FACTORS AFFECTING THE IMPLEMENTATION OF STRATEGIC ASSET MANAGEMENT IN THE STATE-OWNED ELECTRICITY UTILITY COMPANY IN ZAMBIA.

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Factors Affecting the Implementation of Strategic Asset Management in the State-Owned Power Utility Company in Zambia.

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To my cherished children Chama Jr. and Nelly Chishimba

and my late parents Kaleb and Rosemary Kalaba Chishimba (RIP)

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ABSTRACT

Electricity plays a pivotal role in various sectors of every economy such as manufacturing, mining, telecommunication and transportation. It is also a key national resource in the provision of services in hospitals, universities and banks as well as residential areas worldwide. However, power utility companies within Africa, Zambia in particular, are facing numerous challenges related to asset failure in their generation, transmission and distribution systems due to ageing. Ultimately, this has led to power outages or load shedding, lasting 6 to 12 hours a day, in all major mining and industrial cities. In light of the foregoing, the aim of this study was to identify and rank the factors that have affected the implementation of strategic assets management in the state-owned power utility company as well as establishing the root cause of these challenges through qualitative and quantitative methods: in particular, descriptive statistics and content analysis of open-ended questions via inductive and deductive methods. The approach that was taken for this present study involved interviewing senior managers at ZESCO Ltd. Lusaka Division using structured and open-ended questionnaires to probe the respondents on what their views were in relation to asset management by asking strategic questions that focused on the key elements of asset management. In conclusion, the findings of the research revealed that *social and cultural (organisational behaviour), the dearth of clear maintenance strategies and asset lifecycle management, Lack of skilled/specialised manpower in asset management, knowledge Management /documenting critical information, lack of policy implementation, non-cost reflective tariffs, Financial (constrained funding for capital projects), Political interference and Regulatory and Statutory compliance* are the factors that have been impeding the implementation of strategic asset management in the state-owned power utility company. Further, the root causes of these factors were due to the *departmentalized* and the *highly reactive* nature of asset and maintenance management processes and procedures that are used to perform asset management. In addition, it was further revealed that lack of awareness of leadership roles, fragmented information systems and risk management played a role in impeding the implementation of strategic asset management. Also, most of the managers indicated that their training did not prepare them for asset management.

Keywords: *Ageing assets, factors, implementation, Strategic asset management*

ABSTRAK

Bekalan elektrik memainkan peranan penting dalam pelbagai bahagian ekonomi seperti pembuatan, perlombongan, telekomunikasi, dan pengangkutan. Ia juga merupakan sumber utama negara dalam penyediaan perkhidmatan di hospital, universiti dan bank serta kawasan perumahan di seluruh dunia. Walau bagaimanapun, syarikat-syarikat utiliti tenaga di Afrika, Zambia khususnya, menghadapi banyak cabaran yang berkaitan dengan kegagalan aset dalam sistem penjanaan, penghantaran, dan pengagihan disebabkan oleh penuaan. Akhirnya, hal ini membawa kepada gangguan kuasa atau penyisihan beban berpanjangan dari 6 hingga 12 jam sehari di semua bandar perlombongan dan perindustrian utama. Memandangkan perkara di atas, kajian ini bertujuan untuk mengenal pasti dan menentukan faktor-faktor yang menjejaskan utiliti kuasa milik kerajaan negeri serta menentukan punca kepada cabaran-cabaran ini melalui kaedah kualitatif dan kuantitatif: khususnya, statistik deskriptif dan analisis kandungan soalan-soalan terbuka melalui kaedah induktif dan deduktif. Pendekatan yang diambil untuk kajian masa ini melibatkan temuramah pengurus kanan di ZESCO Ltd. Bahagian Lusaka dengan menggunakan soal selidik berstruktur dan terbuka untuk menyiasat responden tentang pandangan mereka berkaitan dengan pengurusan aset dengan bertanyakan soalan strategik yang memberi tumpuan kepada perkara utama dalam pengurusan aset. Kesimpulannya, dapatan kajian mendedahkan bahawa *sosial dan kebudayaan (tabiat organisasi), kekurangan strategi penyelenggaraan yang jelas dan pengurusan kitar hayat aset, kurangnya tenaga kerja mahir/khusus dalam pengurusan aset, pengurusan ilmu /pendokumenan maklumat kritikal, kurangnya pelaksanaan dasar, tarif tidak menggambarkan bukan kos, Kewangan (kekangan dana untuk projek modal), Campur tangan politik; dan pematuhan Kawal Selia dan Berkanun* adalah faktor-faktor yang menghalang pelaksanaan pengurusan aset strategik dalam utiliti kuasa milik kerajaan negeri. Selanjutnya, punca faktor-faktor ini adalah disebabkan oleh proses pengurusan aset dan penyelenggaraan dan prosedur yang digunakan untuk melaksanakan pengurusan aset yang bersifat *berjabatan* dan *sangat reaktif*. Di samping itu, ia juga mendedahkan bahawa kekurangan kesedaran tentang peranan kepimpinan dan sistem maklumat dan pengurusan risiko yang berpecah-belah. Juga, kebanyakan pengurus menunjukkan latihan mereka tidak menyediakan mereka untuk pengurusan aset.

Kata kunci: *Penuaan aset, faktor-faktor, pelaksanaan, Pengurusan aset strategik*

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AAMC	-	Australian Asset Management Council
AM	-	Asset Management
AMS	-	Asset Management System
BSI	-	British Standards Institution
ERB	-	Energy Regulation Report
ESI	-	Electricity Supply Industry
ESR	-	Energy Sector Report
ISO	-	International Organization for Standardization
OHSAS	-	Occupational Health and Safety Assessment Series
PAS	-	Publicly Available Specification
PDCA	-	Plan-Do-Check-Act Management System
SAM	-	Strategic Asset Management
SAMP	-	Strategic Asset Management Plan
SLA	-	Service Level Agreement
SSA	-	Sub-Saharan Africa
ZESCO	-	Zambia Electricity Supply Corporation

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CHAPTER 1

RESEARCH BACKGROUND

1.1 Introduction

Physical assets, particularly those used in the generation, transmission and distribution of electricity perform a vital role in the power utility sector and assist companies in achieving their organisational strategic plans and objectives (ISO 55000, 2014, BSI PAS 55, 2008; assetmanagementstandards.com, 2017). Additionally, these assets are critical in providing reliable services to the various sectors of any nation in the world for economic advancement, prosperity and the general well-being of citizens (ISO 55000, 2014, Lloyd 2010; Crisp, 2004). Furthermore, assets are created or acquired to offer value to both the owners and stakeholders. Consequently, their condition has a bearing on both organisational and national activities. (ISO 55000, 2014; Hastings, 2014; Lloyd 2010; Smit, 2011; Kapika and Eberhard, 2013; Hastings, 2014).

This present research aims to discuss ageing assets in the power utility sector and how the poor performance of these assets has resulted in economic, environmental and social consequences the world over. For instance, in Zambia, the issue of ageing infrastructure assets has resulted in a number of system failures causing national blackouts and power rationing that last for more than 8 hours in a day (ESR, 2015, Zulu, 2015; Smit 2011; Sing'andu, 2009; Parliamentary Committee, 2014/15; KPMG, 2016).

Although Zulu (2015), specifically elaborated that "ageing transmission and distribution facilities have suffered from inadequate operations and maintenance leading

to high transmission and distribution losses thereby affecting the quality of electricity supply" and several other factors that have been identified by institutes and researchers such as Smit (2011), IEC (2015) and Eberhard (2015) who cites reasons attributed to lack of investment in infrastructure assets due to non-cost reflective tariffs, the dearth of skilled personnel, poor infrastructure asset maintenance strategies etc. (Smit, 2011; IEC, 2015; Eberhard, 2015; Kapika and Eberhard, 2013). From a general point of view, the foregoing factors can be regarded as symptoms of other underlying issues (Majeed *et al*., 2010), and this research will, therefore, attempt to identify the root cause of the bottlenecks surrounding ageing assets in the electricity supply industry.

1.2 Background

A number of power utility companies around the world are facing a myriad of difficulties relating to ageing assets particularly those used in the generation, transmission and distribution of electricity (IEC, 2015) and several nation-wide power outages the world over have been attributed to system failures due to obsolete and ageing assets in the production line (IEC, 2015; Parliamentary Committee Report, 2014; Majeed, *et al*., 2010; Der Lei and Herder 2012; Lutchman, 2006).

The following excerpt from a paper by the International Electrotechnical Commission (2015)-"Strategic asset management of power networks" elaborates that-

"Power networks in developed nations are struggling with [ageing assets], whilst those in developing nations wrestle with trying to identify best-practice [to implement]. Compounding these challenges, there is ever-increasing regulatory and funding pressure being placed on electricity network.

Amidst these challenges, there is great variation around the world on how electricity network companies approach what are arguably their number one challenge –

the design, maintenance and operation of a large network of electrical equipment. Network companies often take quite different approaches in testing equipment, calculating the lifetime and costs of various equipment maintenance options, and even reporting on the performance of their [asset] system. The variety here is hardly intentional – it stems from a lack of internationally accepted global standards or guidelines on how to practice asset management in the electricity network sector.

This lack of international standards or guidelines on asset management for electrical networks [has had a] significant impact on the reliability and future viability of the electricity sector" (IEC, 2015).

The electricity sub-sector is going through a phase in which it is experiencing significant change due to technological, technical, social, economic and environmental developments, and the management of assets is at the top of the list of challenges for several utility enterprises around the world. (IEC, 2015; Khuntia et. al, 2016, PWC 2014; Der Lei and Herder 2012). Al-Mehairi and Al-Batayneh (2014) state that problems attributed to old assets and the increase in asset system failures are two of the most arguable and debatable topics in the power utility industry (Al-Mehairi and Al-Batayneh, 2014; Crisp 2004; Majeed *et al*, 2010; Der Lei and Herder 2012).

On the other hand, William *et al*., (2017), holds that ageing assets can cause a number of risks– failure to deliver quality service to customers and meeting regulatory compliance. They point out that the impact and consequences are a great burden to most power companies in the electric sector. They add that in America, assets had poor compliance ratings from the American Society of Civil Engineers and a study on Strategic Directions in the Power Sector conducted by Black & Veatch (2016) indicated ageing infrastructure assets as the number one issue among electricity companies.(bv.com, 2017; Der Lei and Herder 2012).

www.bv.com (2017) further contends that despite the realisation of threats associated with old infrastructure assets, the main challenge has been the assessment process and finding credible ways that power utility companies can employ to assess the threats and rank approaches for implementing asset management (www.bv.com, 2017).

William *et al*., (2017), and Hastings (2014) both suggest that the answer to the assessment problem lies in formal asset management and that it's a decisive tool for recognising, assessing and highlighting issues in the management of assets (William *et al*., 2017; Hastings 2014). Although a number of power utility companies implement certain elements of the asset management concept- very few have established an asset management system that actually works (William *et al*. 2017). Lutchman, (2006) argued that infrastructure asset management has grown in popularity- however, the concept is grossly misunderstood (Lutchman, 2006). Hastings (2010) further adds that asset management is mistakenly understood as the care and maintenance of assets (Hastings, 2010).

According to Khuntia et.al (2016) "In the transforming electric power industry, power system reliability is of primary concern because the pressure to deliver quality services places tremendous stress on transmission and distribution assets, and this gave birth to asset management. Asset Management is classified as an important activity in present day transmission and distribution system planning and operation". Brown (2017) alludes to the fact that over and above any other problem; ageing assets demonstrates the potential of asset management to tackle acute challenges being encountered in the electricity sector (Brown, 2017).

The reorganisation of the industry has led a number of electricity companies to pay attention to the ageing assets and the concept of strategic asset management has become one of the focus areas to increase effectiveness and reliability as a strategy to maintain old assets. It has been noted that power utility companies are justifiably on the lookout for solutions to get the most out of their ageing equipment and at the same time

maintaining the standards in terms of reliability and quality of service (Majeed et. al. 2010).

Lloyd (2012), contends that: globally, asset-intensive enterprises and many other entities that by and large depend on the efficiency and effectiveness of infrastructure assets for achieving organisational goals have collectively identified the need to be more strategic and efficient in the various approaches in which they manage their infrastructure. Asset management provides them and other interested parties with a coherent set of ideologies for determining organisational objectives and establishing the worth of the enterprise in the long term (Lloyd, 2012; Brown, 2017).

Despite the realisation of the importance of asset management in the industry, surveys conducted by the International Electrotechnical Commission (2015) still identified four (4) key asset management challenges in the utility sector that are ubiquitous in most parts of the world. These challenges are:

- *A lot of equipment constructed* [more than 50 years] *remains in service and will soon be operating beyond its designed life.* Brown (2017) and Majeed *et al*., (2010) corroborate this by stating that most of the equipment in the power utility sector has been in service for more than two decades (Brown, 2017; Majeed, *et al*., 2010)
- *Even if the older equipment is performing well, obtaining technical support or spare parts for equipment designed and manufactured decades ago can be very difficult.* The electricalreview.co.uk (2015) explains that this challenge has grown further due to most manufacturers withdrawing support for old assets that still perform critical roles in the network system. (electricalreview.co.uk, 2015)
- *In many cases, at the current rate of replacement, it would take several hundred years to fully replace existing old equipment.* Pell *et al*., (2015), attests to this by stating that there is poor asset planning and demand analysis in most companies (Pell *et al*., 2015).

- *Because of a large amount of old equipment, there is a significant risk of multiple failures occurring simultaneously, more than many electricity network businesses would be equipped to handle.* (IEC, 2015)

The difficulties listed above present major risks with regards to the quality and reliability of electricity supply. Therefore, economic choices on how to move forward with the upgrades and maintenance of infrastructure assets continue to stand out as significant challenges for most electricity companies. (IEC, 2015; Pell *et al*., 2015).

Hastings (2014), mentions that "significant amounts of money and time are spent on managing business-critical assets each year, yet there is still confusion over terminology, and a wide variety of management approaches are in use. In many cases, these approaches serve asset management needs well, but often they do not sometimes result in high-profile failures" (Hastings 2014).

Regrettably, the IEC, (2015) also reported that because of variations in methodologies, terminology and measurements, the practice of asset management pertaining to ageing infrastructure the world over differs significantly; by and large, power utility managers are left to decide themselves how to continue, with little direction from the more extensive industry. When researching the current asset management practices in different utility firms the following crucial asset management challenges were highlighted:

- There is a lack of global specifications on maintenance of old assets;
- The dearth of uniformity in asset refurbishment criteria across industry;
- Difficulties in finding competent people with the right talent and training to manage ageing equipment. Smit (2011), attests to such industry issues.
- The management of old infrastructure assets
- Prioritising investment decisions (IEC, 2015).

As is the case globally, Zambia has not been spared from industry challenges concerning ageing assets and difficulties in asset management. A number of factors relating to poor asset management have been identified in reports prepared by the Energy Regulation Board and other research papers and these factors have been attributed to, but not limited to the following:

- Lack of investment in new infrastructure assets (Zulu 2015; Kapika and Eberhard, 2013);
- Poor funding and prioritisation in the generation, transmission and distribution assets (Zulu, 2015; Eberhard 2015);
- Non-cost reflective tariffs which have had an impact on the financial capabilities of the utility company (ESR, 2015; Zulu, 2015; Sing'andu, 2009; Smit, 2011; Kapika and Eberhard, 2013);
- Availability and transportation of spares (Smit, 2011);
- Human resource productivity and poor maintenance and operation regimes (Zulu, 2015; ESR, 2014, Kapika and Eberhard, 2013).
- Climatic conditions causing assets to deteriorate at a faster rate (Smit, 2011);
- Poor financial management (ESR, 2015) and;
- A lack of experienced personnel or poor management practices (Smit, 2011; Kapika and Eberhard, 2013).

However, in the Journal AWWA (2012) it has been pointed out that companies that have implemented a proactive asset management system have noted that "such programs cost-effectively reduce the risk of failure associated with ageing assets and provide value for both the utility company and the community" (AWWA, 2012). Nguyen and Seow (2016), ISO 55000 (2014) and assetmanagementstandards.com (2017) collectively agree that asset management provides a valuable framework for the power sector by balancing cost, performance and risks (Nguyen and Seow 2016). A PWC power utility roundtable discussion paper (2014) further explains that:

"Many senior executives believe that there is a lot the electricity industry can do to meet these challenges. Most believe they will achieve improvements through activities that are underpinned by the emerging discipline of [strategic] asset management- it is a key foundation for the risk mitigation and improves safety, helping to prioritise which assets are the most in need of attention.

Executives have shared how implementing a robust asset management framework, leveraging PAS 55 and the ISO 55000X series of standards for asset management has positioned their organisations on a journey of excellence. However, as much of the discussions confirmed, making asset management central to how a company operates calls for cultural buy-in and firm leadership from [top management]" (PWC, 2014).

In conclusion of the study background, research conducted by Reliabilityweb.com was done *to determine the status of asset management initiatives worldwide* (2014). More than 1000 firms responded to the study. The research reported that 61% of the participants said that:

"The fundamental reasons to invest in asset management vary, but increased system reliability—the ability of an item to perform a required function under given conditions for a given time interval—stands out as the primary reason with more than three-quarters of asset managers. Not surprising (…) a clear majority of organisations (…) cited (…) ageing assets/infrastructure as [one of the] top three reason to [implement] asset management". (Reliabilityweb.com Research Report, 2014).

1.3 Problem Statement

The generation transmission and distribution assets of any power utility company are regarded as the most critical, playing a vital role in providing electricity used in

various divisions of the economy such as manufacturing, mining, telecommunication and transportation as well as the wellbeing of citizens (Institute of Asset Management 2015, BSI PAS 55 2008). As an asset system, they are undeniably a key national resource in the provision of the services in hospitals, universities, financial institutions and domestic entities (ESR 2015; Policy Monitoring and Research Centre 2014; usaid.gov 2017; BSI PAS 55, 2008).

However, as discussed in the research background, a number of power utility companies around the world are facing numerous challenges relating to system failures attributed to obsolete and ageing assets in the supply chain. For instance, in Zambia, the Parliamentary Committee on Economic Affairs and Labour (2015) received submissions from stakeholders regarding challenges affecting the electricity sub-sector and it was reported in part that:

"Most of Zambia's electricity distribution (assets) are aged. The cables, overhead lines and switchgear were installed over forty years ago. The distribution network had reached its limits and equipment failures were common, resulting in the deterioration of quality and reliability of supply" (Parliamentary Committee Report, 2014/2015).

In the same report, it was also noted that:

"The country's transmission grid was said to be constrained and its efficiency compromised (…) The transmission network (…) required upgrade, reinforcement and expansion in order to improve performance and to carry the load from new generation projects" (Parliamentary Committee Report, 2014/2015).

Ideally, in order to deal with the problems that were pointed out in the parliamentary report, it is important that the root causes of the factors that led to the current situation are properly identified in order to find appropriate solutions.

Notwithstanding all these challenges in the electricity sector in Zambia, an online search reveals that there is little to no literature on studies that have been conducted with regards to ageing assets challenges in the country and it remains indistinct as to what the underlying problems or casual chains of the matter are to date.

Although there are measures that have been put in place to rectify the system failures associated with ageing assets such as the rehabilitation and upgrade projects that are taking place across the country, the same issues will arise in future if the factors surrounding the ageing of assets are not identified and ranked according to criticality.

Implications of failure to manage assets throughout their life cycle have been documented, but not limited to the ones below:

- Reactive work environment and high operational and maintenance costs associated with assets (BSI-PAS 55, 2008; Lloyd 2010; Hastings 2014)
- Missed opportunities because of capacity performance issues (BSI-PAS 55, 2008; ISO 55000, 2014)
- Large asset infrastructure condition deficit (Lutchman, 2006)
- Increase in safety and health-related problems (Lutchman, 2006; Hastings 2014)
- System failures resulting in severe consequences (PWC, 2014; BS-PAS 55, 2008; Hastings 2014)
- Financial losses (Hastings, 2014; Kapika and Eberhard 2013)

In light of the issues raised regarding ageing assets, it is intuitively logical to relate the challenges in the Zambia Electricity Supply Industry (ESI) to those being encountered globally even in the most developed countries. The bottlenecks are undeniably associated with lapses in the implementation of asset management more specifically due lack of policies, poor strategic planning, demand forecasting and management of generation, transmission and distribution assets which can be described

as siloed or departmentalized. Kapika and Eberhard (2013) state that planning for asset renewal should have a time-horizon of not less than 15 years. (Kapika and Eberhard, 2013).

Therefore, this present study aims to first, identify the root cause of the factors apropos ageing assets and secondly, to rank these hold-ups in the implementation of strategic asset management in the power utility sector for prioritisation purposes.

NOTE: ***It is important to note that not all system failures and consequent outages that cause national blackouts in Zambia are as a result of challenges due to ageing assets. Other factors such as climate change etc. which had an impact on the rain patterns in the region over the past 3 years, causing low water levels at major hydropower stations, are out of the scope of this study but will be discussed in the context of constraints and risk management as part of the strategic asset management concept.***

1.4. Research Question

1. What are the factors that have led to ageing assets resulting in power outages and reliability issues?
2. To what extent has the power utility sector (ZESCO Ltd) implemented strategic asset management?

1.5 Research Objectives

The research objectives for this present research are as follows:

1. To identify the factors affecting the implementation of strategic asset management (SAM) in relation to ageing assets.
2. To rank the factors based on frequency from highest to lowest.
3. To establish the root cause of factors impacting on the implementation of strategic asset management in ZESCO Ltd.

1.6 Scope and Limitations

Challenges pertaining to ageing assets are twofold. First, there is the technical facet relating to technology, mechanical and electrical issues such as obsolescence of equipment and spares and second, the strategic management side to these assets which is concerned with the holistic planning, acquisition, deployment, operation and subsequent disposal in order to meet strategic organisational goals. This study was focused on the management aspect only and all technical details of ageing assets were not part of the scope. Nevertheless, there are intersection points that were briefly discussed in relation to documenting information such as the age, having clear maintenance strategies throughout the lifecycle of each asset or asset systems, condition and environment risks which play a vital role in the management processes of these critical assets.

1.6.1 Scope

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assets which is concerned with the holistic planning, acquisition, deployment, operation and subsequent disposal in order to meet strategic organisational goals. This study was focused on the management aspect only and all technical details of ageing assets were not part of the scope. Nevertheless, there are intersection points that were briefly discussed in relation to documenting information such as the age, having clear maintenance strategies throughout the lifecycle of each asset or asset systems, condition and environment risks which play a vital role in the management processes of these critical assets.

1.6.2: Limitations

According to Brown (2017), Asset management is ambitious in scope and requires supporting metrics, organisational design, processes, information systems, and corporate culture (Brown, 2017). Due to time and financial resource factors, the limitations of this study are that:

- It only focuses on factors that affect the implementation of strategic asset management at the ZESCO head office and does not include other parts of the organisations.
- External stakeholders such as The Ministry of Energy and Water Development, Energy Regulation Board and Zambia Bureau of Standards have not be included as respondents in this study.

1.7 Significance of the Study

It is undeniable that ageing assets have become a major challenge in most power utility companies and the systems failures that are rife in a number of electricity organisations have been associated with old infrastructure assets. These failures in the

generation, transmission and distribution assets have resulted in serious impacts and catastrophic consequences as discoursed in the project background and problem statement. To this end, the significance of this research project is that it will help to identify factors that have led to the ageing of electricity infrastructure assets, and ranking them accordingly as well as establishing the root causes of these factors in order to improve planning processes in the future.

Additionally, the research will assist in identifying existing capabilities, competencies and changes that need to be instituted in formulating an asset management system that can effectively support the management of assets throughout their economic life. Furthermore, this present study will be instrumental in establishing tangible targets and inculcating a culture of life cycle management of assets i.e. optimised planning, asset selection, acquisition/development, utilisation, care (maintenance) and ultimate disposal in a timely manner leading to certification in ISO 55000 series of asset management standards.

1.8 Organisation of the Dissertation

This Thesis is made up of five (5) chapters. In chapter one, the research background is given followed by the research problem, research objectives, research questions, the scope, limitation and significance of the study.

The second chapter provides a detailed literature review with a focus on ageing assets from the management point of view, the types of assets, the myriad theories on the asset management concepts and misconception, elements of the asset management system and lastly, the asset management standards.

Chapter three provides the research methodology, justification and framework adapted to conduct the research. The chapter further gives a detailed breakdown of the survey instrument and the rationale behind the questions.

The fourth chapter covers the data analysis of the responses as well as findings and the various methods used to collect the data. The analysis also shows how the responses were triangulated through discussions with key informants for the purpose reliability.

Finally, the fifth chapter draws conclusions from the work carried out in the previous chapters and discourses the findings through synthesis processes with requirements of the assets management standards and general literature by following the framework designed for the research. The closing chapter further gives a recap of the research problem statement, answers the questions as well as indicating how the research objectives were made. In summation, this thesis provides recommendations based on the findings.

- Long-term strategic planning and risk management systems models that can help in assessing the impact of system failures on an organisations goals and objectives.
- Collective frameworks that employ quality, risk and human resources performance management around the lifecycle of critical assets for continuous asset management improvement.
- Development of benchmarking models in strategic asset management models with a focus on how to manage ageing infrastructure assets in the wake of financial constraints.

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