THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

GRAIN STORAGE FACILITIES MAINTENANCE CHALLENGES IN ZAMBIA: A CASE STUDY OF THE FOOD RESERVE AGENCY

MASTER OF ENGINEERING IN ENGINEERING MANAGEMENT

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2023

DECLARATION

I, **Cravans Muntanga** hereby declare that this thesis represents my own work, and that it has not been previously submitted for a degree, diploma, or other qualifications at the University of Zambia or any other University for the purpose of obtaining an academic qualification.

Signed ……..

Date ……

Name of Supervisor: **Dr Edward Lusambo**

Signed ……..

Date ……..

Certificate of Approval

This thesis/dissertation of Mr. Muntanga Cravans has been approved as fulfilling the rquirements or partial fulfilment of the requirements for the award of the Master of Engineerring Degree in Engineering Management by the University of Zambia

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ABSTRACT

This study was aimed at evaluating the effectiveness of strategic maize storage in Zambia. Maize is a staple food in Zambia. However, because of seasonal production, its storage must be such that it is kept in good condition for sustained supply all year round. It has been observed that a large proportion of stored grain is wasted because of poor post-harvest management in Southern African countries such as Zambia. Among the factors responsible for losses are inadequate and ineffective grain storage facilities and poor handling practices. In Zambia, the mandate for management of sustainable national strategic food reserves and ensuring national food security lies with the Food Reserve Agency (FRA). This research therefore used the FRA as a case study to investigate the challenges that the agency faces in the management maize storage facilities. Using the mixed methods approach, the study deployed explanatory case study with the study centered on three key theories, namely: maintenance management, asset management and property management with the scope covering all the silos and six sheds managed by the FRA across Zambia. The specific objectives of the study were to establish the current state of strategic storage facilities, to determine the maintenance philosophy used in the management of strategic storage facilities, to establish the challenges faced in the maintenance of strategic storage facilities and to determine the best and most cost-effective strategies to use in the maintance of strategic storage facilities. The study's participants were drawn from within the FRA and held different portfolios that included marketing, standards and quality, warehousing, property management and monitoring and evaluation. Among the findings of the study was that the depots and sheds of FRA were in fairly good and acceptable condition. The findings, however, showed that the FRA did not have a clear maintenance management policy or a maintenance management philosophy. Much of its approach to maintenance management was on an ad hoc or reactive basis. Additionally, capacity gaps, technical and financial inadequacies were identified as major challenges in conducting effective maintenance management. Other findings showed that the FRA conducted inspections on its property but that these were not structured. Overall, there is need for the FRA to adopt robust policies on maintenance management so that the implementation of maintenance management is well planned and structured.

Keywords: Strategic grain storage, maintenance management, silos, storage sheds

DEDICATION

This thesis is dedicated to my lovely wife Christine Mwape Mwewa and my three children Chengetai, Evans and Tatenda who continued to encourage me even under very difficult circumstances and gave me a reason to work hard.I further dedicate this work to my mother Hellen Tombi Muntanga for the consistent encourangements in my work.

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LIST OF ABBREVIATIONS

1. AC	Audit Coordinator
2. BOMA	Building Owners and Managers Association
3. COVID 19	Corona Virus Disease 2019
4. CT	Caretakers
5. DMMU	Disaster Management and Mitigation Unit
6. EM	Emergency maintenance
7. FRA	Food Reserve Agency
8. M&E	Monitoring and Evaluation
9. MM	Maintenance Management
10. MT	Metric Tonne
11. PMD	Property management Department
12. PM	Preventive Maintenance
13. PT	Property Technician
14. PWC	Price Walterhouse and coopers
15. RDA	Road Development Agency
16. RICS	Royal Institute of Surveyors
17. RMC	Regional marketing Coordinator
18. RPC	Regional Property coordinator
19. SC	Security coordinator
20. WS	Warehouse Supervisor
21. ZNBC	Zambia National Broadcasting Corporation

CHAPTER ONE INTRODUCTION

1.0 INTRODUCTION

The chapter gives an overview of the study with the background of the study, specific objectives, statement of the problem, significance of the study, key concepts, limitation of the study and theoretical framework.

1.1 Background

1.1.1 General Overview

This study explored the challenges that the Food Reserve Agency (FRA) encounters in the maintenance of its grain storage facilities at its different depots. The study further recommended maintenance management strategies of grain storage facilities that could be appropriate and used in order to avoid physical obsolescence of institutional property.

It has been observed by several studies that storage of staple crops, which include maize, plays an important role in many Sub-Saharan countries such as Zambia whose staple food and food security hinges on maize. Because of its seasonal production, maize storage is an important aspect in ensuring that it is kept in good condition for sustained supply all year round. Ekpa et al., (2018), Nukeine, (2010) and World Bank, (2011) indicate that by 2011, an estimated 30% to 50% of stored maize grain was wasted because of poor post-harvest management of cereals in Southern Africa. Among the factors responsible for these losses were inadequate and ineffective grain storage facilities and poor handling practices (World Bank, 2011).

From the foregoing, it is evident that to preserve the maize or other grains, it is important that facilities in which they are stored are constantly maintained in good condition. For instance, leakages in silos and depots during the rainy season can allow in water and spoil the grains. When it comes to property management, David, (1999) emphasised the importance of maintenance of buildings and advanced the view that buildings need constant and regular maintenance to ensure that their condition does not deteriorate. According to David, (1999), buildings immediately start to deteriorate from the moment the construction is completed. He further argues that one of the major challenges facing property maintenance is that building owners tend to effect maintenance on property in a reactive manner when they have realized that there is a problem instead of integrating constant preventive maintenance in organisation operations.

Property management including that of grain storage should be well planned, effectively managed and integrated within the organisational operations as any other corporate activity. This realization has led to a rethink in the way many institutions manage property globally although there is evidence that many still have not adopted a much more systematic approach to maintenance management especially in developing countries such as Zambia (Zailan, 2001). The foregoing has inevitably created a new burden on property managers to adopt a more systematic approach to their work. This is especially with regards to maintenance approaches such as preventive and predictive maintenance.

Globally, it has been proven that property management has several benefits which include generation of income and consumer satisfaction, this is because the property is given due care and a long economic life (Vikash, 2018). When public property is well managed, it facilitates efficacy in service delivery and achievement of the desired targets. Thus, property management has recently gained importance and is receiving a lot of attention as the stock of new buildings requiring huge outlays are being put into operation. There is also an increased realization that a well-managed property stock allows one to save money for future investment in the property industry thus more focus is being placed on property management as a core component not only in the private sector but also in the public sector. This idea was reaffirmed by Zailan (2001) who placed emphasis on establishment of goals, objectives and policies as well as strategies to achieve those goals and objectives in managing properties.

1.1.2 Grain Storage Facilities

Jayas, (2000) asserted that there are over two billion tonnes of cereals, oilseeds, and pulses, collectively referred to as grains, which are produced annually for human and animal consumption globally. For preservation and distribution, the grains are stored at different stages and storage facilities between the producer and the consumer. This places a huge requirement for quality grain storage facilities. Various studies show that for grains to be kept in a conducive and good environment, the storage facility must be regularly maintained in good condition. Rahul, (2021) indicated that a grain storage structure is an important rudiment in which various grains can be stored more safely over a long time to cope with the current and future demand of growing residents for food grains and described four types of storage structures as follows;

1. Traditional storage structure: In this type of storage structures, grain is usually stored in bulk, and typically has capacities between 1 and 50 tons. Grain storage is usually done in various rural and urban areas along with bulk storage as well as bag storage.

2. Improved storage structure: In improved storage structures, some improvements have been made to the traditional storage structures. These types of structures have a larger storage capacity for long-term storage of food grains than conventional storage structures. These structures typically have a range of 1.5 to 150 tons.
3. Farm silos: A silo is an airtight tower, tank, pit, or plastic bag into which some of the uprooted crops are poured and sealed. These silos are categorized differently and include **Sealed Silo** which is used for better grain pest control. Insects in stored grains should be controlled because they damage the grains and excrete moisture that can move into the headspace causing molding. There is also **Silo bag** which is appropriate for storing grains, even if they are wet. The third Silo type is the **Aerated silos** designed particularly for fine powders. The fabric is aerated by pumping air into the underside of the silo, making it act as a fluid through the discharge of the fabric from the underside of the silo.
4. Modern storage structure: Large quantities of food grains are stored in bulk, this is the 'silo' and traditional warehouse (shed) designed for storage. Sidewalls of a shed are fabricated from brick masonry or stone masonry on metal trusses and sloping roofs in asbestos or corrugated galvanized iron (CGI) sheets. Mostly, silos are constructed from both metal and reinforced concrete, any modern large / capacity processing plant has a group of adjacent silos. Modern permanent grain storage systems should be selected to preserve stored grains and other products. They should be chosen on the basis of quality than on the basis of cost. The minimum FRA silo will have a capacity of 15000MT and maximum capacvity of 22500 MT whilst a shed has a minimum capacity of 1500 MT and maximum capacity of 6000 MT (FRA, 2021).

There are various requirements that must be met to ensure that there is a good standard of grain structure and thus the grains produced should be thoroughly cleaned and graded. Furthermore, the structure should be able to take the load of grain stored and should not allow any exchange with the outside humid air. Rahul (2021) indicated that it is also very important to ensure that at all times the grain storage structure should be cleaned and disinfected and maintained to ensure durability on a long-term basis. There should also be provision to safeguard the structure from floor moisture, rain, rats, birds, molds, rodents, ants and insects. This entails that the structure should be constructed in such a way that it may present the necessary facility for

regular maintenance, inspection and disinfection, loading and unloading, cleaning, and reconditioning.

Although grain storage structures are very important and beneficial, they have both advantages and disadvantages and Rahul (2021) discussed these. Firstly, he advanced the view that grain storage is important in having control over weight and quality of shipment and better planning over crops and transportation, improvement in quality of grains and maintaining its origin. Grain storage structures allow for greater flexibility and control for grain distribution with pricing being able to be done multiple times after harvest.

Despite their overwhelming benefits, grain storage structures tend to have their own downsides and among them are that they tend to be highly exposed and amenable to fire and explosion hazards. This is especially in grain elevators which poses a danger to the lives of the people. Furthermore, they are much more inclined to cause accidents linked to suffocation by the accumulation of carbon dioxide and poisoning. There is also a possibility of causing drug addiction risk resulting from the use of fumigants and pesticides (Rahul, 2021). For example, according to Al Jazeera (2023) at least 12 were injured due to an explosion from a grain silo near the port of Derince in western Turkey. In France, AFP (2023) also reported of French firefighters who were dealing with a major blaze in grain storage silos in the western port of La Rochelle. The four silos which were on fire were in a row and contained wheat.

1.1.3 Strategic Grain Storage in Zambia

To ensure food security and sustainability, the Zambian government established institutions that deal with grain management. The Food Reserve Agency (FRA) is the institution that is the main coordinator of such a mandate. The FRA is the national grain marketing agency of Zambia which was established in 1995. It derived its mandate from the Act of Parliament of 1995 which states that "it is an organisation that efficiently manages sustainable National Strategic Food Reserves, ensuring National Food Security and Income through the provision of complementary and high quality marketing and storage services in line with international standards" (National Assembly, 1995). The FRA has properties throughout the ten provinces of Zambia in the form of grain silos, closed sheds, slabs and office space for its use. An example of typical grain silos used by the FRA found in Chisamba District is shown in Figure 1.1. The Agency uses the warehouses for the storage of agriculture produces such as maize which is the national staple food and crops like rice, soya beans, cassava and any other crops that the

Ministry of Agriculture may recommend (FRA, 2019). These properties need good maintenance in order to be effectively used for service delivery. However, it has been observed that most of these storage facilities are dilapidated and remain unused. An example of a dilapidated shed with a leaking roof is shown in Figure 1.2. For instance, according to an FRA report (FRA, 2018), the secure and safe storage is only estimated at 898,500 metric tonnes out of 1,964,212 metric tonnes which represents 45.74% of the total storage capacity. Because of this, the agency is forced to rent more storage facilities from private companies. This is a drain on the treasury. The resources could be better used to rehabilitate more facilities in order to make them secure.

Figure 1.1 Chisamba Silo

Figure 1.2 Leaking shed

Additionally, to manage its properties across the country, FRA has a fully-fledged Property Management Department (PMD) which is in-charge of maintenance of the storage facilities and other buildings and equipment. The PMD has a twelve member team and permanent workforce at the head office that includes the civil engineer, mechanical engineer, electrical engineer, and quantity surveyor. There are also 52 caretakers with various trades in selected depots around the country. The roles of the PMD are: to ensure that all storage facilities are secure and safe for use. To carry out both corrective and preventive maintenance works, to plan and budget for all property management maintenance activities, to keep and update records of all buildings owned by the agency and to advise management on property management matters.

1.1.4 Storage facilities of the Food Reserve Agency

Food Reserve Agency Asset management report (2021) indicates that the Agency has the following storage structures as shown in Table 1.1

Table 1.1 types of storage facilities used by FRA

SI	STORAGE NAME	CAPACITY	LOCATION
1	Concrete Silo	18.5 MT 22.5 MT	Lusaka and Kitwe Chisamba, Kabwe, Ndola, Monze
2	CIDA shed	5000 MT	Southern, Copperbelt, Lusaka, Central, Northern
3	JICA shed	5000 MT	Copperbelt, Southern
4	Minestone shed	2250 MT	Central, Eastern, Northern, Southern
5	DMC shed	38,000 MT	Western and Lusaka
6	Australian shed	1,680 MT	Lusaka, Central and Copperbelt
7	CODECO shed	2,250 MT	Southern
8	27 Upgrade	5,000 MT	Eastern, Muchinga, Northern Luapula, North Western
9	ADAS shed	5000 MT	Lusaka, Muchinga, Northern, Luapula, North Western,Western,Central
10	CAMCO shed	5000 MT	Southern, Northern, North-Western, Western, Central
11	Greenbelt shed	2000 MT	Southern
12	GMB shed	6,150 MT	Lusaka
13	NORAD shed	5,000 MT	Northern, Muchinga
14	EEC shed	1,800 MT	Lusaka, Central, Southern, Western

Source, FRA Asset Management report, 2021

The FRA Storage facilities can be described as follows:

1. Silos – These are 50 meters tall concrete built structures which have holding cylindrical holding bins and small inner bins. The 22500 MT silo has a total of 20 bins with a capacity of 1000MT each and 8 inner bins with a capacity of 315 MT capacity for each bin. The 15000MT silos have 28 bins with a capacity of 500MT and inner bins with a capacity of 166MT. The silos takes in grains through the intake hoppers and with aid of conveyors and elevators stores the maize in the bins for safe storage. It is water tight and air tight preventing foreign particles to go in.
2. The JICA shed is built with a superstructure that is constructed wholly using bricks, and has an asbestos roof and sliding gated made of mild steel.
3. The CIDA,Minestone,CODECO,CAMCO,27 Upgrade and ADAS Sheds are similar in that they are all built with a concrete foundation, with a 2 meters dwarf wall and IBR cladding and roof sheets. The Shed doors are slide and fabricated from mild steel.
4. The Greenbelt, DMC and EEC sheds are built with a concrete foundation with a steel portal flame clad in IBR sheets with a roof made of IBR sheets.
5. The NORAD Shed is constructed with a concrete foundation with a block work for the superstructure and an IBR roof. The doors to the shed are made of mild steel.

The various sheds and silos of the FRA are located in many parts of the country and have different holding capacities in terms of metric tonnes. The biggest sheds are the DMC sheds located in Lusaka and Western province respectively with a capacity of 38,000 metric tonnes. The smallest FRA sheds are the Australian sheds located in Lusaka, Central and Copperbelt province standing at 1,680 metric tonnes. The proportions of storage capacity in metric tonnes for sheds is shown in Figure 1.3.

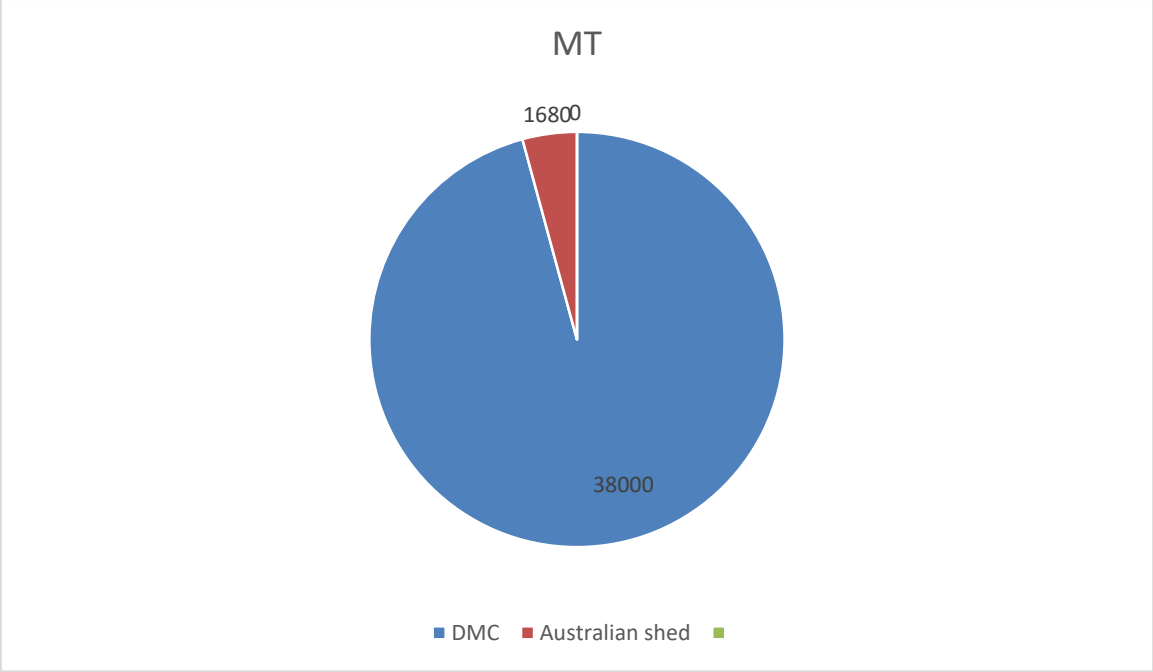

Figure 1.3 Capacity in Metric Tonnes

1.2 Statement of the Problem

The FRA encounters numerous challenges pertaining to the management and maintenance of grain storage facilities as evidenced by the fact that despite having a capacity of 1,964,000 MT of storage space, only 898,500 MT is being fully utilized. The variance is considered unsecure and unsafe storage (FRA report, 2021). This problem has led to the agency renting storage space from the private sector at a high cost. The high percentage (52.5%) of unsecure and unsafe storage facilities can be attributed to challenges in the effective maintenance of the storage structures. This is due to poor maintenance practices (FRA annual report, 2022). Additionally the absence of a property management policy means the maintenance philosophy in use cannot effectively be implemented because its enforcement is not backed by any policy or existing legal mechanisms other than the administrative systems and overall organisational legal framework. The maintenance philosophy thus lacks the necessary specific legal mandate and legitimacy to allow full compliance and enforcement. This is not only a deterent to the effective implementation of maintanence management but it also creates a legal and procedural gap. If the maintenance of storage facilities is not enhanced, more silos and sheds will become dilapidated and the agency will continue renting storage space from the private sector at a very high cost. The resources could be used to rehabilitate the unsecure and unsafe storage facilities. In considering the foregoing, the study therefore investigated the challenges that FRA faces in maintaining its storage facilities with a view to making recommendations that would mitigate them.

1.3 Objectives of the Study

1.3.1 General objective

To investigate the maintenance challenges of strategic grain storage facilities in Zambia.

1.3.2 Specific Objectives

The specific objectives of the study were to:

1. establish the current state of strategic storage facilities at selected depots and silos;
2. determine the maintenance philosophy that is employed in the management of strategic storage facilities;
3. establish the challenges FRA faces in the maintenance of strategic storage facilities at selected depots and silos; and
4. determine the best and cost-effective strategies that can be used in the maintenance of strategic storage facilities.

1.4 Research Questions

1. What is the current state of the storage facilities at FRA depots?
2. What engineering maintenance philosophy does the agency employ on grain storage facilities?
3. What are the challenges faced in maintaining the FRA storage facilities in the depots?
4. What are the best and cost effective strategies in the maintenance of FRA grain storage facilities?

1.5 Significance of the study

This study focussed on the maintenance of strategic grain storage facilities in Zambia. The findings will contribute to highlighting the best engineering maintenance strategies of grain storage properties and strategies on how a sustainable but affordable maintenance strategy can be implemented in Zambia for similar facilities. Furthermore, the findings will contribute towards policy interventions on the importance of scheduled engineering maintenance programmes on the life span of the grain storage facilities and similar infrastructures.

1.6 Theoretical framework

The study was underpinned within three main theories namely maintenance management, asset management and reliability centered maintenance. The first theory is **Maintenance Management** defined as the function of providing policy guidance for the maintenance activities and the provision of technical and management control of maintenance programmes

(Dhillon 2002). This is an important aspect within the overall property management discipline because it helps to contextualise, analyse and understand how the maintenance policy, work order system, material control, job planning and scheduling and equipment records can be used as important tools in developing a working maintenance management plan. Furthermore, it provides an analytical framework for the functioning of property management systems within FRA. The second theory which was deployed by the study is Asset Management which the Royal Institute of Chartered Surveyors (2008) defines as a structured process that seeks to ensure best value for money from property assets in serving the strategic needs of public sector organisations. This definition takes into account strategic asset management for land and buildings and makes a clear distinction between strategic asset management and operational property management. Kaganova (2012) postulates that asset management as a concept is a process of decision-making and decision implementation regarding real property acquisition, use, and disposition. Therefore property management encompasses not only management of the fixed property, but includes the governance of property rights. Davis (2019) reinforces the foregoing and assert that Asset Management is a mind-set which sees physical assets not as inanimate and unchanging lumps of concrete, but as objects and systems which respond to their environment, change and normally deteriorate with use, and progressively grow old then eventually fail or stop working.

Emphasis is placed on recognition that assets have a life cycle and that they require careful and systematic management. In view of the foregoing, this theory was important in providing the study with a theoretical basis to analyse the FRA practices in managing their properties around the country. Reliability Centred Maintenance is the third theory used by the study and it is the systematic process used to determine what has to be accomplished to ensure that any physical facility is able to continuously meet its designed functions in its current operating state as stated by (Afefy, 2010). This is important because it helps in the planning of maintenance programmes that focus on preventive maintenance of specific failure modes that are likely to occur. This theory was used in the study's analysis of the strategies used by FRA to integrate preventive maintenance in its property management.

1.7 Scope of the study

The research was mainly focused on all the FRA silos and six main holding depots of the provincial FRA Marketing offices in the country. For its administrative and internal systems, the FRA has delineated the 10 provinces of Zambia into 12 zones with Eastern and Southern Province divided into 4 regions. Subsequently, the FRA management

administrative structure is distributed in 12 zones for ease of operations since the two provinces are widely spread with the highest number of storage facilities. The above depots and silos are the control centres of the grain management and maintenance in the regions and house all the key personnel who took part in this research. In addition these storage facilities have the highest storage capacity in the provinces and operations run throughout the year. The respondents for this study were selected from the personnel that manage the storage facilities at national, regional, provincial, district and depot levels. This line of command was helpful in obtaining operational and administrative information that was relevant for the investigation.

1.8 Limitation of the Study

The study was faced with limitations regarding parameters for generalisation of data because the focus of the study sample was restricted to only one Zambian institution, the FRA. Consequently, the findings and conclusions could not be generalised to, or be valid for, all the agencies similar to FRA in Africa, or the world. However to mitigate this limitation, the study will draw on lessons and practices from other neighbouring countries such as Zimbabwe, Malawi, Kenya and Ethiopia.

1.9 Operational Definitions

Engineering Maintenance Management: It is the function of providing policy guidance for the maintenance activities and the provision of technical and management control of maintenance programs (Dhillon 2002)

Maintenance policy: This is a written statement, developed by the organization's leadership team, articulating the target maintenance standard and formal commitment by the management to that standard (Dhillon 2002) (Reference).

Materials control: It is a systematic control over purchasing, storing and consumption of materials, so as to maintain a regular and timely supply of materials while at the same time avoiding overstocking. (Dhillon 2002)

Work order system: This system has two components namely the document used for planning, executing and controlling maintenance activities and the work order flow process. (Dhillon 2002)

Job planning: These are detailed descriptions of work tasks (operations), labor, materials, time estimates and tools for a type of work. (Dhillon 2002)

Equipment record: This means all records, logs, and other documents related to the company's operation and maintenance of the Equipment. (Dhillon 2002)

Deferred maintenance: This is the practice of postponing maintenance activities such as repairs on both real property (infrastructure) and personal property (machinery) in order to save costs, meet budget funding levels, or realign available budget monies. (Dhillon 2002)

Property management: The operation, control, maintenance, and oversight of real estate and physical property. (Dhillon 2002)

Asset management: The management of real estate investments on behalf of others (Zailan, 2001)

Strategic Management: The formulation and implementation of the major goals and initiatives of the organization taken by the top management (Dhillon 2002)

Public property: These are assets owned by the state for public use (David, 1999).

Private property: Properties owned by non-governmental entities (Dhillon, 2002).

Fixed assets: Long term tangible piece of property or equipment that a firm owns and uses in its operations (RICS, 2008).

Preventive maintenance: Maintenance that is regularly performed on a piece of equipment to lessen the likelihood of it failing. (Dhillon 2002)

Predictive maintenance: The periodic or continuous equipment monitoring to evaluate performance. (Dhillon 2002)

Corrective maintenance: Maintenance carried out to rectify a faulty so that the failed system can be restored to an operational condition. (Dhillon 2002)

Reactive Maintenance: Repairs that are completed after the equipment has already broken down. (Dhillon 2002)

Proactive maintenance: The maintenance strategy that works to correct the root causes of failure and avoid breakdowns caused by underlying equipment conditions. (Dhillon 2002)

Emergency maintenance: The maintenance carried out when an asset or piece of equipment suffers an unexpected breakdown that results in an immediate threat to health and safety. (Dhillon 2002)

Food Reserve Agency: A quasi government institution established by the Act of Parliament in 1995 with a mandate to be an organisation that efficiently manages sustainable National strategic Food Reserves, ensuring National Food Security and Income through the provision of

complementary and high quality marketing and storage services in line with international standards" (National Assembly Food Reserve Act of April 1995).

Depot: A complex of sheds ,silos and offices that is used grain store and management

1.10 Organisation of the Study

The first chapter of this thesis is the introduction, which is followed by the background contextualising the grain storage facilities and its status in Zambia. Additionally, the chapter highlights the statement of the problem; research objectives and research questions; the study's scope and limitations; discusses the conceptual definitions and outlines the three theories employed for this study. Chapter two provides a review of the literature and highlights the knowledge gaps which exist on grain facilities. The chapter further offers a critical review of similar work. Chapter three provides the methodology used including research design methods, how the data was collected and analysed through the deployment of both mixed methods, and the explanatory case study methods. Chapter four is a presentation of the findings. Chapter five discusses the findings. Chapter six provides the conclusion and the recommendations based on the findings. The chapter also suggests how the study may be used for future research.

1.11 Ethical Considerations

The DRGS granted the student ethical clearance to conduct this research. Furthermore, the study's ethical approach was situated within Shamoo and Resnick (2009) who suggested the principles that underpin the ethical application when conducting research. These include:

1. respect for persons and their confidentiality and non-disclosure of their details; however the pictures could be used.
2. justice, fairness and respect regardless of the position within the research;
3. beneficence or doing well;
4. non-maleficence which means no harm should be done;
5. fidelity which entails honesty and truthfulness; and
6. academic freedom.

The above mentioned formed the ethical framework of the study from the start of the research to its conclusion. Ethical issues are pertinent in research because they help to cast a good legal and moral posture that increases the credibility of the study (Bryman, 2012). Therefore, among the ethical considerations taken into account by this study was, firstly, to gain prior consent and confidentiality of the respondents. The study assured and guaranteed respect to the privacy

and confidentiality of the study participants. Other ethical issues bordered on the right to informed consent and value-neutrality. Additionally, the study adopted the approach whereby participation in the study was voluntary with prior informed consent being sought from respondents. The reseacher sought permission to carry ou the research at FRA for academic purposes. The respondents were also assured that the study would be used for purely and entirely academic purposes, specifically, for this study. Thus, the study was conducted with clearance from the University as part of fulfillment of the study/academic requirements

1.12 Chapter Summary

Chapter one has presented the introduction, background, problem statement, the research objectives and questions as well as purpose of the study, conceptual framework, theories, study scope and the organisation of the study.

CHAPTER 2 LITERATURE REVIEW

2 LITERATURE REVIEW

2.1 Historical perspective

Historically, grains represent one of the most important nutritional elements, both for humans and animals. Its storage is especially important to guarantee food safety, sustainability and also for price stability. FAO (2021) estimates that one third of the food produced globally for human consumption is lost or wasted along the supply chain due to poor and improper storage conditions. Factors like humidity, heat, pests and aeration on storage conditions affect the quality and quantity of grains and tend to truncate the storage period. In this regard, proper storage techniques are among the most important elements in food supply chain of grains which is a significant nutritional source. Kimenju et al, (2009) state that the ability to store grain translates into commercial farmers keeping crops throughout the season or save it until they can sell it for the best possible market price. Successful grain storage requires a dry, aerated area which is high off the ground and protected from the rodents and other hazards. Other factors such as temperature, relative humidity and air flow also play a significant role in the product's quality. With the transformations which have brought modern technology, storing grain safely and efficiently has become easier than ever. Farnworth and Colverson (2016) submit that technology adoption and grain storage have been very important in controlling pests and insects within grain storage facilities. Additionally, technology has enabled the reduction of haphazard use of pesticides in grain storage thus lessening environmental impacts and avoiding exposure of workers to different toxic products. Literature also shows that the quality of the storage grain has considerably improved (Othira et al., 2009).

Moreover, Kimenju et al., (2016), submit that facilities for grain storage require creativity, novelty, development and innovation. Grain storage has posed a challenge in various civilizations for centuries, and the solutions that have evolved over the years range from storage of grains in caves to the modern slip-form concrete bins. Current grain storage systems are characterized by a wide range of storage facilities, management practices, environmental conditions, and fumigation and other integrated pest management practices (Kimenju et al., 2009). Navarro & Donahaye, (2005) in their work presented a thorough review of developments in the technology as it relates to the grain industry. Some of the aspects brought to the fore are proper silo design which is concerned with bin geometry, discharge equipment and flow pattern, and load stress on silo walls. During storage, variables such as grain moisture,

interstitial air, and temperature have an effect on pressure in silos and stress on walls. He suggests that the bins used for storage should be designed with wheat quality preservation and further processing in mind (Navarro & Donahaye, 2005)

Colverson (2016) reinforces the views of Kimenju et al., (2009) and Navarro and Donahaye (2005) though he premises his argument much more on the suitable utilization of agricultural products and how storage is critical in sustaining and increasing agricultural production. However, ultimately, the major aim of storage is to preserve properties of products and their freshness. Thus, if suitable storage conditions are not applied, according to product variety, quality and quantity, then losses are more likely to increase. Lessening these losses is possible with providing suitable storage conditions and storage management. For instance, Alam et al., (2018) assert that food security is a critical issue in Bangladesh with a large population of the country gravely affected by chronic food insecurity worsened by poverty, natural disaster, human induced calamities and disaster, lower agricultural production and unemployment. It was assumed that adequate production would assure adequate availability of food in the market as well as in the house holds. However, much of the grains are lost due to poor storage facilities.

The historical context of grain storage facilities highlights that there is a close nexus between the quality of the grains and the condition of the grain storage facilities. Furthermore, there has been transformation in the storage of the grains since the first traced storage facilities and with time more technology and strategic interventions have been adopted to improve sustenance, preservation and longevity of grains. The major highlights of the literature shows that the majority of the work recognises the changes in technology and the importance of appropriate conditions for grain storage facilities.

2.2 Efficiency of grain storage facilities within the context of maintenance management

In developing countries such as Zambia, grain storage facilities are constructed under the auspices of governments and the prerogative to manage the properties is vested within the jurisdiction of specific government institutions. The programme is mainly structured within the overall government agricultural programme of provision of food security and sustainability. Grain storage is an important component in ensuring commodity price stabilization, availability of food, inflation control, climate change mitigation and averting hunger (Coulter et al., 2000). For example, in Zambia, grain storage facilities are under the jurisdiction of the FRA which is a semi-government agency with facilities located in different parts of the country to mitigate the traveling distance of all farming clusters. Part of the approach to efficiency in grain storage

facilities involves the strategic location of grain storage facilities across a reachable geographic space to achieve distance minimization.

However, the fundamental concern revolves around how the grain storage facilities are maintained and the literature is replete with works on determining the efficiency of grain storage facilities especially as it pertains to the aspects of maintenance management. Ahi et al, (2016) identifies some key elements in measuring efficiency of the grain storage facilities such as detailed financial reports, queuing times, operational and environmental parameters and maintenance routines. Other measures of efficiency are denoted in the economic sense. These parameters in most situations are never satisfied and according to the World Bank (2021) in most developing countries, there is a huge problem of inefficiencies in grain storage with a large proportion of post-harvest wastage being witnessed especially in the handling and storage of grains. An estimated $4 billion in post-harvest losses in Sub-Saharan Africa alone was indicated and when that is further analyzed it is equivalent to the annual calorific requirements of 48 million people (World Bank, 2021).

Various assertions are made to rationalize the importance of efficiency when it comes to grain storage and these characteristically include the maximization and scaling up of storage capacity, risk transfer, and maintenance, effective and innovative utilisation of grain storage facilities (Mushira, 2005). For instance, one of the major concerns for efficiency with the FRA depots is the under utilisation of their capacities due to poor conditions (FRA, 2021)

Much of the literature points to the overall maintenance management aspects of grain storage facilities and takes cognizance of the institutional flaws in fully implementing it. In grain storage facilities, maintenance plays an important role in ensuring that the facilities are kept in the best possible conditions that are necessary to ensure that grains are well preserved. Dunn (2007) buttresses the foregoing and submits that maintenance management ensures that any facility subjected to it can optimally perform its intended functions. Smith and Hinchcliffe (2004) equally make similar assertions by arguing that maintenance has two major structural threads namely, technical and administrative functions which institutionally provide the framework for protecting, preserving or preventing functional failure of a storage facility before its time to become obsolete. Thus maintenance is viewed as an important cog in efficiency of grain storage not only for sustenance of its functions but also in reducing and leveraging unnecessary costs incurred from run down facilities and losses resulting from wasted grains. Maintenance management as an overall framework to efficiency of grain storage facilities therefore invariably contributes to the long-term durability, long lifespan and

efficiency of the storage facilities. Maintenance as a framework for efficiency averts possible degradation, dilapidation and damage of grain storage facilities and helps to preserve the grains to remain in good condition.

Dekker (1996) identifies some key systemic functional objectives of maintenance management within the context of any facility including grain storage facilities. These include ensuring an equipment asset or production system is reliable, available, efficient, and capable of optimally serving its intended purpose, managing the system as an asset and keeping it in proper working condition, ensuring risks are kept within acceptable limits and/or meet statutory requirements and fulfilling a psychological need that has no direct fiscal or technical necessity. These benchmarks are important in the implementation of maintenance management that will ensure proper efficient care of grain storage facilities. Ahire (2000) reiterates Dekker (1996)'s view and argues that maintenance management should always be an integral component in any management of facilities approaches because it proffers the framework for efficiency and interventions that contribute to the quality, durability and life cycle of any facility.

Various factors need to be taken into account in the maintenance management of grain storage facilities. Mushira (2005) avers that grain storage can be risky and difficult if the maintenance of the storage facilities is poor and the preconditions for storage are not of good standards. The grain itself and the storage facilities in which the grain is stored have to meet certain prescribed criteria all the time. For instance, there must be regular thorough inspections, monitoring and control to ensure that the storage facilities have the right temperature and relative humidity (Gitonga, et al, 2013). Additionally, the storage facilities must be designed and constructed to keep the grain free from water ingress, insects, rodents and birds.

Poor conditions of the storage facilities can have adverse impact on the grain in various ways including deterioration which leads to loss in quality and quantity of the grain. This has financial ramifications. Navarro and Donahaye (2005) indicated that poor conditions of the storage facilities can lead to heat damage, discoloration, off-odour, rancidity, caking, mold growth, pest and insect infestation, loss in nutritive value and contamination. These changes can render the grain unfit for end use applications and create stock shortages and inadequacies.

Mushira (2005) submits that in countries where grain storage losses are high, the growth in population is also high leading to increase in food demand and due to high losses, there are usually food shortages. In response to the growing demand for food, the policy makers and scientists have responded by placing emphasis on exponentially increasing the general production of food with major staple foods being given prominence. They also ensure that

during off season the grains are well stocked to cater for the periods when there is no production. However, despite these efforts, there still remains very little attention directed towards reducing grain storage losses. In terms of grain availability, which must increase as the world population grows, investments in good grain storage systems would be a necessity in ensuring that grains are kept in good condition and help to cushion any possible food deficits. The foregoing should be ascertained within the maintenance management vouch and as Ngwira and Malawi (2016) identified, this would palpably provide a management framework which can predict, project, combine strategic management, financial, economic and modern practices appropriate in efficient management of storage facilities. When considering efficiency in grain storage facilities and their maintenance management ambit, there are key management aspects that are important. For instance, asset management forms part of maintenance management ethos and when it comes to storage facilities, it plays a cardinal role in the technical and maintenance provisions of properties. RICS (2008) reinforces the foregoing and avers that asset management is an important conduit for fostering the technical and management work necessary to ensure that the facility is in the appropriate condition and delivers the basis for efficient approaches to its management. Ngwira and Malawi (2016) further advance the notion that asset management within maintenance management provides an important basis for a much more structured and programmed method to long-term transformation and any improvements needed. Davis (2012) further adds that maintenance forms part of the stewardship of assets, but so is design, procurement, installation, commissioning, operation and other activities which underlie the significance of administrative perspectives of maintenance.

From the literature reviewed, there is evidence that many of the authors acknowledge that a major component in attaining efficiency in grain storage facilities depends on having a robust maintenance management framework which integrates asset management approaches and guides the routine maintenance activities that keep the storage facilities in appropriate and good conditions for storage of grains for much longer periods. More so, efficiency in grain storage facilities must have systematic with well-structured procedures and processes that determine the routines for maintenance and managing properties. Thus for attaining efficiency in grain storage facilities, systemic mechanisms, technical, human and financial capacities are important factors that must be integrated within the overall property management strategies.

2.3 Storage facilities maintenance management by the FRA

There are various suggested maintenance management alternatives that are very important when it comes to improving efficiency in grain storage facilities, these include preventive maintenance, reactive maintenance and maintenance inspections. Cloete (2001) and Carnero (2006) suggest that any available maintenance management options for ensuring efficient maintenance management are anchored on the nature of the need but recommend that for institutions that are involved in grain management, the most viable and apposite approach which is cost-effective is preventive maintenance. Dhillon (2006) buttresses the foregoing and contests that preventive maintenance is one of the most appropriate maintenance management approaches because it lessens downtime and the cost of maintenance.

The FRA has a structured approach when it comes to property management and maintenance with a well-functioning property management department (FRA, 2022). According to FRA (2021), the institution has continued sourcing funds from government to rehabilitate and upgrade its storage facilities. With the need to increase capacity, it is reported that the FRA (2021) has previously tried to scale up storage facilities by seeking concession loans and also maintain some of the bigger silos. For instance, there were efforts towards rehabilitating the grain silo located in Lusaka. Grain stored in a silo can remain in good condition for a longer period because fumigation and grain management is more effective as compared to sheds. In addition, silos are desirable and appropriate for bulk transportation of grain. However, it was established that the FRA has a weak enforcement of the maintenance management philosophy because of the absence of legislative backing to fully implement it (FRA, 2021).

Kangwa and Olubodun (2003) argue that effective maintenance management is premised on regular and scheduled inspections to determine the state of the building. Cloete (2001) states that there are three major categories of maintenance inspections such as routine or day-to-day inspections which are specifically intended to identify defects needing immediate repairs and to identify some of the key routine inspections. Then there are also annual inspections which are carried out once a year to assess the buildings and project the planning for the subsequent year. The third type is special inspections which is carried out to determine the feasibility of replacing the existing components of the building and services which would have deteriorated due to ageing of the building or which would be caused by functional obsolescence. According to Muntanga (2021) the FRA does not follow nor adhere to any of the above stated inspections when it comes to its grain storage facilities. This is due its technical and financial constraints.

From the aforementioned, there is limited literature that focuses on the procedural and processes that show the extent to which FRA applies property management aspects.

2.3.1 Quality management of grain and warehouses at FRA

According to the stock quality procedure manual of the FRA (2021) a good and clean enevirоment is required for the storage of grain.The agency annually cleans and disinfects all the facilities such as slabs,sheds,warehouses and silos.Furthermore the agency carries out residual spraying when the grain bags are being stacked at the depots.The recommendation is to apply a residual chemical at every layer as the stack is being constructed.

The others quality control measures include fumigation which is a practice to eliminate the possible the possible increase of the insect pests on the stock.This is done through the injection of tablets under a tight environment using a good hole-free tarpaulin to kill all possible stages of the insect pests.Rodents are also controlled by the agency by the use of rat bait put in rat stations placed in the warehouses to manage the possible infestation of rodents that may damage the bags as they attempt to get stock.Finally the agecy carries out continuous monitoring,routine cleaning,probing and inspections.Stocks are cleaned on a daily basis ,inspected and probed 7if necessary to ensure no infestation had begun.

2.4 Challenges of grain storage facility maintenance in selected countries in Africa

Maintenance of grain storage facilities globally is faced with various challenges and according to Kyle, et al., (2000) these are generally associated with the management of assets. These include the institutional rigid and bureaucratic administrative structures. For instance, FRA report (2021) reported that the institution encounters delays in funding, exigencies in decision making due to political encumbrances considering that it is a Governments funded entity. Muntanga (2021) identified the procedural and administrative challenges posed by the bureaucratic nature of the FRA as a contributory concern which impacts on the effective management of grain storage facilities.

Befikadu (2014) avers that without proper maintenance management of the grain storage facilities, the grain can briskly deteriorate and lose its quality leading to high wastage. Spoilage of grain tends to be cumulative as a consequence of several different factors based on its handling and management. Therefore, the overall management should be good to have a good chance of maintaining grain quality (Befikadu, 2014). From the instance of harvesting to the time of its use grain should be stored well to prevent deterioration of quality (Abebe & Bekele, 2006). However, due to lack of proper maintenance management, the grain storage facilities

are not regularly maintained to those standards that ensure that grain is kept at optimal quality. The literature shows that various challenges associated with how the grain storage facility is maintained tend to have impact on the quality of the grains. Thus key is the maintenance management framework which must guide how the storage facilities should be managed.

2.4.1 Malawi

According to the NFRA (2022), in Malawi there is a deliberate and systematic rigorous routine to maintain their grain storage facilities so that they are kept in very good condition. For instance they reportedly have 38 silos, of which 28 are working and regularly serviced and maintained so that they remain functional and productive. For example, hybrid maize in the silos is recycled every 3 months whereas local varieties are recycled every 6 months. Additionally, during recycling, maize is moved from one silo to another and fumigated with aluminium phosphide. All waste is hand-removed as it passes through the conveyor belts. To avert possible losses that can cost farmers 25-30% of their yield per season, efforts are made to manage high moisture, pest damage, fungal and bacterial infections, and rodent damage and use of grain protectants against storage insect pests is applied. This has to be done regularly and the facility must be maintained in such a way that any defects are well monitored and managed (Farnworth et al., 2014).

2.4.2 Zimbabwe

Farnworth et al., (2014) assert that in Zimbabwe, grain storage is a very important practice starting from household levels to the general farming populace and as such, there have been effort not only under the government initiatives but also from informal interventions to equip farmers with information on how best to handle grain in post-harvest periods. This is one of the best practices where the initiatives tend to target small scale farmers, subsistence farmers and large scale farmers and integrate important principles for proper grain storage and handling, as farmers are harvesting their grain crops. It has been long observed that losses can generally be incurred in terms of quantities and consumer quality deterioration, if grains are not well managed (Alam et al., 2007). Among the reasons for post-harvest losses include mechanical damage linked to poor maintenance of storage facilities, excessive exposure to high storage temperatures, relative humidity, contamination by fungi or bacteria and rapid invasion by birds, rodents and pests (WFP, 2014). Figure 2.1 shows damaged depot in Zimbabwe.

Figure 2.1 Damaged depot in Zimbabwe (Source: Herald Newspsaper)

Kabir, et al., (2019) assert that among the critical areas that need regular repair and maintenance for grain storage facilities are boundary walls of the facilities, floors, drainage and main gate. Kabir, et al., (2019) in their study also observed that there are different repairs that need to be regularly done on grain storage facilities. For instance boundary walls must be regularly maintained because they anchor both safety and security of the premises protecting it from any encroachment and trespassing. Other key areas that need consistent maintenance include drain around the grain storage facilities. For instance, grains tend to be affected and susceptible to moisture thus need good and adequate drainage system to avoid flooding and runoff water. A well brick built drainage system will help to avoid erosion and siltation (Kabir, et al.,2019). Periodic maintenance will also help to ensure proper functioning of the drainage system around the grain storage facility be it a silo or shed. Other critical components that need regular maintenance are the main gate of the food grain storage facility because they are the major entry-exit points of vehicles including those loaded with food grain. Therefore, the structure of the gates must always be in good condition thus needs regular and periodic repair and maintenance (Kabir, et al., 2019).

Kabir, et al., (2019) further identify that one of the most critical components of each storage facility is the warehouse, silo or depot where food grains are stored because they need to be kept within acceptable moisture levels to prevent deterioration and weight loss prior to distribution or onward dispatch. Walls are susceptible to the wear and tear that affects

properties such as silos and depots. For instance, they have cracks and suffer damage to layers of plasters and weather-proof paint, thus they need regular maintenance to be in good condition (Alam et al., 2007). Singano et al., (2019) suggests that one of the solutions would be use of hermetic storage technologies which are still scarcely used within Zimbabwe. Additionally, more use of synthetic grain protectant pesticides would help to kill storage insect pests. Alam (et al., 2007) attribute the damages mainly to lack of proper regular maintenance work which eventually predisposes the building to collapsing. Every building requires routine maintainance but if neglected, it becomes weak with cracks and sometimes overburdened due to extensive usage.

2.4.3 Ethiopia

Abay, et al., (2016), assert that food policy is better informed when food wastage is understood in the context of food storage behavior and perceived associated losses. Bachewe et al., (2018) argue that in Ethiopia there has been a realisation that use of technology in grain storage is important and there have been deliberate efforts intended to make grain storage technologies available at reduced costs. For instance, in some parts of Ethiopia, airtight and hermetic bags have been adopted as part of grain storage facilities (Bachewe et al., 2018). Bachewe et al., (2018) indicated that grain storage losses recorded across Ethiopia significantly vary based on socio-economic factors and wealth, agro-ecological zone, crop and humidity levels. Regions with high humidity levels are much more prone to high storage losses compared to those regions that are drier. Bachewe et al., (2018) observed that Ethiopia has attempted to encourage use of technology in grain storage by leveraging on policies that help improve storage facilities. The interventions to improve the adoption of improved storage technologies that reduce storage losses cut across from farm level to the national level. For instance, upgraded hermetic bags, storage silos, and pesticides are sold at relatively reduced prices to enable farmers afford them. Figure 2.2 shows a depot in Ethiopia in a dilapidated condition.

Figure 2.2 A depot in Ethiopia in a dilapidated condition (Source: Internet)

2.4.4 Benin

Benin's staple food is maize just like Zambia. Maize in Benin is not only for household consumption but serves as a major and important source of income and employment for many farmers. According to Gbénou-Sissinto et al., (2018), the average annual maize production accounted for 78% of annual total cereal production in Benin between 2009 and 2014. At household level, maize is kept in traditional storage structures and preserved with protectant products. There are also storage facilities that are at national level which are more modern and structured to keep much large quantities of grains. For instance, the ditcher stave silos which are cylindrical shaped, constructed with concrete blocks supported by steel wires are commonly developed in Benin. The grain storage facilities are specially made using smoothened cement in the outer and inner walls with the manhole in the cover slab and an anti-theft outlet in the bottom (Gbénou-Sissinto et al., 2018).

The traditional storage methods are not always effective in ensuring that the grain is safeguarded from moisture and pest infestation which can lead to storage losses (Gbénou-

Sissinto et al., 2018). Gbénou-Sissinto et al., (2018), assert that an estimated 17% to 40% quantity of maize harvested is lost due to poor conditions of storage facilities. However, in dealing with the losses, the government has put up measures to support producers of grains to access and adapt to better storage technology. For example, the introduction of plastic cans, bags and improved silos fitted with drainage valves. This form of preservation facilitates destocking and pest control. New storage technologies are being introduced although many people especially in rural parts of Benin still use traditional storage structures (Gbénou-Sissinto et al., 2018).

2.5 Gaps and Critique on the literature

Much of the available literature on the maintenance management of grain storage facilities is premised on what has been done in the developed countries which have the resources at their disposal to implement advanced technological practices. These countries can afford the associated maintenance cost of the facilities. This may not apply in the case of a developing country such as Zambia because prescribed methods require huge capital injection as well maintenance cost. Furthermore the differences in the duration of preserving the grain may not be applicable because strategic reserves are kept for longer durations in a developing country than in developed countries which have advanced processing plants and a relatively higher population to feed. Other factors in the literature show that much of the analysis deals with the challenges associated with the grains rather than the facilities. It is for this reason that this research attempted to investigate the maintenance strategies used in Zambia and to establish cost effective maintenance strategies that suit the Zambian conditions and can also be managed financially.

The literature indicates that much of the work focuses on the importance of storage facilities because of the role they play in mitigating hunger and poverty. In Zambia, as in other countries, storage facilities are being constructed mainly to reduce wastage of the harvested grains in the hope of reducing the poverty levels. However available literature does not focus on the linkage between storage facility maintenance and grain storage. Additionally, there is very little literature especially on Zambia regarding specific issues of storage facilities, their maintenance and the challenges thereof. This study therefore sought to address the gaps especially with regards to the challenges of maintenance management in relation to grain storage facilities.

2.6 Chapter Summary

The focus of Chapter Two was to present the literature that was reviewed in this study. The study identified gaps in similar studies as highlighted in this chapter. The next Chapter is the presentation of the methodological approaches of the study.

CHAPTER THREE METHODOLOGY

3 METHODOLOGY

3.1 Research Design

Creswell and Clark (2007), submit that a research design is the framework or structure of a research that ties all the elements of the research together and provides the plan of the proposed research work in a concise and succinct manner. Creswell (2014) defines research design as "the arrangement of conditions for the collection and analysis of data in a manner that seeks to bring together significance to the research purpose with economy and procedure". In essence, what comprises the research design is a plan, structure, strategy and investigation reinforcing the empirical backing of the conclusions and hypotheses. The research design provides the overall strategy for entwining the conceptual research problems with the scientific perspectives of the study. The foregoing is buttressed by Given (2008), who argues that how a researcher designs their study forms the foundational and organising basis of the study by arraying and triggering a series of decisions pertaining to how the study will proceed and be conducted. Additionally, research design leverages over dynamics that have the potential to impede and disrupt the validity of the findings.

The research design of this study included both quantitative and qualitative approaches to collect both primary and secondary data. Creswell (2013) avers that qualitative data involves gathering, evaluating and analysing data to reach objective conclusions that produce findings that are theorized. Kothari (2004) describes a quantitative method as a systematic investigation of phenomena by gathering quantifiable data and performing statistical, mathematical, or computational techniques.

The use of mixed methods approaches in this study further enhanced its reliability and validity. Bryman (2012) argues that reliability is very important especially when a study is of a qualitative nature. Creswell (2013) also states that the use of mixed methods creates the possibility for triangulation of both qualitative and quantitative data thereby making it more reliability as the data is backed with statistical information and vice-versa. Use of mixed methods in this study further provided access to multiple types of data which strengthened its validity. Marshal and Rossman (2011) observed that a researcher can be much more confident about the validity of the findings when they are supported by multiple and complementary types of data.

The research specifically used the explanatory study approach which helped to investigate the maintenance challenges that exist in strategic grain storage facilities in Zambia with the Food Reserve Agency as a case. This approach was useful for the study especially in generating preliminary background information to the phenomenon that was being investigated and also providing a framework for investigating different study components.

3.2 Research Methodology

A good research methodology is very important for any credible study. Kothari (2004) stresses that the research methodology provides the general approach to the research process from aspects of definitions to choosing of apposite research method, data analysis and coming up with logical conclusions. Additionally, he described the research process as a systematic, logical and scientific arena that should observe the following logical structure and characteristics:

(a) Identify and communicate the research problem;
(b) Have a hypothesis and questions to address the research problem;
(c) Develop a clear design of the relevant research process;
(d) Design concise methodological interventions for data gathering and analysis to answer the research questions;
(e) Have an analytical framework and analyse the data; and
(f) Come up with findings and conclusions that attend to the hypothesis and research problems.

The above stated structural and logical aspects are central to the cohesive and effective carrying out of a credible and reliable research as they provide an analytical framework for the study. Thus they were used by the study as a guiding frame work. The section below presents how the study deployed the explanatory case study.

3.2.1 Explanatory Case Study

Explanatory approaches are contextualised within the ambit of case studies and therefore it is important to start by describing cases studies in general. Yin (2003) gives a concise definition of case study method as an in-depth study of one or a few events or cases in order to understand the phenomenon being investigated. Essentially, case studies are suitable when dealing with the how, why, what, and who questions. Much of this study was dealing with those aspects. Yin (2003) identifies three conditions for deployment of a case study and he avers that firstly

the case study must be situated to answer all aspects of the "how" or "why" components of the research, secondly investigators must have little control over events, and thirdly, the research focus should be on a contemporary phenomenon within a real-life context, for situations where the context may evidently not be obvious between the phenomenon and events. Creswell (2013) submits that when a researcher deploys a case study method, they explore a real-life contest and apply multiple contemporary structures premised on exhaustive and in-depth data gathering approaches from several sources. Thus a case study is very appropriate to explore patterns and presumed causal links that are too complex for a survey or experiment only.

There are different case study approaches which include explanatory and exploratory case studies. However, for this study, explanatory case study approach was deployed. This approach was used because it provided a framework for answering the"how" and "what" aspects of the research. Explanatory case study was very significant in establishing the challenges in grain storage maintenance and determining how the maintenance philosophies were being applied in grain storage facility management. Thus, the explanatory case study method was used to analyse the deeper linkages between the challenges in grain storage facility maintenance and the maintenance philosophy within FRA. Additionally, explanatory case study helped in critically synthesizing and systematically interrogating the why and how components of particular circumstances and variables that may not have been explored by other approaches. Yin (1984) states that an Explanatory Case Study triggers deeper probe and analysis of any complex phenomena and subsequently leads to finding appropriate generalisations pertaining to the broader population from which it is categorised and drawn from.

3.3 Study area

The study area solely focused on the Food Reserve Agency main depots in the six provinces of Zambia namely Lusaka, Monze, Choma, Kabwe, Ndola, Chambishi and Kasama because these depots are high grain storage areas in the country and fully operational throughout the year. Additionally, the depots also house the type of grain storage facilities which was investigated in this study.

3.3.1 Sample Size and Interviews

According to Saunders et al., (2019), a population is a full set of cases from which a sample is taken. After ascertaining the relevance of the positions to the study and staffing levels within the FRA, 73 staff were identified. The study's sample size of interviewees arrived at included 73 respondents within the Food Reserve Agency holding different portfolios in the institution.

Among those interviewed are Provincial Marketing Coordinator, Marketing Assistant, Standards and Quality officer, Warehouse Supervisor, Caretaker/provincial foremen, Regional Marketing Coordinator, Regional Property Coordinator and Monitoring and Evaluation Officer. All these brought varying dimensions and information to the study. The table below provides the disaggregated breakdown of the interviewees and the rationale for interviewing them.

3.3.2 Rationale for the interviews

Table 3.1 Rationale for interviews

SI	Respondent	No of Interviewees	Data collection method	Reason for Interview/Maintenance Challenges
01	Provincial Marketing Coordinator	12	Questionnaires	Maintenance challenges at provincial level.
02	Marketing Assistant	12	Questionnaires	Maintenance challenges at district level
03	Standards and Quality officer	12	Questionnaires	The quality of storage facilities.
04	Warehouse Supervisor	20	Questionnaires	Maintenance challenges encountered daily
05	Caretaker/provincial foremen	12	Questionnaires	Overall maintenance challenges on the different types of sheds
06	Regional Marketing Coordinator	2	Interviews	Challenges encountered and how they affect grain quality
07	Regional Property Coordinator	2	Interviews	Maintenance philosophy used and the challenges in maintenance
08	Monitoring and Evaluation Officer	1	Interviews	State of storage facilities and challenges in maintenance works

Source, Researcher, 2023

3.3.3 Sampling techniques and instruments,

According to Bernard (2002) data collection is crucial in conducting any study because the data contributes to a better comprehension of the theoretical framework and sampling techniques form an integral component of research. Kumar (1999) defines sampling as that part of statistical practice which deals with the selection of an unbiased or random subset of individual observations within a population intended to yield some knowledge about the targeted population for the purpose of making predictions based on statistical inference. The study deployed purposive sampling also referred to as judgmental or expert sample for face to face interviewees. The main data collection instruments used were questionnaires with semi-

structured open ended questions and a survey questionnaire with close ended questions. The interview guide was used for face to face interviews to gather qualitative data whilst a survey questionnaire with close ended questions was used to collect quantitative data from purposively sampled respondents.

3.4 Data Collection methods

Primary data for the study was gathered using face to face interviews targeting officials from the FRA who hold different positions. This type of interview guide was used in order to draw appropriate responses from interviewees and proffer them an opportunity to comprehensively give enough details when providing responses. This enriched the data collected and provided complete perspectives, explanations and accounts from relevant respondents. Marshal and Rossman (2011) justify the use of semi-structured interview guide with open ended questions in qualitative studies and argue that its application supports the conveyance of the contextual nuances of the interviewee's reactions and rejoinders.

Additionally, the study engaged in an arduous review of collecting and analysing secondary data mainly through desk study review of literature. The specific categories for secondary data that were used were drawn from various sources such as the internet, grain storage maintenance reports, publications, journals, articles, books, YouTube, earlier research and mass media reports. The literature review was framed within the framework of the main research question. The whole exercise was guided by building up key hypotheses of the authors and what they were researching. The identified materials were interpreted and analysed.

3.5 Data Analysis

Much of this study deployed a triangulation technique for analysing the data. According to Creswell (2015), triangulation is an approach used mainly in analysing data drawn from mixed methods. It is primarily premised on the logic that it is more credible and possible to obtain a real situation of certain social phenomena if the researcher applies use of multiple levels of analysis, methods and measurements. Thus triangulation is an apposite analytical archetype that can lead to a more demanding, less biased and valid conclusion in the analysis of a social phenomenon (Creswell, 2015:62).

Data processing and analysis was conducted using the thematic approach by identifying the main themes that emerge from the interviews and quoting them extensively in verbatim format in relation to the research objectives. Codes were assigned to the main themes to classify the responses before the integration was eventually done. Once the data were sorted, they were put

into several categories. The core dependent variables were divided into different categories in line with the objectives of the study. The categorizing of the data and placing it in themes for analysis was based on the three theories that underpin the research. In analysing data from surveys, the excel software was used in coming up with different charts. The study additionally deployed categorical aggregation, a widely applied technique that helps to generate undeviating and controlled analysis for the data collected. In this technique, data are sorted while interpreting relevant meanings from them. Furthermore, themes from the data was framed and then theorised. Creswell (2013) suggests that this type of technique in research is very informative as it establishes significant denotations across copious cohorts of the data. Afterwards both the qualitative and quantitative data was triangulated to make empirical conclusions.

3.6 Reliability and Validity

In enhancing the validity of the study, qualitative and quantitative research methods were used which enabled the data not only to be corroborated but also triangulated to capture diverse dimensions of similar singularity and phenomena. Furthermore, systematic verification and checking of the data afterwards, fitting the data in suitable categories and themes, was done to enrich its validity and reliability. There was also constant verification and monitoring of the theoretical aspect of analysis and inquiry thus being able to classify data and indicate when to continue, stop or adjust the research process in order to achieve reliability and validity (Bryman, 2012; Creswell, 2013).

3.8 Chapter Summary

The focus of Chapter Three was to discuss and contextualise the methods used in the study; and justify their choices. The Chapter outlined the methods, procedures for sampling and tools for data analysis, coding, a description of the study population, reliability and validity and ethical considerations. The next Chapter is the presentation of the findings and analysis of the study.

CHAPTER FOUR RESULTS AND DISCUSSION

4.RESULTS AND DISCUSSION

4.1 Demographic Information of Study Participants

The biographical data from the interviewees covered areas such as their sex, age distribution and education level. These variables were significant in comprehending the type of the sample population, and for characterizing them and putting into perspective their responses. Sixty (60) participants were purposively sampled and interviewed. The Table 1 shows the demographic data.

4.1.1 Distribution by Gender

It can be observed that the majority of the interviewees were male, accounting for 80% compared to 20% females.

Table 4.1 Gender of respondents

Variable	***Frequency***	***Percentage***
SEX		
Male	48	80
Female	12	20
Total	**60**	**100**

Source: Researcher, 2023

4.1.2 Distribution by Age

The age distribution was from 26-30 years as the minimum age category and these accounted for 3.3% of the total interviewees. From the age of 31-35, the interviewees accounted for 20%. The age range from 36-40 had 20% of the total interviewees. The majority of the interviewees were drawn from the age range of 41-45 representing 26.7%. The age range 46-50 years accounted for 15% of the study respondents whereas 51-56 had 11.7%. The final age group was ages from 56 and above which accounted for only 3.3%.

Table 4.2 Age of respondents

Variable	*Frequency*	*Percentage*
AGE		
26-30	2	3.3
31-35	12	20
36-40	12	20
41-45	16	26.7
46-50	9	15
51-56	7	11.7
56-above	2	3.3
Total	**60**	**100**

Source: Researcher, 2023

4.1.3 Distribution by Education

In terms of the education levels, the first degree holders were at 15% of the interviewees while those who possessed diplomas, were in the majority at 38.3%. Those with Master's degrees accounted for 11.7%. Certificate holders were perched at 33.3% and others who included those with PhDs were at 1.7%.

Table 4.3 Education level of respondents

Variable	*Frequency*	*Percentage*
EDUCATION LEVEL		
Certificate	20	33.3
Diploma	23	38.3
First Degree	9	15
Master's Degree	7	11.7
Others	1	1.7
Total	**60**	**100**

Source: Researcher, 2023

4.2 Findings and Analysis

The study findings and analysis are aligned according to the objective which essentially formed the themes of the study. Interviews were conducted with different respondents as outlined in Chapter Three and established different responses from the respondents which was then extrapolated and eventually concluded into an analysis.

4.3 Current state of strategic storage facilities at selected depots

The study considered various factors to determine the current state of the strategic grain storage facilities. Among them were the measures being taken by FRA to improve unsafe and unsecure storage facilities and the conditions of the infrastructures at the depots and sheds whether there were any rehabilitations or repairs being conducted. The study further considered how long it took to make repairs or any rehabilitation once they were reported from the depots and sheds to the head office? The following findings are;

4.3.1 National grain storage capacity

The respondents were requested to indicate the national grain storage capacity for the FRA. The results are shown in Figure 4.1. The results indicate that the national storage capacity comprises of 83% depots with below 1,000,000 MT storage capacity and 17% is storage capacity between 1,00,000 MT and 1,500,000 MT.

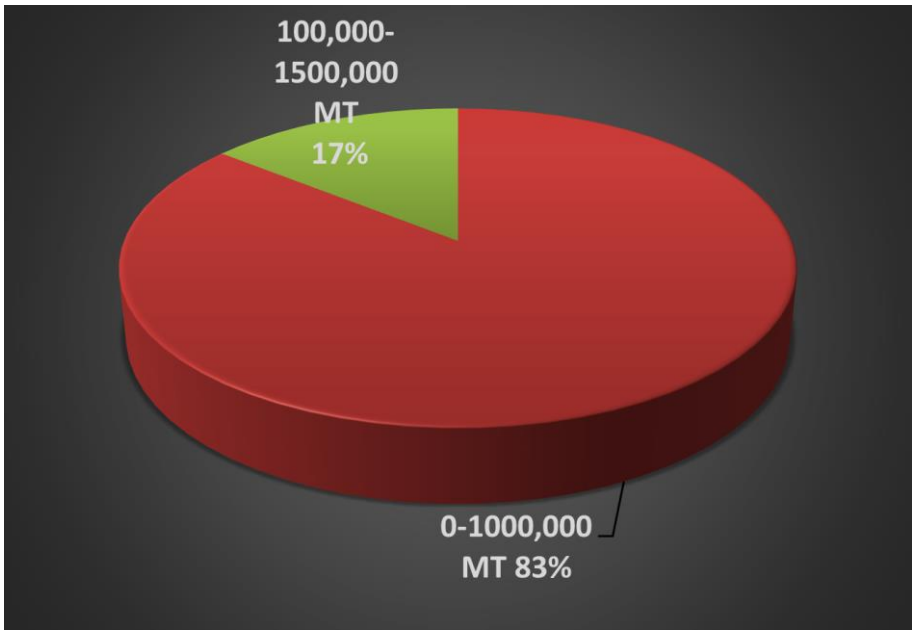

Figure 4.1 FRA National grain storage capacity

Source: Researcher, 2023

4.3.2 Safe and secure Storage facilities

The safe storage capacity in FRA storage facilities is given in Figure 4.2. The results based on the views of the respondents indicate that 39% of the storage capacity below 20000 MT is safe and secure, 37% of the storage capacity between 20000 MT and 50000 MT is safe and secure while 24% of the storage capacity between 50000 MT is 100000 MT is safe and secure.

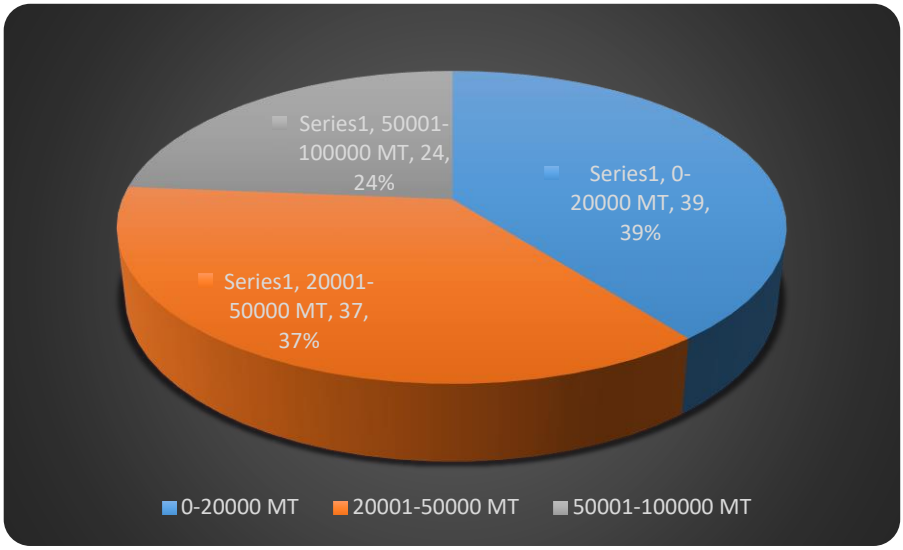

Figure 4.2 Safe and secure storage facilities

Source: Researcher, 2023

This shows that out of the storage capacity below 1,000,000 MT,16% is unsecure and unusable for use because the structures are not in a good condition for storing grain. Furthermore, the storage depots with capacity above 1,500,000 MT are all safe and secure.

4.3.3 Measures to improve unsafe and unsecure storage

Respondents were requested to rate the measures taken by the FRA to improve unsafe and unsecure storage sheds. The results are given in Figure 4.3. It was established that more than 37% of the interviewees stated that there was nothing being done to try and improve unsecure and unsafe storage sheds that are under the management of the FRA. 34% of the interviewees asserted that there were repairs being done to the storage facilities. 24% of the interviewees indicated that there were rehabilitation works to improve unsecure and unsafe storage sheds. 2% of the respondents asserted that there were overhaul works to improve unsecure and unsafe storage sheds. 3% of the interviewees didn't give a response.

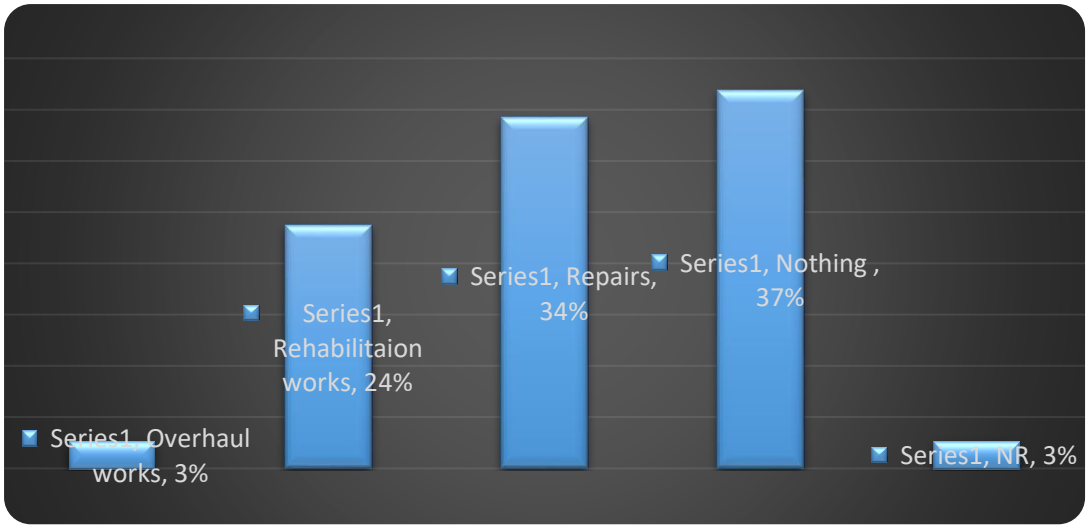

Figure 4.3 Measures to improve unsafe and unsecure storage

Source: Researcher, 2023

This shows that the effort to improve the condition of the grain storage facilities is not very good as guided by the mandate of the FRA that storage facilities should be managed according to international standards.

4.3.4 Maintenance of the grain facilities

Respondents were requested to indicate the type of maintenance works that the FRA undertakes in their sheds and depots. The results are shown in Figure 4.4 The study established that 38.3% of the maintenance works on grain storage facilities are repair works, rehabilitation works 28.3%, and 1.7 percent are overhaul works. However, 31.7% of the interviewees indicated that there was nothing being done in the depots and sheds in relations to upgrade, rehabilitations or repairs.

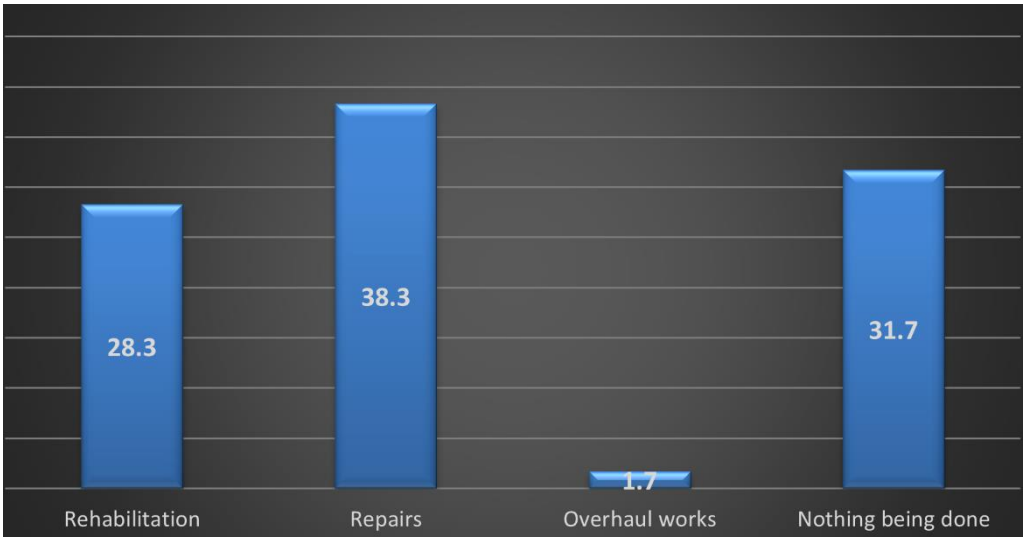

Figure 4.4 Maintenance on the grain facilities

Source: Researcher, 2023

These findings above illustrate that the FRA is not investing in improving storage facilities and overhaul works in order to revamp the obsolete facilities but carries more of repair works in order to keep the facilities in a usable condition. Furthermore, the agency is not consistent with the repair works as evidenced by the 31.7% respondents who feel that nothing was being done in form of repairs or rehabilitation works.

4.3.5 Reporting breakdowns and damages to property

Respondents were requested to indicate how often breakdowns were reported from the depots and sheds to the FRA head office whenever they occurred. The results are given in figure 4.5. 97% of the respondents indicated that breakdowns or any damages to property were always reported on time whereas 3% indicated that they were not reported at all.

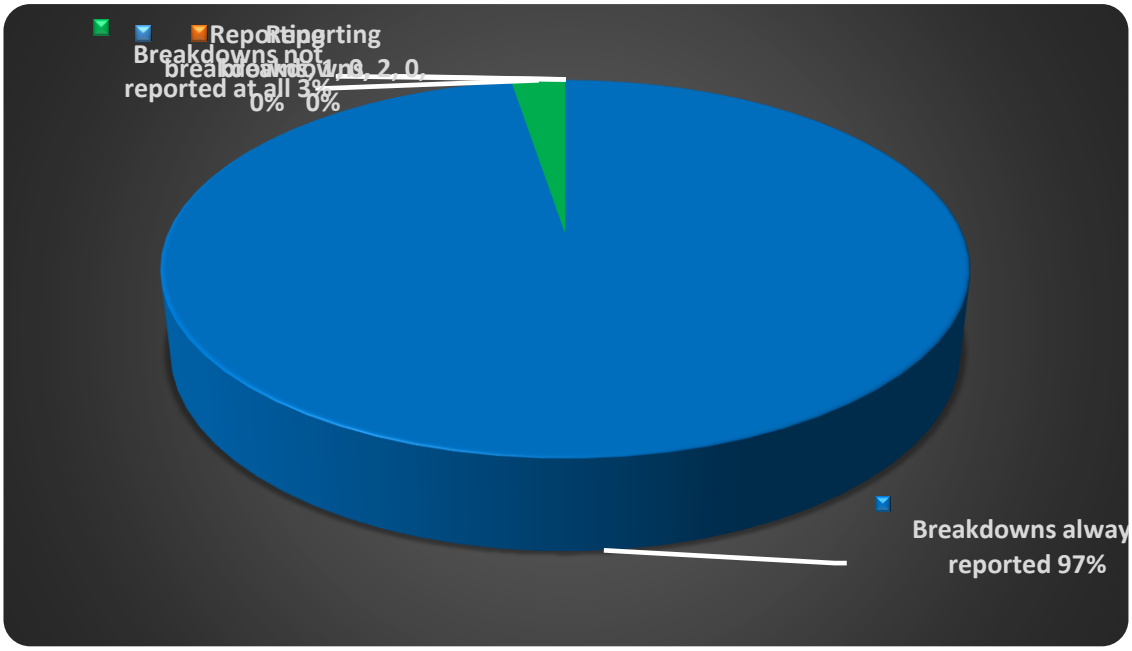

Figure 4.5 Reporting of breakdowns and damages to property

Source: Researcher, 2023

This shows that almost all the maintenance problems are reported to the maintenance department by the people in the depots for action. Secondly the above findings means that the FRA Property management department does not have a formal way of reporting and recording these reports.

4.4 FRA maintenance management philosophies

The study sought to ascertain what maintenance management philosophies are used by FRA in the management of strategic storage facilities. The majority of the respondents interviewed, indicated that they were not aware of any maintenance management policy.

4.4.1 Maintenance management policy

The respondents were requested to indicate if there was a maintenance management policy in FRA. The results are given in figure 4.6. 8% of the interviewees indicated that there was a maintenance management policy in FRA whilst 53% indicated that there was no maintenance management policy and 39% didn't know.

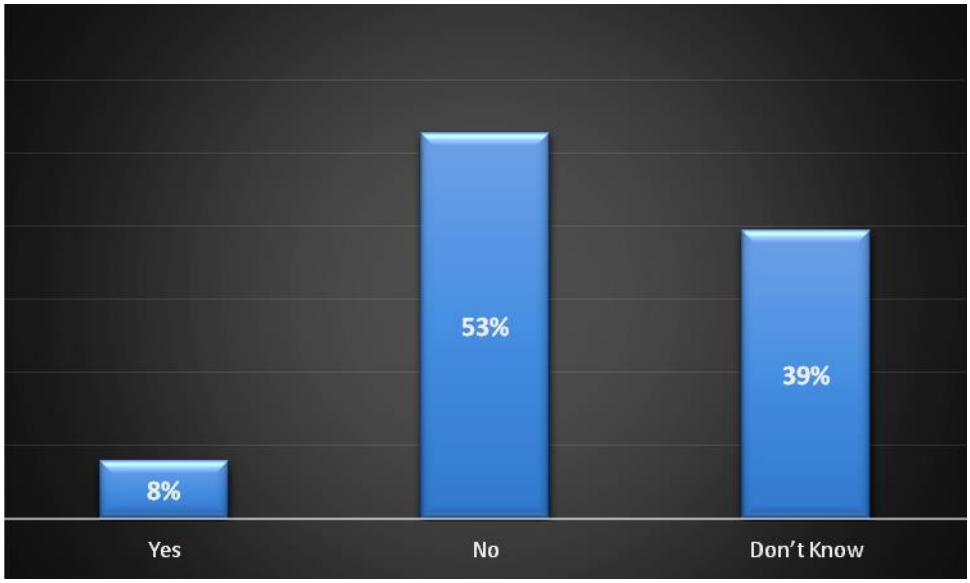

Figure 4.6 Maintenance management policy

Source: Researcher, 2023

This is an indication that the FRA may not have a maintenance management policy document and if they have, then people have not been oriented or trained to understand the policy, the standards and procedures in carrying out maintenance works.

4.4.2 Maintenance System

The respondents were asked to indicate maintenance management philosophy that the agency uses mostly . The results are given in figure 4.7. 57% of the respondents indicated that the FRA uses reactive maintenance, 29% said corrective maintenance and 14% said preventive maintenance.

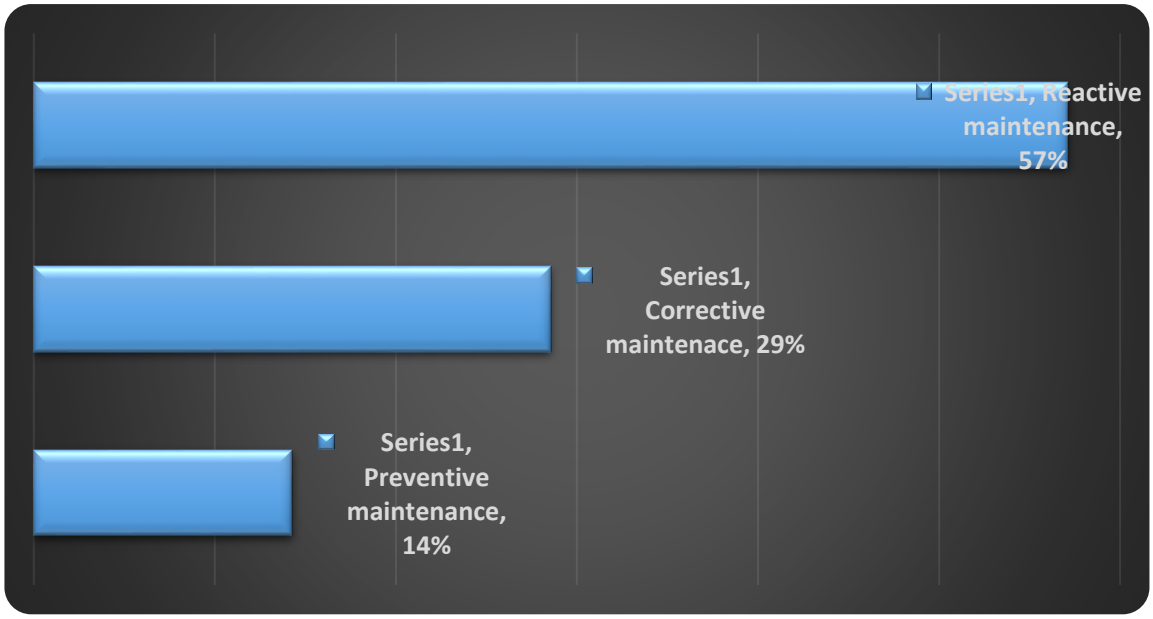

Figure 4.7 Maintenance System

Source: Researcher, 2023

The results above show that the FRA priotizes reactive maintenance instead of preventive maintenance which increases plant availability and has low maintenance cost compared to reactive and corrective maintenance strategies as potential breakdowns are addressed before they even happen.

Furthermore, lack of a clear management policy explains why there is no specifically structured and scheduled maintenance management of grain storage facilities which is consistent and anchored on any particular maintenance management philosophy. For instance, it is understood from the study that FRA sporadically applies reactive maintenance measures with an indication that preventive maintenance is least deployed

4.4.3 Maintenence management manuals and procedures

The respondents from the property management department and marketing department were requested to indicate if there were specific maintenance management manuals and procedures within FRA. The results are given in figure 4.8. 90% of the respondents indicated the unavailability of the maintenance management manuals and procedure compared to only 10% who said those were available. However, if the policy did exist, then mainatenance management manuals and procedures could have been made available.

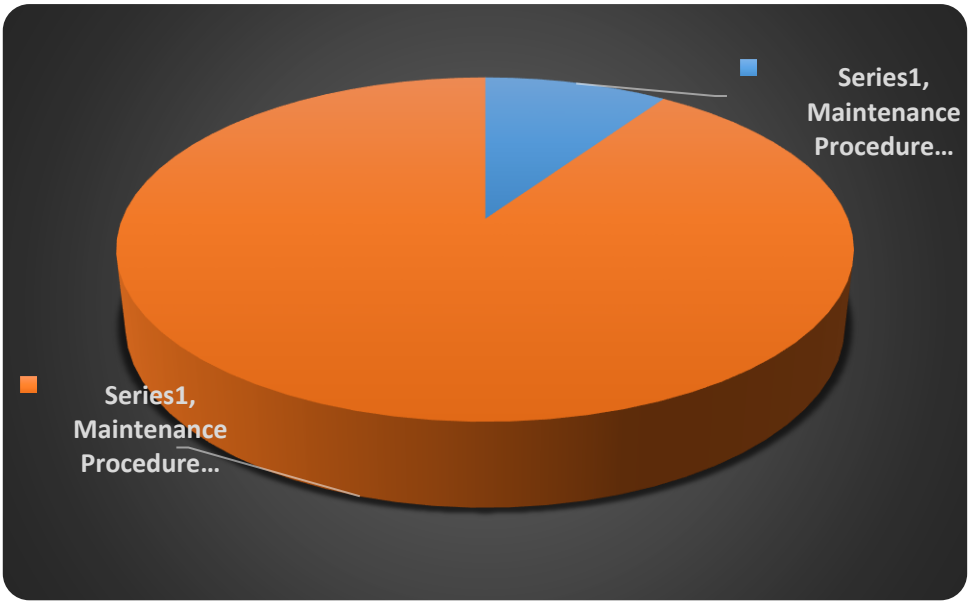

Figure 4.8 Maintenance management manuals and procedures

Source: Researcher, 2023

The above results show that FRA had no maintenance management manuals and procedures to guide its operations. Therefore, relied on administrative direction.

4.4.4 Work Order System

The respondents were requested to indicate how maintenance requests are generated and if they tracked using a work order system. The results are given in figure 4.9. 17% indicated that FRA had a work order system and 83% said FRA had no work order system in place .

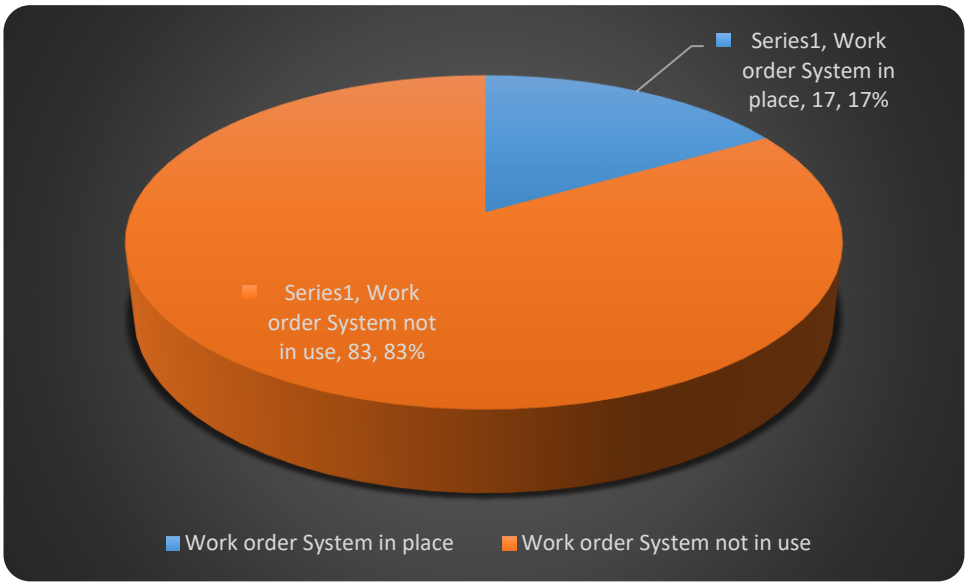

Figure 4.9 Work Order System

Source: Researcher, 2023

From the interviewees, it is clear that FRA has no work order system which is very critical element of an effective maintenance system as it is used to make maintenance requests,allocate resources and track the works.This also shows that much of the property management framework of FRA is dependent on its structural establishment and government regulations rather than its own internally designed policies, procedures and guides on maintenance management processes.

4.4.5 Response Time

The respondents from property management department and marketing department were asked to indicate how long it takes for breakdowns to be resolved after a request has been made. The results are shown in 4.10. 85% of respondents said the response time was delayed whilest 15% said the reponse time to breakdowns wa timely.

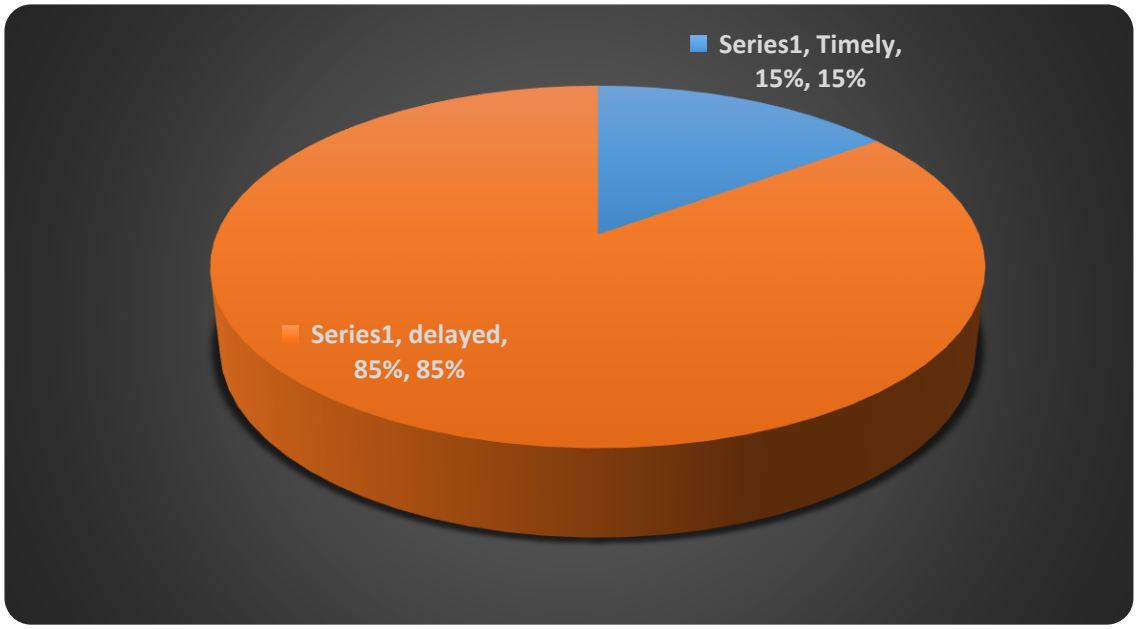

Figure 4.10 Response time

Source: Researcher, 2023

The results indicate that most of the breakdowns were not attended to immediately once a request is made contrally to recommend 24hours response time for emergency works,one week for corrective maintenance and according to the scheduled time for preventive maintenance.

4.5 Challenges by FRA in maintenance of strategic storage facilities

4.5.1 Operational Challenges

The respondents were requested to indicate availability of important expertise within FRA. The results are given in figure 4.11. The respondents were asked the challenges that FRA faced in relation to maintenance management. Financial challenges are at 76.19% followed by operational challenges at 9.52%, no response 9.52% whereas administrative hitches accounted for 4.75%.

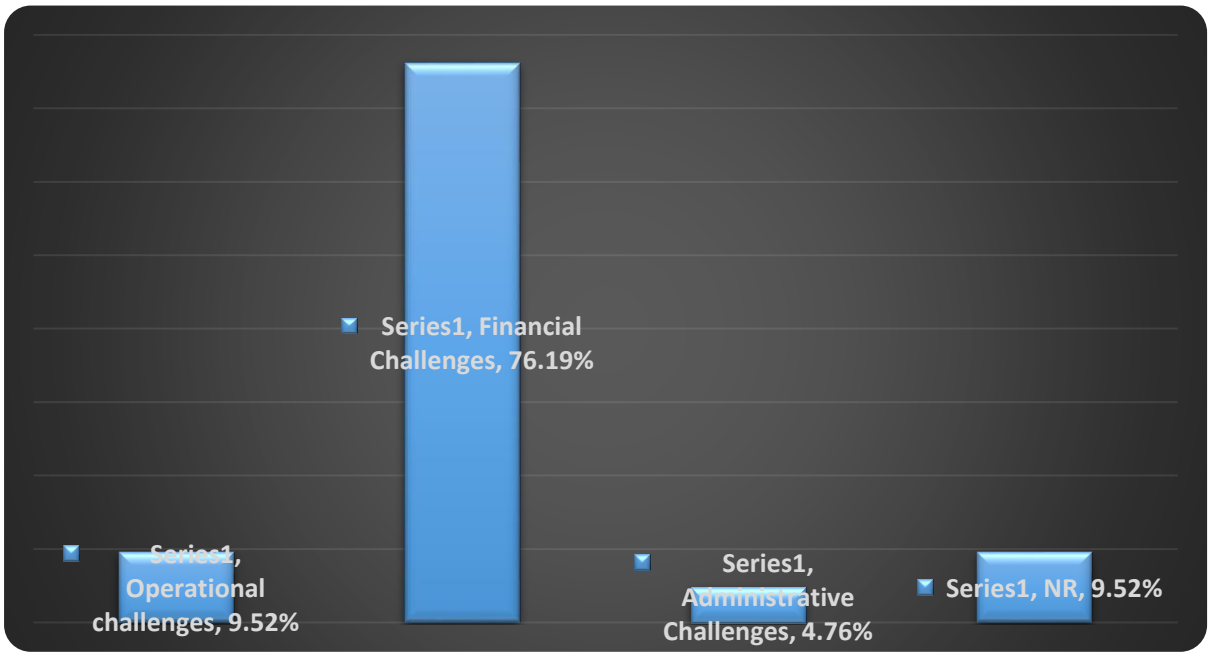

Figure 4.11 Operational Challenges

Source: Researcher, 2023

Generally, the major problems that FRA faces in terms of grain storage facilities revolve around financial, administrative, operational and staffing concerns which could be addressed by planning ahead and having cost effective systems in place.

4.5.2 Staffing levels and qualifications

The respondents were requested to indicate the staffing levels and qualifications. The results are given in figure 4.12. Both technologists and engineers were at 2.78%, Technicians represented 5.56% whilst tradesmen where the majority at 55.56%. 5.56% did not respond and 27.78% were unclassified.

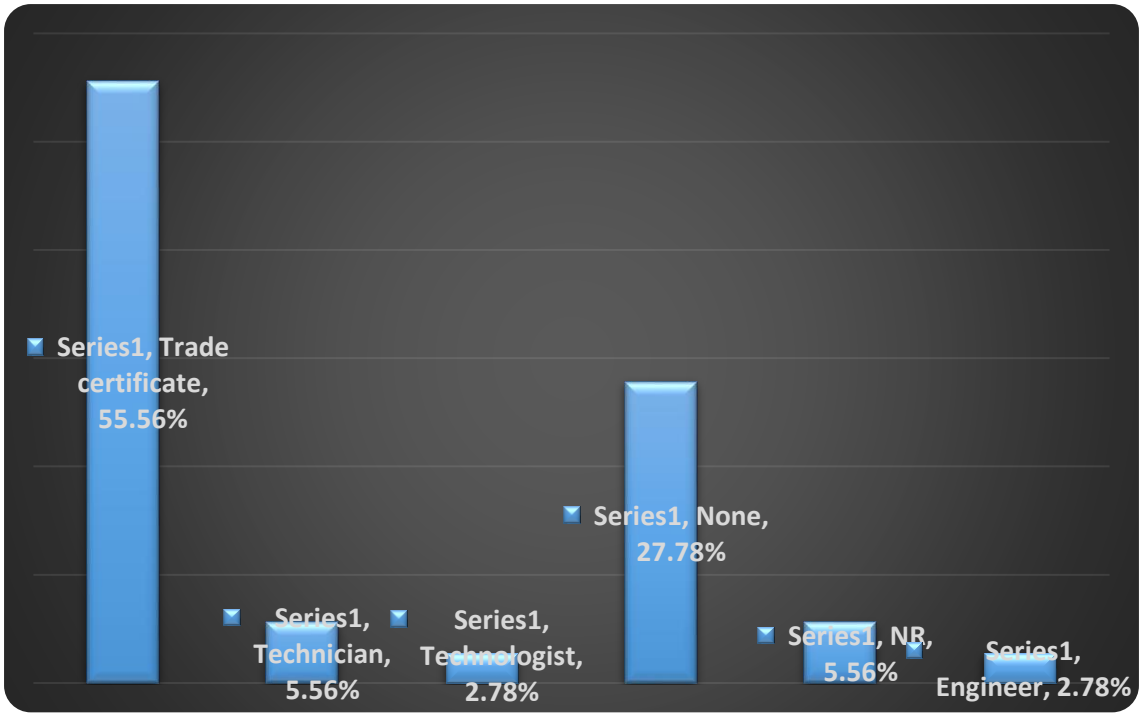

Figure 4.12 Staffing levels and qualifications

Source: Researcher, 2023

This shows that the department has personnel that are not qualified for the job in some depots and may be needing training in the management of storage facilities.

4.5.2 Logistical Support

The respondents were requested to indicate whether support towards maintenance management was well facilitated by FRA. The results are given in figure 4.13. 71% of the respondents indicated that support towards maintenance management was not well facilitated and only 29% stated that it was sufficiently facilitated.

Figure 4.13 Logistical Support

Source: Researcher, 2023

This shows that maintenance works are not given enough support particularly in the form of materials for repairs and maintenance and transport to enable them attend to breakdowns and any other maintenance related works on time.

4.5.4 Availability of Materials

The respondents were asked whether the materials for maintenance management were available or not. The results are given in figure 4.14. 85.71% of the respondents observed that materials for well-functioning maintenance management were never available whereas only 9.52% asserted that the materials were available and 4.76% did not respond.

Figure 4.14 Availability of materials

Source: Researcher, 2023

The results above show that the agency does not keep maintenance materials in the depots to be used for urgent repairs instead materials are only procured when a maintenance need arises.

4.5.5 How Maintenance can be improved

The respondents were asked maintenance management could be improved. The results are given in figure 4.15. 20.83% of the respondents suggested that the system should be computerised. 50% of the responded stated that there should be improved logistical support. 25% of the respondents suggested that there should be more training whereas 4.17% didn't give responses.

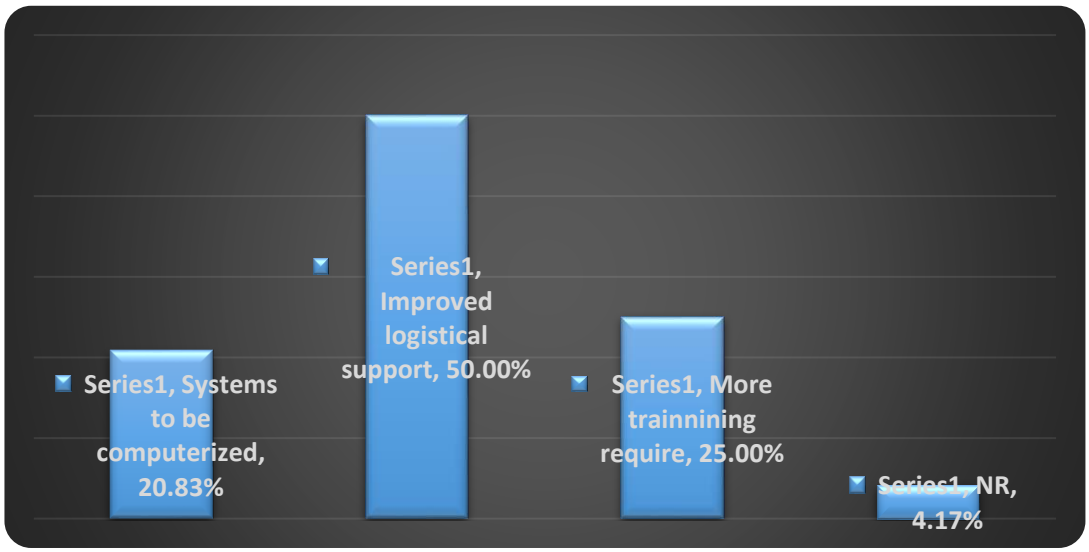

Figure 4.15 How maintenance can be improved

Source: Researcher, 2023

The results above shows that the staff recognise that the agency has to put in place certain specific measures that are intended to improve maintenance management.

4.5.6 Skilled and unskilled personnel

The respondents were asked to indicate if the staff managing the depots were skilled for the job.Results are given in figure 4.16. 47.62% of the respondents indicated that there was unskilled personnel whilst 47.62% indicated that there was skilled personnel. 4.76% didn't give any response.

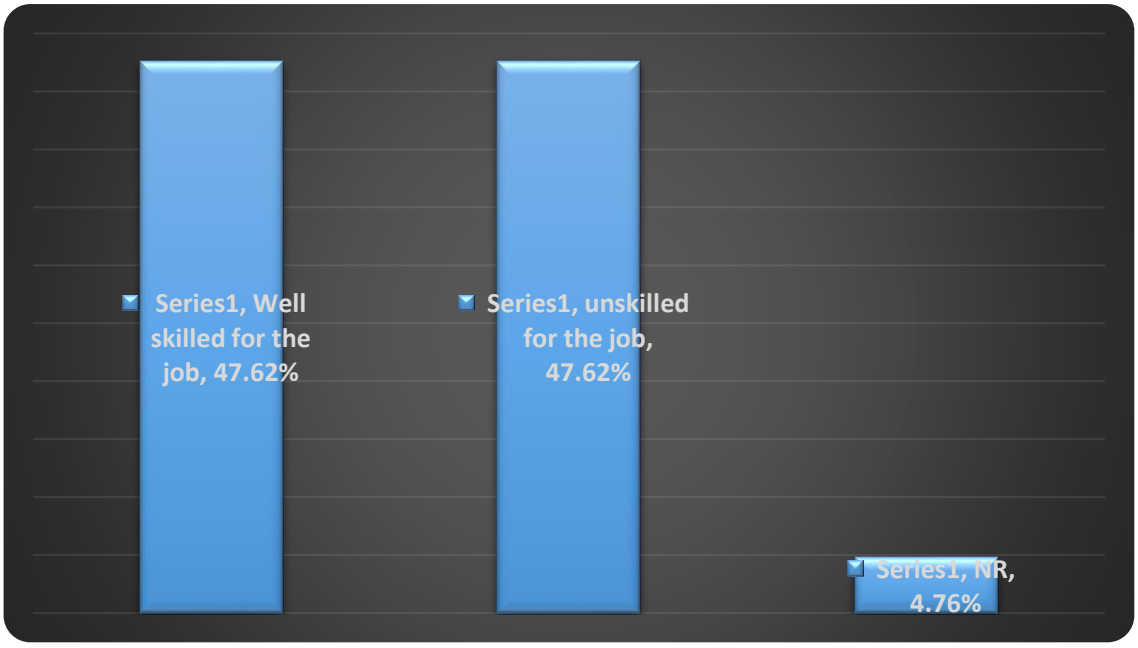

Figure 4.16 Training and Skills

Source: Researcher, 2023

The results above show that the FRA need to have more skilled staff who are were trained for the specific tasks particularly in maintenance of grain storage facilities.

4.5.7 Common maintenance problems

The respondents were requested to indicate the levels of challenges in different sections of FRA. The results are given in figure 4.17. Challenges in carpentry represent, 36%, mechanical problems at 27%, electrical problems at 23%. Bricklaying problems at 9% whilst 5% didn't give a response

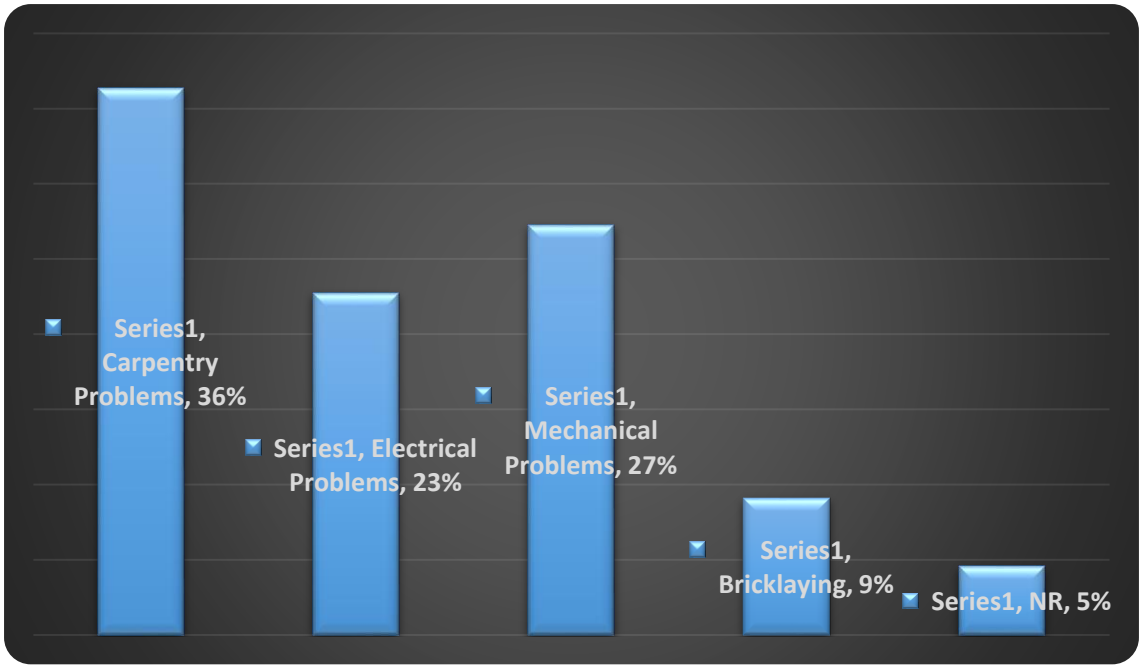

Figure 4.17 Common maintenance problems

Source: Researcher, 2023

This shows that most depots faced more carpentry and mechanical problems compared to electrical and bricklaying challenges which shows that there is a mismatch with current labour distribution in the depots.

4.5.8 Response time, repairs and rehabilitations

The respondents were requested to indicate the response time whenever reports for repairs and rehabilitations were made. The results are given in figure 4.18. 19.44% of the respondents indicated that it took one week before repairs or rehabilitations on depots and sheds could be done, 5.56% of the respondents indicated that it took 2 weeks before repairs could be done, 13.89% of the respodents indicated that it took 3 weeks before repairs could be done, whereas 55.56% indicated that it took more than three weeks for the repairs and rehabilitations to be done after reporting while 5.56% were not responsive.

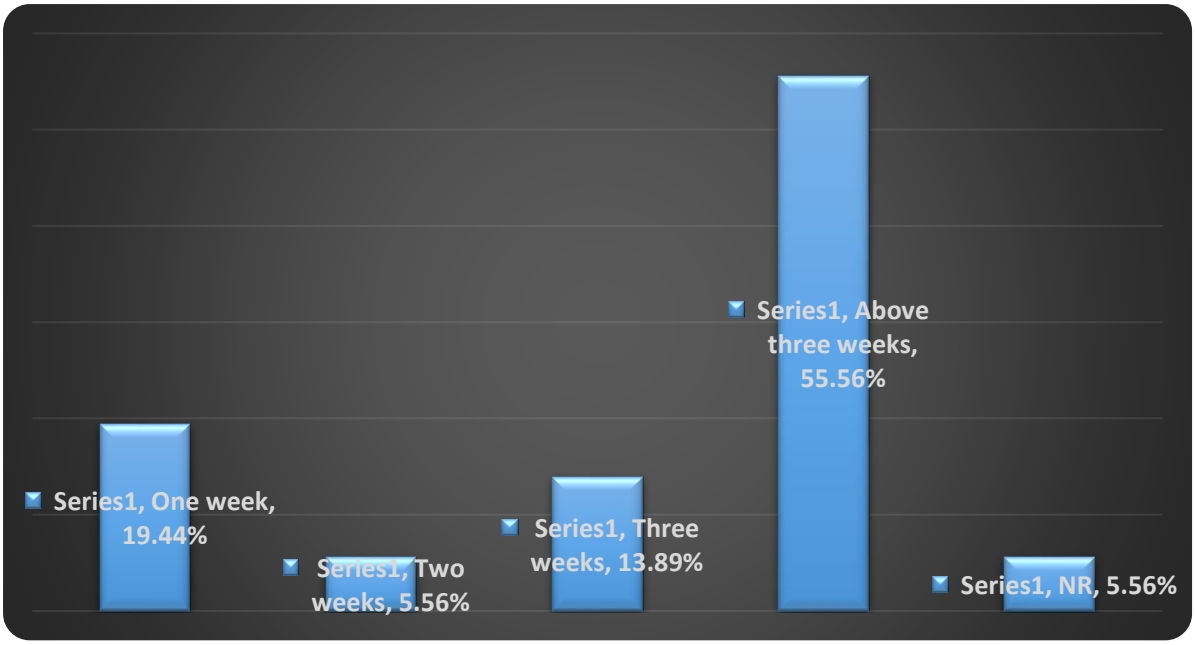

Figure 4.18 Length of response time for for any repairs and rehabilitations

Source: Researcher, 2023

This shows that the response time on breakdowns was not consistent, which further suggests that the department has no prescribed system concerning the response time on emergency, corrective and preventive maintenance works.

The study suggests that although the FRA conducts various maintenance works on its properties, these are not regular but rather they are a response to reported cases of damages or breakdowns. From the study, it was further observed that much of FRA's approach to maintenance was reactive rather than preventive thus they used repairs, rehabilitation and overhaul as much as indicated by the interviewees. Additionally, FRA approached maintenance management in rather ad hoc manner because their approach lacks a systematic and methodical approach. Additionally, the foregoing indicates that FRA does not prioritize maintenance management despite the importance attached to it in view of the role the institution plays. This is because it has no specific systematic and structured approach. Equally its financing is erratic and inadequate. The findings from the study also show that for those FRA depots and sheds needing repairs or rehabilitation, the caretakers make immediate reports and once they report, works are usually scheduled within an average of one to three weeks as the response time after reporting of the needed repairs or rehabilitation.

4.6 The best and cost-effective strategies for maintenance of strategic storage facilities.

In order to understand the best and cost effective maintenance management strategies, one has to have a good knowledge of maintenance management principles and best practices. There are several maintenance strategies proved to be useful over the years.

4.6.1 Monitoring and evaluation of the grain stores

The respondents were requested to indicate how often inspections were done at FRA grain storage facilities. The results are given in figure 4.19 below. 28.75% of the interviewees stated that grain storage facility inspections were done three times a year by FRA, whereas 23.81% indicated four times, 19.05% stated that there were no inspections, 9.52% indicated twice and 14.29% stated that its once.

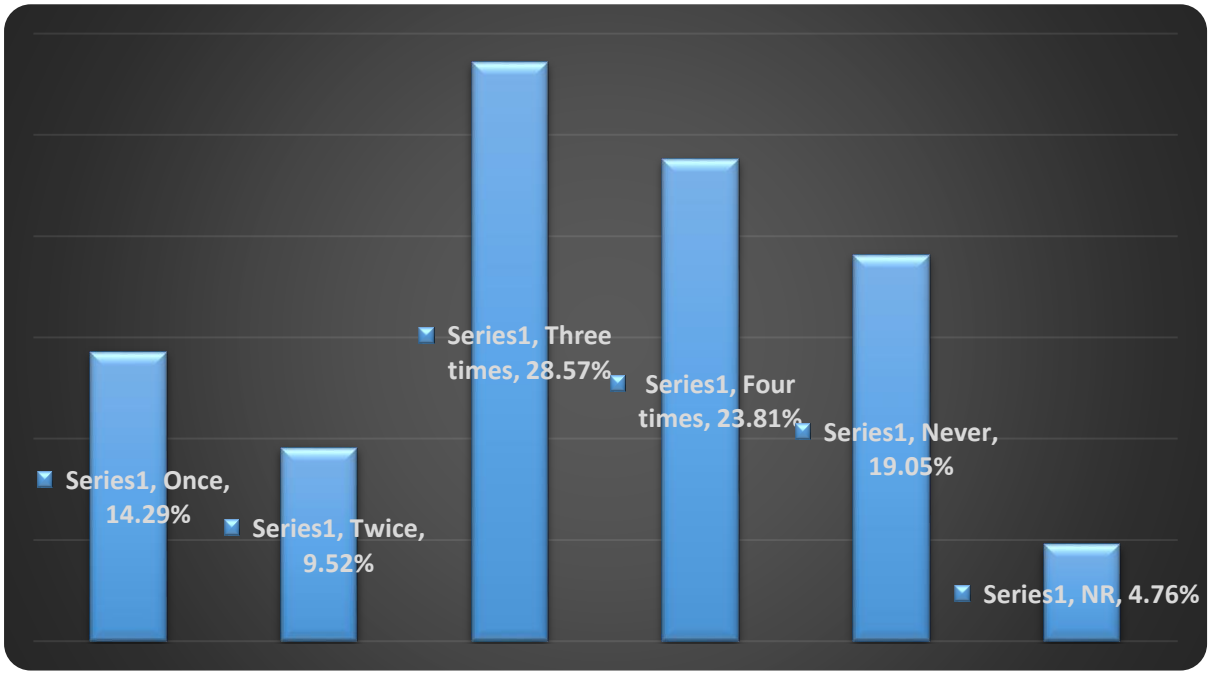

Figure 4.19 Inspection of storage facilities

Source, Researcher, 2023

It can be observed from the results above that most people who indicated that inspections were consistently carried out are caretakers from the depots who do not generate reports of their findings. However, the decision makers at head office responded that inspection were not being done. This means that the Engineers and Technicians do not go out to inspect and generate reports on the works to be done and the conditions of the facilities.

4.6.2 Monitoring systems

The respondents were requested to indicate if there were any deliberate monitoring and evaluation maintenance management systems in FRA. The results are given in figure 4.20 below. 47.62% of the respondents indicated that there were no deliberate monitoring and evaluation systems at FRA and 47.62% also said deliberate monitoring evaluation systems were there at FRA while 4.76% were not responsive.

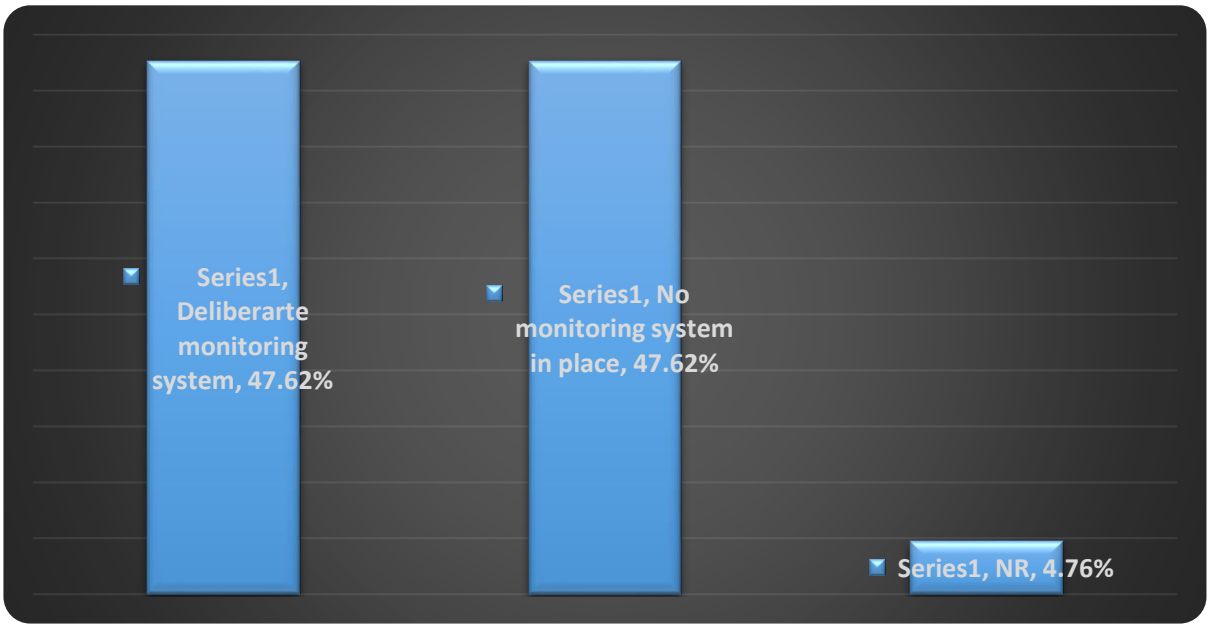

Figure 4.20 Deliberate Monitoring and Evaluation System

Source: Researcher, 2023

The illustrations above show that FRA has no structured and documented procedures on how maintenance works are suppose to be carried out.This means that the agency does not carry out condition monitoing of the assets. Monitoring and evaluation is important for maintenance systems because it informs the teams of the condition of the assets and the type of maintenance to be performed. Furthermore, it helps in informing the budget.

It can also be concluded from the findings that, there is some form of inspection that is done on grain facilities by FRA, however these are sporadic and unscheduled. The foregoing, explains why the frequency of inspections, monitoring and maintenance may vary from depot to depot but ultimately inspections are done in most of the facilities. The variations in number of times as demonstrated by the respondent could explain the spontaneity with which FRA conducts its inspections, monitoring and maintenance. Basically there is no structured guide as to how often FRA conducts these inspections so that they are uniform in all storage facilities.

The idea is to ensure that these inspections help to proffer an effective maintenance strategy which will consequently optimise equipment uptime and facility performance at a cost effective rate and ensure that FRA gets sufficient return on investment.

4.6.3 Efficiency of evaluation systems

The respondents were asked whether evaluation systems are important and effective in maintenance management. The results are given in figure 4.21. 67% of the respondents felt that evaluation was important and effective in maintenance management against 33% who felt that it was not effective.

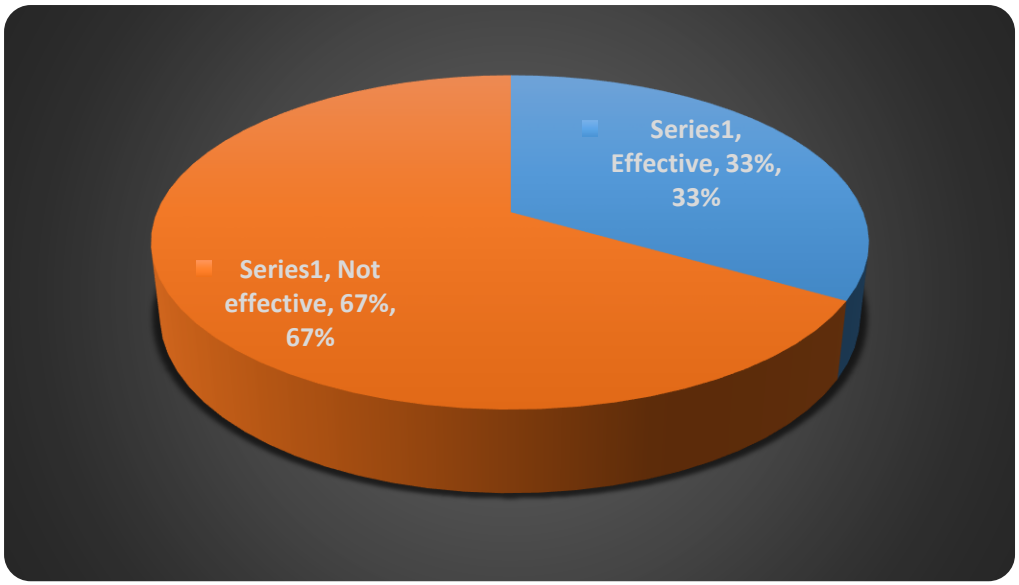

Figure 4.21 Effectiveness of Evaluation Systems

Source: Researcher, 2023

The majority of the interviewees indicated that evaluations were usually effective and important in the organisation because they brought out information which is relevant in determining the challenges, projecting and identifying what works well. Monitoring and evaluations also help to provide clarity on the current conditions and constraints that may exist in storage facilities. For example, they can inform if there is need to improve property uptime, moderate maintenance costs, decrease equipment operating costs, extend equipment life, cut down on spare parts inventory. According to Crespo et al., (2006) many organisations adopt a risk-based approach because it prioritizes resources in an effective way and appraises the requirements and effectiveness of maintenance tasks which are populated in the CMMS way in advance.

The study established that among the best approaches to maintenance management is the preventive maintenance approach. However, FRA does not use that approach but rather deploy a reactive maintenance approach. They also do not use Planned Maintenance Optimization which is specifically designed towards existing maintenance programs (Ahire, 2000).

4.7 **Chapter Summary**Chapter four was a presentation of the results and analysis of the findings of the study. It highlighted the responses from the study participants and analysed the findings. The next Chapter is the presentation of the recommendations and the main conclusions of the study.

CHAPTER FIVE CONCLUSION AND RECOMMENDATION

5. CONCLUSIONS

5.1 State of strategic storage facilities

The study ascertained numerous factors which established key findings around the current status and conditions of the strategic grain storage facilities of FRA. Firstly, it was noted that the levels of maintenance and general conditions of the majority of the depots and sheds under the FRA jurisdiction were found to be fairly of acceptable standards although more could be done to improve the status quo especially if well scheduled maintenance would be conducted. The general view by the interviewees is that the infrastructure is still generally in fair condition and there are always repairs and rehabilitations works that are going on at various depots and sheds to improve them and maintain their good state although these are done on an adhoc basis.

The study further observed that up to Two Thousand Metric Tonnes (20000MT) capacity was very safe and secure storage which could be optimised for grain storage but this would have been much more had there been a more structured maintenance management approach by FRA. The study further concluded that although the FRA conducts various maintenance works on its properties, these are not regular and consistent. Additionally, it was established that those depots and sheds needing repairs or rehabilitation, the caretakers make immediate reports and once they report, works are usually scheduled within an average of one to three weeks as the response time after the reporting of the needed repairs or rehabilitation. Although this was good response time, it was established that the condition of the buildings deteriorated because of the lack of scheduled preventive maintenance activities as much of the maintenance was reactive. It was further established from the interviewees that FRA was not consistent with its maintenance of the depots and sheds and lacked well-structured maintenance schedules. This leaves some of the property unattended to for much longer periods leading to high rate of deterioration and often times subjecting storage facilities to poor conditions.

5.2 Maintenance philosophies used in management of strategic storage facilities.

The study established that FRA had no maintenance management philosophies on which its activities on maintenance of its property were anchored. Additionally, the study revealed that there was lack of a clear maintenance management policy which has resulted in the absence of a specifically structured and scheduled maintenance management approach of grain storage facilities in the organisation. The maintenance management policy was inconsistent and not

based on any particular maintenance management philosophy. Much of the property management framework of FRA depends on its structural establishment and government regulations rather than its own internally designed policies, procedures and guidelines on maintenance management. This makes the institution not to prioritize maintenance management in terms of resource allocation and well-structured activities.

5.3 The challenges faced by FRA in the maintenance of strategic storage facilities

The study established that the major challenges faced by FRA in the maintenance of its strategic grain storage facilities include capacity gaps, technical and financial inadequacies. Other challenges identified are ineffectiveness in responding to maintenance by the property management department and poor provision of the required tools to the caretakers. Maintenance work is also centralized and only done once the personnel from head office are assigned to go to locations to do the repairs even when on many instances some repairs could be done by caretakers. Additionally, there are transport challenges which affect effective monitoring and inspections. There is lack of consistent transport to effectively monitor maintenance programmes in a timely and effective manner. Furthermore, there are gaps in terms of skills, particularly among caretakers with regard to several aspects necessary to effectively execute maintenance management programmes of the sheds and storage facilities of FRA.

5.4 The best and cost-effective strategies for maintenance of strategic storage facilities.

The study established that inspection is done on grain facilities by FRA although it is not within any structured framework but rather ad hoc. Additionally, the numbers of times these inspections and monitoring are conducted vary from depot to depot. The variations in number of times could explain the spontaneity with which FRA conducts its inspections and also shows a lack of a well-planned schedule. There are no structured guidelines as to how often FRA should conduct inspections so that they are uniform in all storage facilities.

The FRA deploys a reactive maintenance approach which responds to reported incidents and breakdowns or damages. FRA also does not use Planned Maintenance Optimization which is specifically designed towards existing maintenance programmes but they are rather prompted by reported damages and needed repairs. Additionally, the study established that FRA places more emphasis on conducting defect elimination which is a maintenance strategy that particularly focuses on the design of the property to prevent defects being introduced at the

early stages of the property life span thus eliminating the defects during the operational stage of the property life cycle. Based on the fore going, the study makes recommendations.

5.5 Recommendations

1. There should be interventions to ensure deliberate efforts which are intended to improve maintenance management within FRA, thus the institution needs to adopt its own specific maintenance management policies and regulations which should be supported with systems and mechanisms for compliance and enforcement as well as procedural and manual with guidelines. For instance, FRA could adopt policies such as age replacement policy, periodic preventive management policy and failure limit policy. These would drive its maintenance management activities.
2. FRA should increase its financial allocation towards maintenance management and prioritise maintenance management including attending to capacity needs such as training of storage facility staff and technicians. Skills development should be enhanced to improve the technical capacities of the different staff tasked with property maintenance and storage facilities within FRA. This could be by conducting several training activities and directing more resources towards improving knowledge and skills. Doing so will help in resolving technical inadequacies and capacity gaps associated with maintenance management in the institution.
3. There is need for FRA to invest in CMMS and ensuring that all the maintenance management information is computerised and coordinated. Furthermore, the institution needs to decentralise its operations to enable maintenance works to be done by staff within the depots and sheds without waiting upon the staff from headquarters.
4. The FRA should devise strategies that will ensure that there is consistent and continuous monitoring and inspection of the depots and sheds at scheduled periods to ensure that scheduled maintenance is informed by inspection and monitoring reports and urgent repairs are attended to within the shortest possible time. Furthermore, FRA should adopt preventive maintenance as its main maintenance management philosophy. Additionally, the response time for reported damages and repairs needed should be improved.
5. The FRA needs to allocate more resources towards maintenance management of its property since it forms an integral and important part of the mandate of the institution.

In essence, they must prioritise maintenance management of the property to ensure that storage of grains is done optimally and in very good conditions.

5.6 Future Research

The study findings offer an important starting point for further research within the domain of maintenance management in Zambia. The study takes into account the limitations associated with it, therefore, it created opportunities for future studies which could further be built on in the context of its identified limitations which include limited number of study subjects and scope. The study makes the following recommendations for future studies:

1. The study provides a basis to further explore the policy structures and frameworks particularly by the government and its relevant public institutions as it pertains to property management and maintenance management by FRA in Zambia.
2. The study proffers an entry point to conduct a much more profoundly detailed study on the impact of policies and systems pertaining to maintenance management at FRA and how these can stimulate effective maintenance management in public institutions
3. The study further provides an opportunity to conduct a comparative study between public and private institutions in property maintenance in Zambia and demonstrate the differences that exist between the two.

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APPENDICES

1. Questionnaires

QUESTIONAIRES FOR REGIONAL PROPERTY CORDINATORS AND REGIONAL MARKETING COORDINATOR

AGE: ……

GENDER: Male ☐ Female ☐

NAME OF DEPOT: …….

STATION: …….

1. What is the storage capacity of the FRA?

   0 – 1,000,000 MT ☐ 1,000,001 MT - 1,500,000 MT ☐

   1,500,001 MT – 2,000,000 MT ☐ above 2, 000, 0001 MT ☐

2. What capacity is safe and secure storage?

   0 – 1,000,000 MT ☐ 1,000,001 MT - 1,500,000 MT ☐

   1,500,001 MT – 2,000,000 MT ☐ above 2, 000, 0001 MT ☐

3. What are the maintenance challenges with the unsecure and safe unsafe storage?

   Financial Challenges ☐ Operational Challenges ☐ Administrative Challenges ☐

4. How much storage space do you normally use?

   0 – 1,000,000 MT ☐ 1,000,001 MT - 1,500,000 MT ☐

   1,500,001 MT – 2,000,000 MT ☐ above 2, 000, 0001 MT ☐

5. What maintenance system are you using at the FRA?

   Preventive maintenance ☐ Reactive maintenance ☐

   Condition based ☐ Corrective maintenance ☐

6. Do you think the system is answering to your challenges?

   YES ☐ NO ☐

7. Do you have a Maintenance policy as an agency?

   YES ☐ NO ☐

8. Do you have a work order system?

   YES ☐ NO ☐

9. Are you satisfied with the staffing levels in your region?

   YES ☐ NO ☐

10. What challenges does the Agency experience in the management of grain storage facilities?

    Staffing challenges ☐ Operational Challenges ☐ Funding challenges ☐

11. Do you have a maintenance record management system? YES ☐ NO ☐

12. Is the above system computerized? YES ☐ NO ☐

QUESTIONAIRE 2 FOR PROPERTY MAINTENANCE TECHNICIANS AND CARETAKERS

AGE: ……

GENDER: Male ☐ Female ☐

NAME OF DEPOT: ……

STATION: ……

1. What trade are you trained in?

Civil ☐ Mechanical ☐ Electrical ☐

Carpentry ☐ Bricklaying ☐ Metal Fabrication ☐

None ☐

2. What is your level of training?

Grade 12 ☐ Certificate ☐ Diploma ☐

Degree ☐ Master's Degree ☐ None ☐

What is your level of computer literate literacy?

Poor ☐ Average ☐ Good ☐ Excellent

3. Do you have knowledge of computerized maintenance systems?

YES ☐ NO ☐

4. Do you keep a record of all your maintenance activities?

YES ☐ NO ☐

5. How are requests for maintenance handled by your department?

Work Order system ☐

Phone calls ☐

Mails ☐

Verbal reporting ☐

6. Would you consider the department's response to maintenance problems as being effective?

YES ☐ NO ☐

7. Would you consider the department's response to maintenance problems as being timely?

YES ☐ NO ☐

8. How do you rate the current state of the grain storage facilities in the country?

Poor ☐

Average ☐

Good ☐

Very Good ☐

9. How has the situation changed in the last five years?

Improved ☐ Worsened ☐

10. What in your opinion is impeding effective maintenance of the storage facilities?

Financial Challenges ☐

Administrative Challenges ☐

Operational Challenges ☐

11. What are the most common maintenance problems on grain storage facilities?

Electrical problems ☐

Mechanical problems ☐

Carpentry Problems ☐

Bricklaying problems ☐

12. What do you consider as the greatest challenge in maintaining grain stores?

Financial ☐

Operational ☐

Administrative ☐

Operational ☐

13. Are you sufficiently facilitated in your work?

YES ☐ NO ☐

14. How can this deficiency be improved?

Improved logistical Support☐

More training required ☐

Systems to be computerized☐

15. Do you have sufficient training and skills to execute your work?

YES ☐ NO ☐

16. In your opinion are the departmental maintenance processes and procedures effective in addressing maintenance needs of the Agency?

YES ☐ NO ☐

17. Does the department store enough levels of materials to adequately support maintenance and repair works?

YES ☐ NO ☐

18. In your view what is the level of commitment by the Agency or departmental management to building maintenance?

Poor ☐

Average ☐

Good ☐

Very Good ☐

19. Do you have any documented maintenance procedures that you can guide your work?

YES ☐ NO ☐

20. Have you taken time to understand the maintenance and operations procedure manual?

YES ☐ NO ☐ N/A ☐

21. How many times in a year do you carry out monitoring/inspections on your grain storage facilities?

Once ☐

Twice ☐

Three times ☐

Four times ☐

Never ☐

22. Do you have any deliberate system that enables you to know the status of the sheds before crop marketing?

YES ☐ NO ☐

23. Any suggestions on how maintenance management can be improved given challenges faced at implementation stage.

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QUESTIONAIRE 1 FOR MARKETING PERSONNEL

AGE: ……

GENDER: Male ☐ Female ☐

NAME OF DEPOT: ……

STATION: ……

1. What is the capacity of the storage facility in MT?
   0 - 20000 ☐ 20001 – 50000 ☐ 50001 – 10000 ☐ Above 100000
2. How much of that capacity you have indicated above is secure and safe?
   0 - 20000 ☐ 20001 – 50000 ☐ 50001 – 10000 ☐ Above 100000
3. What measures are being taken to improve the unsafe and unsecure storage sheds?
   Rehabilitation works ongoing ☐
   Repairs being done ☐
   Overhaul works ongoing ☐
   Nothing so far ☐
4. How would you describe the conditions of the infrastructure at the depot?
   Poor ☐ Fair ☐ Good ☐ Excellent ☐
5. How many employees do you have at the depot?
   0 – 10 ☐ 11 - 20 ☐ 21- 30☐ above 31 ☐
6. How many of these are maintenance personnel?
   1 ☐ 2☐ 3☐ 4☐
7. What are some of the qualification of the maintenance team?
   Trade certificate ☐ Technician ☐ Technologist ☐ Engineer ☐ none ☐
8. To whom do they report the maintenance jobs?
   PMC ☐ MO ☐ MA ☐ RPC ☐
9. Do they have any form of training specific to the storage maintenance which they have undergone? YES ☐ NO ☐
10. Do you have a maintenance guide on how breakdowns are reported? YES ☐ NO ☐
11. Do you document the maintenance works that are done at the depot? YES ☐ NO ☐
12. What are some of the maintenance challenges at this depot?
    Financial ☐ Operational ☐ Staffing ☐ Administrative ☐
13. Have you reported the challenges to the responsible office? YES ☐ NO ☐
14. How long does it normally take for repairs to be done?

One week ☐ 2 weeks ☐ 3 weeks ☐ above 3 weeks ☐

15. Does the agency have any maintenance manual in place?

YES ☐ NO ☐ don't know ☐

16. Have you read the maintenance policy of the Agency? YES ☐ NO ☐

17. Any other concerns that you would like to add on the maintenance of the grain stores?

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THE UNIVERSITY OF ZAMBIA

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APPROVAL OF STUDY

IORG No. 0005376

HSSREC IRB No. 00006465

5th August, 2022

REF NO. NASREC-2022-AUG-010

Cravans Muntanga
The University of Zambia
School of Engineering
P.O. Box 32379
LUSAKA

Dear Mr. Muntanga,

RE: "AN INVESTIGATION INTO THE GRAINSTORAGEFACILITIES MAINTENANCE CHALLENGES IN ZAMBIA"

Reference is made to your protocol dated as captioned above. NASREC resolved to approve this study and your participation as Principal Investigator for a period of one year.

REVIEW TYPE	**ORDINARY REVIEW**	**APPROVAL NO. NASREC-2022-AUG-010**
Approval and Expiry Date	Approval Date: 5th August, 2022	Expiry Date: 4th August, 2023
Protocol Version and Date	Version - Nil.	4th August, 2023
Information Sheet, Consent Forms and Dates	• English.	To be provided
Consent form ID and Date	Version - Nil	To be provided
Recruitment Materials	Nil	Nil
Other Study Documents	Questionnaire.	

Specific conditions will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed.

CONDITIONS OF APPROVAL

- No participant may be involved in any study procedure prior to the study approval or after the expiration date.

- All unanticipated or Serious Adverse Events (SAEs) must be reported to NASREC within 5 days.

- All protocol modifications must be approved by NASREC prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address.

- All protocol deviations must be reported to NASREC within 5 working days.
- All recruitment materials must be approved by NASREC prior to being used.

- Principal investigators are responsible for initiating Continuing Review proceedings. NASREC will only approve a study for a period of 12 months.

- It is the responsibility of the PI to renew his/her ethics approval through a renewal application to NASREC.

- Where the PI desires to extend the study after expiry of the study period, documents for study extension must be received by NASREC at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Documents received within 30 days after expiry will be labelled “late submissions” and will incur a penaltyfee of K500.00. No study shall be renewed whose documents are submitted for renewal 30 days after expiry of the certificate.

- Every 6 (six) months a progress report form supplied by The University of Zambia Natural and Applied Sciences Research Ethics Committee as an IRB must be filled in and submitted to us. There is a penalty of K500.00 for failure to submit the report.

- When closing a project, the PI is responsible for notifying, in writing or using the Research Ethics and Management Online (REMO),both NASREC

- and the National Health Research Authority (NHRA) when ethics certification is no longer required for a project.

- In order to close an approved study, a Closing Report must be submitted in writing or through the REMO system. A Closing Report should be filed when data collection has ended and the study team will no longer be using human participants or animals or secondary data or have any direct or indirect contact with the research participants or animals for the study.

- Filing a closing report (rather than just letting your approval lapse) is important as it assists NASREC in efficiently tracking and reporting on projects. Note that some funding agencies and sponsors require a notice of closure from the IRB which had approved the study and can only be generated after the Closing Report has been filed.

- A reprint of this letter shall be done at a fee.

- All protocol modifications must be approved by NASREC by way of an application for an amendment prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address or methodology and methods. Many modifications entail minimal risk adjustments to a protocol and/or consent form and can be made on an Expedited basis (via the IRB Chair). Some examples are: format changes, correcting spelling errors, adding key personnel, minor changes to questionnaires, recruiting and changes, and so forth. Other, more substantive changes, especially those that may alter the risk-benefit ratio, may require Full Board review. In all cases, except where noted above regarding subject safety, any changes to any protocol document or procedure must first be approved by NASREC before they can be implemented.

Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of NASREC, we would like to wish you all the success as you carry out

your study. Yours faithfully,

Dr. Mususu Kaonda

VICE-CHAIRPERSON

THE UNIVERSITY OF ZAMBIA NATURAL AND APPLIED SCIENCES RESEARCH ETHICS COMMITTEE - IRB

CC: Director, Directorate of Research and Graduate Studies

Assistant Director (Research), Directorate of Research and Graduate Studies Assistant Registrar (Research), Directorate of Research and Graduate Study