role in social and economic development of South Africa, thus contributing to the well being of communities, by reducing poverty levels, and improving access to basic services such as drinking water, sanitation, electricity, telecommunications, transportation etc. In many cases the delivery of such services is hampered by risks that are unforeseen and unplanned for.

I am conducting a research study to indentify risks and mitigations associated with infrastructure development projects in South Africa, to aid in developing a list of risks and mitigations, which can be utilized when preparing risk management plans for infrastructure development projects.

The attached questionnaire presents a list of infrastructure development risks that have been identified from literature review study, and I am asking you to please take a moment to identify the risks that you have experienced while implementing infrastructure projects in South Africa, and provide possible mitigations for such risks. If some of the risks you have encountered are not listed, please list them and provide a short description, and the potential mitigations applied to the risks. Please note that, only projects implemented in South Africa should be considered.

To answer the questionnaire, please follow these steps:

a) From the list provided, select risks that you have encountered while implementing infrastructure projects;
b) State the mitigations that were implemented to control the risks you have selected;
c) State if the impact of the risk on the project was cost (C), time (T) and scope (S), or a combination;
d) State how often the selected risk occurred, by using the following rating, high (H), medium (M), and low (L)
e) If some of the risks you have encountered are not mentioned in the provided list, please state them and repeat steps a) to d).

Position	Legend:
Qualification	C-Cost, T-Time, S-Scope
Years of experience	H-High, M-Medium, L-Low

			C	T	S	H	M	L
Risk Category	**Description**	**Risk Mitigation**	**Impact**			**Rating**		
1. Lack of funding	This type of risk involves the lack of funding to implement infrastructure projects, whether partially or completely							
2. Inadequate skills capacity	This type of risk is concerned with the lack of formal training in technical and management skills (project management, construction management, financial management etc.), which are required for the implementation of infrastructure projects.							
3. Corruption	This type of risk involves both private and public sector organizations. Corruption involves activities associated with stealing from project resources, bribing to force matters to ones advantage without following procedure, selection of projects that favour specific contractors by public entities and structuring bids to favour certain contractors. Some companies bribe to obtain project contracts, and increase profits, while lowering construction cost at the expense of the quality of the finished product.							
4. Financial	Financial risks are associated with interest rates, cash flows and credit ratings. These factors may result in delays in payment, which may result in cash flow problems that will cause a ripple effect resulting in an undesired outcome on the project.							

5. Economic	Economic risks include factors impacting on material availability; labour sourcing; machinery rentals; inflation; pricing of goods and materials; fiscal policies; and exchange rates.			
6. Commercial	This type of risk is induced by factors that affect the environment in which the project is being implemented; some of these factors may include possible supply of raw materials, community concerns, and local authorities.			
7. Political	Political risks involve factors that affect countries, and they may be induced by government decisions, social unrests or war.			
8. Performance risks	This type of risks involve poor project definition, inadequate design input, rework due to poor quality, disputes.			
Below is space provided for the risks not listed above that you have encountered on projects:				
9.				
10.				
11.				

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