Developing a Model Framework for Effective Maintenance of Public Office Buildings in Kenya:
A survey of Multi Storeyed Office Buildings in Nairobi.

Raphael Rauf Odida Ochien'g

This Thesis is submitted in partial fulfillment for the degree of Master of Science in Construction Project Management in the Jomo Kenyatta University of Agriculture and Technology

2012

DECLARATION

This thesis is my original work and it has not been presented for a degree in any University

Signature: ……………………..………………   Date:…………………………

Raphael Rauf O. Ochien'g

This thesis has been submitted for examination with our approval as University supervisors.

Signature: …………………………..………   Date:…………………………

Dr. Stephen O. Diang'a

JKUAT, Kenya

Signature: ……………………………..……   Date:…………………………

Dr. Githae Wanyona

JKUAT, Kenya

DEDICATION

This Research Thesis is dedicated to my immediate family members; Phoebe Adhiambo, Denis Odida, Nelson Mandela, Caroline Atieno, William Odongo and Tracy Achieng.

ACKNOWLEDGEMENT

This Research Thesis was a success due to direct and indirect contributions from various personalities or organizations encountered during the study programme. I am therefore indebted to and acknowledge valuable assistance from the following:

My supervisors, Dr. Stephen O. Diang'a and Dr. Githae Wanyona for their tireless effort in guiding the preparation of the Research Thesis;

The entire staff of the Department of Construction Management, Jomo Kenyatta University of Agriculture and Technology for offering assistance in one way or another to facilitate success of the study;

All public servants encountered in the course of field study for co-operating during field data collection;

Typists M/s Edith Lijina and M/s Felister Chebor for availing the necessary typing services throughout the report writing period;

Last but not least I sincerely thank my wife for being patient and accommodative in the course of the entire study period.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABREVIATIONS/ACRONYMS

ALLOC	-	Allocation
APBA	-	Annual Predicted Budgetary Allocation
APMC	-	Annual Predicted Maintenance Cost
AWP	-	Annual Works Programme
BLD	-	Building
BOOM	-	Buildings Organization and Operations Manual
CBM	-	Condition Based Maintenance
CCTV	-	Closed Circuit Tele-Vision
CMMS	-	Computer Management Maintenance System
CONST	-	Construction
GOK	-	Government of Kenya
FM	-	Facilities Management
MGT	-	Management
MOH	-	Ministry of Housing
MOPW	-	Ministry of Public Works
MTCE	-	Maintenance
NCC	-	Nairobi City Council
SYS	-	System
TECH	-	Technology
TQM	-	Total Quality Management
VBM	-	Value Based Maintenance
UK	-	United Kingdom
USA	-	United States of America

LIST OF PHOTOGRAPHS

ABSTRACT

Public buildings create space within which the organs of any government operate to deliver the much needed services to the citizens. An effective and efficient maintenance system is key to enhancement of the service life of buildings. In Kenya and most other third world countries, the national budgetary allocations are way below the projected cost of building maintenance programmes leading to prolonged and unchecked deterioration of buildings.

The aim of this study was to develop a model of maintenance framework for effective maintenance of public office buildings in Kenya with the purpose of minimizing maintenance costs. Consequently, the study endeavored to develop an effective maintenance model addressing budgetary constraints and operational structures of public institutions.

The research strategy is both qualitative and quantitative and was executed through a survey of sampled public office buildings in Nairobi. Thirty nine out of the targeted population of fifty two highrise public office buildings were sampled through a stratified random sampling technique in three locations of Nairobi with major concentrations of this category of buildings. Research data was collected through structured questionnaires, interviews and observations. Data was also sourced from review of literature on previous research findings, text books including facts and statistics from the Kenya government.

The study established that the existing maintenance framework is inefficient and ineffective and therefore developed an alternative model of maintenance framework that is effective and will in the long run minimize maintenance costs through adoption of cost minimization strategies established from the findings. The model of maintenance

framework was developed through adoption of maintenance standards and guidelines established from the study findings.

The formulated building maintenance management framework can be applied towards the revitalization of the management of maintenance programmes in both the public and private sector office buildings. The framework can further be applied towards effective conservation of historical buildings.

CHAPTER ONE:

1.0 INTRODUCTION

1.1 Background to the Study

Public buildings are important infrastructure that provide governments with space within which to transact their business with the aim of delivering services to the public. The functionality and quality of these built up spaces depends on the effectiveness of their maintenance. Effective maintenance is in addition, key to prolonging service life of buildings. According to Lateef *et al* (2010), all maintenance activities, processes and operations must be carried out to achieve reasonable targets and standards as set by organizations. It is therefore necessary that maintenance strategies are backed by an effective legal and institutional framework to ensure that the functionality and quality of spaces are maintained.

The use and exposure of buildings to elements of weather leads to deterioration which if not addressed in good time may culminate in reduced performance and to some extent structural failure. Non-regular maintenance contributes to defects backlog with the consequences of eminent equipment breakdown or building component failure (Cane, 1998). An effective maintenance strategy should provide for regular maintenance to eliminate or minimize the costly consequences.

Maintenance is broadly classified as proactive or reactive. Proactive maintenance is planned/scheduled and includes predictive and preventive maintenance while reactive maintenance is unplanned/unscheduled and is corrective in nature (Olila and Malmipuro, 1999). The choice of a particular classification of maintenance has some bearing on the success of maintenance strategies.

Some experiences on how maintenance has been practiced in developed and developing countries give an insight of the different maintenance approaches and strategies in use globally. In Australia, sustainable building policy is in practice and recognizes the link between building maintenance and sustainability (Wilkinson and Reed, 2006). In the United Kingdom, there has been developed a feeling that strategic maintenance option is the way to go since the concept lays long term strategies to deal with challenges facing building asset maintenance rather than the short term corrective version (East Sussex County Council, 2001). Strategic maintenance as underscored by Peterson (2007) refers to a management process which is hinged on consistency and execution of the highest value decisions concerning use and care of assets. While Idris *et al* (2009) suggests value based maintenance model for adoption by the Malaysian Public Universities, Lekan (2005) advances total quality management principles as a solution to problems that have bedeviled building maintenance in Nigeria.

In Kenya, the approach to maintenance of public buildings is spelt out in chapter nine of the Buildings Organization and Operations Manual (BOOM) (Republic of Kenya, 1970) which has been overtaken by current globalization trends meaning that maintenance is currently being carried out haphazardly leading to the poor state of public office buildings. According to Republic of Kenya (1970), building maintenance works were at one time coordinated through designated maintenance depots located at strategic points all over the country. Maintenance of Public buildings in Nairobi Zone had hitherto been coordinated through eight maintenance depots, five of which have been closed down leaving Park Road, Machakos Road and Regional Yard facilities as the only remaining depots in Nairobi city.

The closure of the majority of the depots was mainly due to decentralization of maintenance budgetary allocation to various government departments and ministries starving the depots of the much needed operational and maintenance funds for sustainability. Staff retrenchment initiative through the Civil Service Staff Rationalization Programme which came into effect between the late 1990's and early 2000's aggravated the scenario through loss of key experienced maintenance staff lowering the capacity of maintenance units to handle maintenance programmes effectively (Republic of Kenya, 1998).

Further, even though the importance of building maintenance cannot be over emphasized, its annual budgetary allocation is only 17% of the overall building development vote (Republic of Kenya, 2010). In 2010/2011 financial year, the actual budgetary allocation was Ksh. 14 billion against a requisition of Kshs. 25 billion indicating a significant shortfall in funding allocation leading to non-accomplieshment of maintenance targets. The funding for maintenance programmes as confirmed by Republic of Kenya (2011) is therefore way below expectations and it is uncertain whether additional funding will be voted for this item as the government's spending priority continues to be diverted elsewhere.

In the same financial year, about 1900 requests for new public buildings had been submitted to the Ministry of Public Works Annual Works Programme and are at different stages of implementation. These new public buildings are continuously increasing the scope of building maintenance activities. While the number of completed public projects keeps on soaring up, the budgetary allocations for building maintenance keeps on dwindling to the extent that no effective maintenance is achieved. The haphazard manner within which maintenance has been executed coupled with insufficient budgetary support have contributed to considerable backlog of defects leading to dilapidated state of Public Office buildings. Although a number of researchers have covered some ground in this field of study, some gaps however remain unexploited.

In Kenya, Rukwaro (1990) articulates the influence of architectural design parameters in the maintenance cost of building services of office buildings which is closely related to the subject of this study. This however only forms a small component of building maintenance scope. Magolo (1994), another Kenyan researcher, reflects on the role of management information systems in built asset management and concludes that management information systems is key to modern maintenance management systems. Riapan (1990) concentrated his studies on the challenges of the flat roofing as a major concern in maintenance in Kenya which culminated into a major re-roofing programme for public buildings which are flat roofed.

These past studies therefore indicate that there is still a research gap to be filled in the area of formulation of an effective maintenance model. To fill the gap of knowledge, the study therefore endeavors to develop a model framework for effective maintenance of public office buildings with the purpose of minimizing maintenance costs in the long run. This is in view of the fact that the existing official document that guide maintenance of public buildings in Kenya is Chapter Nine of the Buildings Organization and Operations Manual (BOOM) which was developed by our colonialists over forty years ago and is no longer in use having outlived its usefulness as a result of changing economic, technological and social demands.

1.2 Statement of the Problem

In Kenya, maintenance of public office buildings is being executed ineffectively in a haphazard manner and without adequate budgetary support. Effective building maintenance is necessary to maximize service life of buildings by delaying deterioration, decay and failure thereby enhancing service delivery (Idrus et al, 2009). The 2010/2011 budgetary requisition for maintenance was approximately Kshs. 25 billion against a corresponding budgetary allocation of Ksh. 14 billion indicating how gloom the situation is (Republic of Kenya, 2010). The haphazard and ineffective systems currently being applied coupled with low budgetary allocations imply that maintenance targets cannot be met resulting to serious defects backlog The consequences for ever increasing defects backlog include disruption of delivery of services through equipment breakdowns or building element/component failures. It is against this background that this study has been crafted to investigate the existing maintenance framework with a view to developing an appropriate maintenance model framework for maintaining public office buildings.

1.3 Objective of the Study

The aim of the study is to develop a model framework for effective maintenance of public office buildings in Kenya with the purpose of minimizing maintenance cost in the long run.

Specific objectives are as follows:-

1. Determine causes and ratings of common maintenance defects in public office buildings.
2. Establish the maintenance workscope for public office buildings
3. Assess the existing maintenance framework for public office buildings.

4. Describe maintenance cost/budget and factors that influence them.
5. Formulate a cost/budget prediction model for maintenance of public office buildings.
6. Formulate a legal and institutional framework for maintenance of public office buildings.

1.4 Research Questions

1. a) What are the causes of common defects in Public office buildings?

b) What is the rating of the causes of common defects in a public office building?

2. a) What is the composition of a major maintenance workscope for public office buildings?

b) What is the composition of a minor maintenance workscope for public office buildings?

3. a) How effective is the existing maintenance framework for public office buildings?

b) How can the existing maintenance framework of public office buildings be improved?

4. a) What is the cost of maintenance requirements for public office buildings and how does this compare with budgetary allocations?

b) What factors influence maintenance cost of public office buildings and how are they rated?

5. a) What is the existing mode of drawing maintenance costs and budgets for public office buildings and how effective is it?

b) What is the appropriate model for formulating and predicting maintenance costs/budgets?

6. a) Is the existing maintenance framework for public office buildings guided by any legal and institutional framework?

b) What legal and institutional framework are relevant for effective maintenance of public office buildings?

1.5 Assumptions

The standard of finishes and electrical/mechanical services provided in buildings may vary considerably from one to the other with differing maintenance requirements. For the purpose of this study, it was assumed that the sampled public office buildings have got more or less similar standard of finishes and electrical/mechanical services.

1.6 Justification and significance for the Study

Whereas the importance of maintenance to public office buildings cannot be understated, there is no effective framework within which to execute maintenance works leading to uncoordinated, costly maintenance systems. The study therefore endeavors to investigate the existing maintenance framework with a view to making it more effective and efficient.

In addition to introducing new knowledge to the field of study, the findings are intended to offer an effective maintenance management model for adoption by the Kenyan government towards revitalizing maintenance systems for public office buildings.

1.7 Scope of the Study

The study was confined to a study of sampled public office buildings in Nairobi.

1.8 Limitations of Study

The ideal situation is to carry out a study of all public office buildings spread all over Nairobi. Since the study was carried out within limited budgetary and time constraints it is not possible to achieve this. In addition, for the sake of homogeneity, the public office buildings sampled for this study were at least four floors high to maintain uniformity in level for finishes and electrical/mechanical services. Public office buildings in the storey category of less than four floors are so varied in construction that some are even constructed of timber/iron sheets prefabricated system and may jeopardize data validity and reliability.

1.9 Operational Terms

Maintenance

Combination of all technical, administrative and managerial actions during the life cycle of an asset intended to retain it in or restore it to a state in which it can perform the required function.

Maintenance Cost

All direct and indirect costs regarding maintenance activities

Effectiveness

A measure of the degree to which an item, system or person can be expected to achieve a set of specific objectives.

Efficiency

Ability to do something well or achieve a desired result without wastage of energy or effort.

Minimize

According to oxford dictionary, to minimize is defined as to reduce to the smallest amount or degree. In the context of building maintenance cost it refers to reduction of cost to the bear minimum.

Maintenance System

Maintenance Strategies including approaches, structures, policies formulated to guide the execution of maintenance programmes.

Maintenance Management

All activities of management that determine the maintenance objectives, strategies and responsibilities including planning, controlling and supervision.

Maintenance Plan

Structured set of tasks that include activities, procedures, resources and time scale to carry out maintenance.

Maintenance Strategy

Management method that covers all aspects of maintenance activities including firm action plans for achieving short and long term maintenance objectives.

Maintenance Objectives

Targets assigned and accepted for maintenance activities and may include availability, cost minimization, quality, safety, user satisfaction etc.

Backlog of Maintenance Works

Maintenance work not completed by the scheduled date. In other words, it is overdue maintenance work.

Condition Based Maintenance (CBM)

Maintenance strategy based on measuring condition to assess whether and when there will be failure in the future then taking appropriate action to avoid the consequence of that failure. The approach is mainly used in equipment maintenance.

Emergency Maintenance

Maintenance action taken to respond to sudden unexpected equipment breakdowns, building component or element failures through accidental or deliberate damage (vandalism).

Planned Maintenance

Any maintenance activity for which a pre-determined job procedure is documented for which all labour, materials, tools and equipment required to carry out the task are estimated and their availability assured before commencement. It involves tasks carried out on a regular or scheduled basis.

Predictive Maintenance

Maintenance process based on inspection, monitoring and prediction.

Preventive Maintenance

Maintenance process based on preventing unexpected events from occurring by employing proper maintenance procedures.

Total Quality Management (TQM)

Oxford dictionary defines TQM as a system of management based on the principle that every member of staff must be committed to maintaining high standards. In the corporate world, it can also be defined as a multifaceted, company-wide approach to improving all aspects of quality and customer satisfaction.

Corrective Maintenance

Maintenance activity required to correct a failure that has occurred.

Maintenance Framework

An outline or overview of interlinked items which supports a given approach or strategy to fulfill maintenance objectives.

1.10 Outline of the Study

Chapter One

Chapter one discusses background to the study, statement of the problem including identification of the key objectives of the study. It further highlights the justification and significance of the study. Finally, it sets out the scope and limitations of the study.

Chapter Two

Chapter two is a consolidation of literature review on past research findings on the subject of study to identify research gaps for exploitation. It goes ahead to identify theories and concepts that are applicable to the field of study.

Chapter Three

Chapter three presents the appropriate research methodology for undertaking the study. It sets out the research approach, design, target population, sample/sampling techniques, methods of data collection and the means by which to analyse data.

Chapter Four

Chapter four is the discussion of results/findings section and involves categorization and tabulation of raw data from the field which is subsequently analysed through appropriate research approach methods.

Chapter Five

Chapter five presents annual maintenance cost and budgetary prediction model as a planning tool for ascertaining future maintenance costs and budgets of Public office buildings. It goes further to formulate an effective legal and institutional framework within which the maintenance of Public office buildings should be anchored.

Chapter Six

Chapter six is conclusion/recommendations section. In this section, the results and findings are discussed with a view to arriving at appropriate conclusion and recommendations. Gaps that remain for exploitation in future research are also identified.

1.11 Conclusions

Chapter one identified six research objectives and the corresponding research questions in an effort to address the aim of the study. The next chapter, literature review attempts to look at past studies on the topic of study and try to link them with the aim of this study.

The literature review therefore focuses on the following issues in regard to building maintenance; historical perspective, approaches, manual, policy and budgeting. It also looks at the relationships between building maintenance to design, construction materials/technology, innovation/ research and it finally considers the theoretical and conceptual framework from which this

study is derived.

CHAPTER TWO:

2.0 LITERATURE REVIEW

2.1. Introduction

The aim of this study was to develop a model framework for effective maintenance of public office buildings in Kenya with the purpose of minimizing maintenance costs in the long run. According to Oxford English Dictionary, a framework is a system of rules or ideas which help one decide what to do. A model framework is therefore a broad overview or outline of interlinked items and/or systems upon which a particular approach is anchored.

A desirable building maintenance model framework is one that provides effective and efficient maintenance services that would ensure that buildings are kept in reasonable conditions to facilitate continuity of services. Lateef (2010) views a building maintenance model framework as a comprehensive and structured approach for effective and efficient delivery of maintenance services to satisfy clients, users and public expectations. Therefore effectiveness and efficiency of maintenance management system is dependent on the appropriateness of the maintenance model framework.

The ultimate goal of a maintenance model framework is to provide leverage to achieve maintenance plans and objectives as set by an organization. Chartered Institute of Buildings (1990) argue that the key rationale for carrying out maintenance is to keep, restore and improve a facility or building and its services to set standards and budgets. A maintenance model framework therefore provides plans, standards, guidelines, policies and strategies within which to execute maintenance programmes.

Maintenance standards, guidelines and policies form what is known as a building maintenance policy. Various studies Seeley (1987), Spedding (1987), Lee (1987), Barret 1995) view maintenance policy as an important ingredient of a maintenance model framework that ensures building assets or facilities are maintained properly. This statement confirms the role maintenance policy plays in enhancing the success of maintenance model framework.

Legal and institutional framework lays out appropriate statutes legalizing and institutionalizing maintenance systems and structures within a maintenance framework. Republic of Kenya (2011) confirms that the legal and institutional framework indeed lays a foundation for effective execution of maintenance programmes. Lack of legal and institutional framework is therefore responsible for the deteriorated status of Public buildings in Kenya.

The literature review therefore discusses past studies in the major aspects of building maintenance model framework. The literature review attempts to discuss in particular the historical perspective of building maintenance, the buildings defects, the scope of building maintenance, the approaches to building maintenance, the building maintenance policy/manual and building maintenance budgeting. The review further focuses on the relationships of building maintenance to design, construction materials/technology, innovation and research. Lastly, the chapter discusses the theoretical and conceptual framework from which the study is derived

2.2. Historical Perspective of Building Maintenance

In the early beginning of civilization, the basic function of any building was then provision of basic shelter to protect man from the environment. The first shelters built by mankind date back to before 12,000 BC and were mainly stone structures (Construction Contacts, 2010). This era was followed by the Hellenic, Roman, Gothic and Renaissance Architecture which mainly concentrated on function and structural support. In the successive periods, it became necessary to associate buildings with other specific functional requirements developed through generational and technological advancement giving birth to office buildings, churches, mosques, commercial buildings, industrial buildings and so on. During the industrial revolution in the 18^{th} and 19^{th} centuries there evolved modern architecture with different and more complex building types. The simple nature of these first structures implies that maintenance demand was very minimal in relation to maintenance workscope and cost.

The demand for organized maintenance has therefore been driven by emerging complexity of buildings through technological advances in the building industry. The desires of building users to operate in spaces with reasonable quality and with enhanced functionality became a reality with time (Maver, 1971 and Ozguner, 1986). Langevine, Allouche and Abourizk (2006) reveals that most Public facilities in Canada are over 40 years old and are suffering from continuous deterioration mainly as a result of aging, environmental conditions and deferred maintenance decisions. The scenario which is also replicated in Kenya is therefore posing challenges to asset managers to develop a more organised approach to maintenance of public buildings.

2.3. Scope of Building Maintenance Works

The rationale behind building maintenance and identification of components of building maintenance form a basis for deriving the building maintenance workscope. Martin (1987) and Gibson (1977) acknowledge the need to define accurately maintenance workscope to facilitate drawing of budgets and planning. Knowledge of the building maintenance workscope is therefore key to formulation of building maintenance budgets, an aspect that can be effectively utilized to prioritize items to be targeted for cost minimization to arrive at an effective maintenance model. To understand the scope of maintenance works, this section reviews the rationale behind building maintenance, components of a building maintenance workscope.

2.3.1. Rationale Behind Building Maintenance

The idea of public office buildings is to offer space for delivery of quality services to the public. According to Idris *et al* (2009), the essence of building maintenance is to increase service life of a building by delaying deterioration, decay and failure thereby extending usage. Effective maintenance strategies are therefore needed to keep the spaces in set standards.

In order to meet maintenance targets, maintenance managers should plan for maintenance programmes in line with an organization's maintenance objectives. Service life planning involves consideration of the likely performance of a building over its entire life under the prevailing environmental conditions (Shohet *et al*, 2002 and Chew *et al*,1999). Performance of buildings therefore depends on how well they are maintained. Desai (2008) confirms this fact in his paper titled "Dilapidation of Buildings". (http:/knowledge adda4u. blog spot.com/). The rationale behind maintenance of public office buildings is therefore to keep them in reasonable standards to enhance delivery of services to citizens.

2.3.2. Components of a Building Maintenance workscope

Different classes and categories of public buildings exhibit varying component weightings within a maintenance workscope. Chanter and Swallow (2007) identifies the following as major items for maintenance workscope for an office block by their relative weighting with regard to cost:-

- Utilities - 28.0%
- Overhead - 21.5%
- Administration - 17.0%
- Cleaning - 16.5%
- Fabric - 6.5%
- Services - 6.0%
- Decorations - 4.5%

From the above tabulation, utilities account for the largest proportion of expenditure while fabric, services and decorations combined amounts to only 17% reflecting on the need to strategize on how to minimize cost of utilities. The proportions assigned to various building components or elements may however fluctuate depending on complexity of a building or design solutions providing for renewable sources of utilities presenting a challenge to the adoption of the above weighting scale.

2.3.3. Deriving Building Maintenance workscope

There exist various methods for deriving a building maintenance workscope, the choice of which depends on their relative applicability. Langevine, Allouche and Abourizk (2006) suggests a deterioration model which is based on current and future facility condition. The deterioration model has come at a right time when asset managers are keen on strategic building maintenance vision to be able to predict future maintenance workscope in order to forecast budgets for short and long term planning.

One of the commonly used prediction technique for building component or element deterioration is based on the assumptions that future condition depends only on the present state and is independent of past events. The prediction system is based on stochastic probabilistic modeling approach coined by Abraham *et al* (1999). This is an alternative way of planning for cyclic maintenance which involves replacement of building components or elements whose service life has expired.

Alternatively, maintenance workscope can be derived from an inventory developed through inspections conducted on a hierarchy of components and elements based on a specific performance scale (Uzarki and Burley, 1997). The eminent drawback from this methodology for defining workscope is that it is limited to the condition revealed through an inspection and therefore may not be always be suitable for forecasting maintenance workscope.

2.4 Buildings Defects

This section outlines common defects, their causes and ratings. This is necessary to establish scope of maintenance works and also determine the root causes of defects so that maintenance does not only target repairs of defects but also their root causes.

2.4.1 Common Buildings Defects

The ability to establish various classes and magnitude of present and future maintenance defects has got a significant bearing on how to derive the building maintenance workscope. A number of researchers have identified various common defects associated with buildings. Teo and Harikrishna (2006) links the following defects to plastered and painted external facades:

- Crazing – Starts as a series of fine hairline cracks eventually leading to disintegration of the surface.

- Cracklines – Cracks appearing on the external surface
- Delamination – Differential movement due thermal changes.
- Chalking – Loss of colouration with age.
- Algae growth – Greenery plant growth on the surface
- Peeling – Gradual loss of adhesion to paint with age.
- Un even discolouration – Organic pigmentation on the surface

The speed and degree of manifestation of these defects is however influenced by a number of factors which are both natural and man-made which can be controlled by effective maintenance strategy. This list of common defects is only limited to plastered and painted facades while the modern public office buildings have their exterior facades cladded and do not require painting.

Lounis and Vanier (2000) identifies the following as major defects expected from a roof:

- Envelope failure – Loss of water tightness and thermal control
- Structural failure – Failure that may lead to collapse of roof structure.

Just as for external facades, the rate of deterioration depends on both natural and man-made factors, of which can be managed either through preventive maintenance strategy at post-occupancy or incorporation of appropriate measures at design/construction stage. Desai (2008) highlights various common defects associated with concrete, masonry and plaster as follows:

Concrete

- Structural cracks weakening stability and may lead to collapse.

- Dampness as a result of leaking with the possibility of damaging reinforcements through corrosion.
- Spalling involving internal separation.
- Falling of cover to reinforcements exposing them to the weather.
- Corrosion of exposed reinforcement bars.
- Deflection or sagging of structural elements.
- Sinking of ground floors and columns.

Masonry/Plaster

- Dampness on walls.
- Salty deposits on surface
- Efflorescence
- Fungus/plant growth on walls
- Holes in walls.
- Fallen plaster
- Hairy and structural cracks.
- Loose plaster
- Disintegration of mortar joints
- Sinking of walls

The degree of deterioration of these elements is dependent on natural and man-made factors whose manifestation calls for effective maintenance strategy at post-occupancy stage and quality control during construction. A building condition survey conducted by

Chohan *et al* (2011) highlights the following common defects established through an inspection of private housing stock of metropolitan areas of Kiang valley in Malaysia:-

- Dampness penetration.
- Façade deterioration.
- Fungi/mould growth on surfaces.
- Leakages in wet areas affecting external facades.
- Cracks caused by thermal expansion.
- Water seepage due to improper water proofing.
- Cracks and water penetration through structural elements
- Sagging of floors.

The above defects are majorly attributed to deficient design which should have been avoided at pre-construction phase and would have contributed to reduced maintenance workscope. An effective maintenance strategy should incorporate maintenance issues as part of design.

Ahmad (2004) while conducting a study of heritage buildings in Malaysia for preparation of a dilapidation survey report documented the following defects:

- Fungus stain and plant growth
- Erosion of mortar joints
- Peeling paint
- Defective plastered renderings
- Cracking of walls and leaning walls
- Defective rainwater goods

- Decayed floor boards
- Insect or termite attacks
- Roof defects
- Dampness penetration through walls
- Unstable foundations
- Defective Electrical/Mechanical installations, plant and equipment.

The above defects documented through a study of heritage buildings are majorly attributed to deterioration through aging. Effective regular maintenance increases service life of buildings and their components and therefore controls age related defects.

It is considered important that buildings are regularly maintained to enhance their service life and functionality. The various studies quoted above share, more or less similar listings of defects with the implication that these are common defects that would be expected from one building to another. The listings are however not exhaustive, as there are many more that has not been included. The topic of common defects is so wide that it may require a study of its own. The common nature of these defects gives a justification for the need to focus on preventive strategies towards the same in circumstances where cost minimization is a priority.

2.4.2 Causes and Ratings of Defects

Establishing and managing the root causes of building defects is significant in minimizing building maintenance cost, a strategy that could do well in the developing world where financing of maintenance of public buildings is a major challenge. This fact is confirmed by Ahmad (2004) and Kamal *et al* (2007) who argue that building defects should not just be managed through treatment of symptoms but through accurate diagnosis of their root causes for either elimination or minimization. Al-Khatam (2003) and Lee (1987) reinforces further this argument by stressing that failure to identify root causes of a defect would not ony do nothing to rectify the original defect but may substantially worsen the condition of the building. Chong and Low (2006) however indicates that eliminating building defects altogether can be an uphill task. Timely and accurate diagnosis of defects is therefore a fundamental strategy towards effective management of maintenance of public office buildings.

The importance of diagnosing causes of building defects is exemplified by the numerous studies that have been directed in this area. Hall (2009) cites substandard workmanship, lack of expertise, non-compliance with standards, lack of adequate maintenance, aging, lack of professional supervision and insect infestation as major catalysts for defects manifestation. The National Building Agency (1985), however attributes causes of defects primarily as design deficiency, poor supervision or not following design specifications while Kamal *et al* (2007) refers to five main factors that include designs not being sensitive to climatic and geological conditions, subjecting the buildings to the functions and loads for which they were not designed for, in-adequate maintenance to check further deterioration of building elements and gross neglect arising out of failure to regularly inspect/carry out maintenance. Studies by Al-Khatam (2003) reveal that most building defects arise out of faulty designs, poor workmanship and poor management attributed to designers, maintenance experts and contractors' expertise; experience and non compliance with specifications, a scenario that is also projected by Ramly *et al* (2007) and Chohan *et al* (2010). Olubodem and Mole (1999) also argues in favour of design criteria but however includes ageing as a major contributor to general wear and tear in public buildings. Olubodun (2001) however cites vandalism and improper use of property as major instigators of defects in public buildings, an aspect that has resulted to the dilapidated condition of public office buildings in Kenya. An investigation done by Diyana (2009) concludes that poor workmanship as a result of in-effective supervision during the construction stage is a major contributor to defects manifestation confirming the fact that buildings whose construction do not allow for appropriate quality control measures have major defects at post-occupancy state. Inadequate funding of maintenance programmes leads to defects backlogs and can in essence trigger more severe and costly defects that could even cause total structural failure. (Bowles *et al* (1997), Chanter and Swallow (2007), Adenuga *et al* (2007). That the maintenance funding allocations for public builidngs is never adequate is also experienced in Kenya and has significantly contributed to the dilapidated state of Public buildings (Republic of Kenya, 2011).

The study therefore aims to rate these factors in order of severity to determine those with significant impacts for prioritization for management which in the long run will minimize maintenance costs of public office buildings in Kenya.

2.5. Approaches to Building Maintenance

Various new approaches to building maintenance have emerged due to the shortcomings of conventional maintenance which is known to be reactive rather than proactive.

Ollila and Malmipuro (1999), identifies four main categories of approaches to maintenance as reactive, preventive, predictive and proactive maintenance. Reactive maintenance can also be referred to corrective while proactive maintenance implies planned preventive with the indication that the four approaches can be summarised instead as three. A broader classification of maintenance groups it as either routine or periodic depending on the timing of its execution. Tse (2002) argues that most maintenance practices are failure driven, time based, reliability centred and are therefore both predictive and condition based. Lekan (2007) views total quality management principles as the answer to the challenges facing the state of deterioration of public buildings in Nigeria while Lateef (2010) argues strongly in favour of the value based approach to maintenance of public universities in Malaysia. Whereas Peterson (2007) has some preference to strategic based asset maintenance for mainly business oriented industrial assets, Chanter and Swallow (2007) argues that the facilities management concept is ideal for the maintenance of the United Kingdom building stock. The various approaches have both advantages and disadvantages with the applicability depending on the maintenance objectives and therefore influences the content and scope of a maintenance framework to be developed.

2.5.1. Conventional Maintenance

The conventional maintenance approach is widely used in the maintenance of public buildings in Kenya and most other third world countries. The approach uses procedures that are corrective and condition based (Lateef, 2010). This is reactive rather than proactive and is executed just on the condition of the building as revealed by inspection. This version of maintenance is therefore not planned but only undertaken during breakdowns or when defects have arisen.

The conventional maintenance management approach involves planning, organizing, directing and controlling maintenance resources in a short term (Figure 2.1). Lateef

(2010) however faults the conventional maintenance approach for being ineffective and looks at building maintenance in a different perspective and reflects a new thinking of maximizing resource use in building maintenance. It is noteworthy that maintenance should not just be based on the results of physical inspections and neither should maintenance be managed correctively. This view point seems to give some general direction on strategic maintenance discussed later in this sub topic.

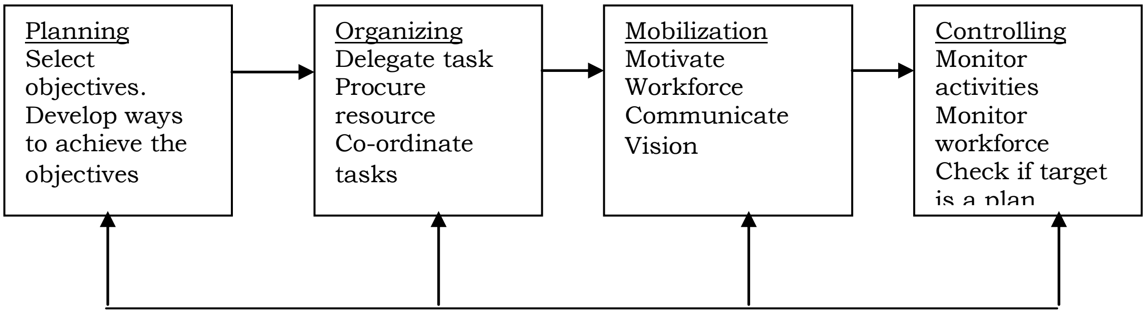


Figure 2. 1: Maintenance Management Definition Model
Source: Idrus *et al* (2009)

Conventional maintenance as practiced by most third world countries is associated with in-effective structures and systems calling for a shift to modern approaches.

Past studies on public buildings in Malaysia confirm that the conventional building maintenance approach is non-cost effective, an observation that may be presumably true to other third world countries (Idrus *et al*, 2009). Continued use of this approach which is corrective is bound to result to more equipment breakdowns and building component failures, thus disrupting delivery of services.

Conventional maintenance is just executed when a defect arises or when equipment breaks down and is therefore short term with no long term maintenance objectives. General observations indicate that buildings deteriorate and decay with age calling for the need to forecast maintenance requirements through life prediction techniques in contrast to conventional maintenance where maintenance action is just taken only when a failure or defect occurs (Chanter and Swallow, 2007) This approach to maintenance is in effective in that it fails to anticipate costly breakdowns or failure that should have been minimized through preventive actions.

2.5.2. Value Based Maintenance

The concept of value based maintenance is new in the building maintenance fraternity and is being propagated by a number of researchers in Malaysia. Idris *et al* (2009) and Lateef (2010) views the significance of maintenance as that of ensuring optimal performance over its life cycle which can be measured from a user's perspective over how efficient and effective the building is. Ahmad (2004) adds that callous incidences of improper diagnoses of building conditions, and the resultant ineffective remedial measures may pose serious safety concerns as well as being too costly. The above view points support the idea of value based maintenance, a deviation from the contemporary building maintenance management system. Figure 2.2 shows the relationship between cost, quality and function in a value based maintenance while Figure 2.3 shows period of intervention vis-à-vis cost intervention framework.

Value	=	Benefits	Or	Quality + Functions
		Investment		Total cost

Figure 2.2: Value Concept
Source: Idrus *et al* (2009)

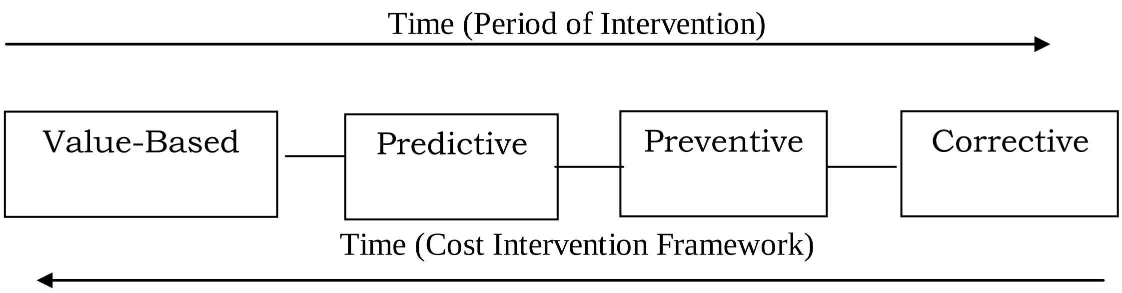


Figure 2.3: Time-Cost Maintenance Intervention Framework

Source: Idrus *et al* (2009)

As indicated in figures 2.2 and 2.3, value as referred to in building maintenance is a function of benefits and investment or quality, function and total cost. The principle of value refers to utilization of resources effectively and efficiently to provide a function or service that meets the user's or customer's satisfaction (Bateman and Smell, 2009). The major challenge with the principle of value is that it may not be easy to strike a balance within its competing ingredients of cost, function and user satisfaction. The above studies on value management approach are not fully conclusive in the field of building maintenance and have left out some research gaps that still need to be explored. One area that remains un-explored is how to craft an effective maintenance framework to achieve more maintenance work with the low budgetary provisions an aspect that this study intends to investigate.

2.5.3. Planned Maintenance

Planned maintenance is an alternative approach to conventional maintenance and encompasses a wide variety of building maintenance activities. According to East Sussex County Council (2001), planned maintenance is a schedule based maintenance necessary to prolong the life of plant/equipment and building fabric and can be preventive, routine and/or cyclic. The wider variety and inclusiveness of this approach has the implication that it is a more effective approach as it incorporates planned, preventive maintenance strategies.

The principle of planned maintenance is derived from compliance to statutory requirements and systematic repair, renewal or replacement of building components including electrical/mechanical equipments which encompasses preventive and cyclic maintenance strategies. Straub (2005), Alberta Infrastructure (2004) and Okwemba (1981) indicate that preventive maintenance is proactive and is aimed at preventing unexpected equipment breakdown or building component failure which in the long run reduces total maintenance costs while cyclic maintenance can also be preventive and usually involves replacement of building components, for instance building elements and fittings as well as electrical/mechanical equipments whose life span have expired. Planned maintenance offers an opportunity for an effective alternative to conventional building maintenance in that it seeks to maintain structural characteristics of buildings to limit interruptions to functionality through repair or replacement programmes of internal and external decorations, fittings, finishes and so on (Seeley, 1987). The emergence of planned maintenance approach is therefore a significant step towards effective maintenance management.

On the other hand corrective maintenance is reactive and unplanned and is normally undertaken when a breakdown or a failure has occurred (Cane, 1998). The corrective maintenance approach has negative impacts in that it can lead to interruption of services, costly repairs as well as injuries or death to the occupants.

Planned maintenance also provides for emergencies which are eminent and cannot therefore be avoided. Republic of Kenya (1970) indicates that some maintenance works cannot be planned or predicted and are therefore addressed as emergencies. This include sudden un-expected breakdown of equipment or damage attributed to natural calamities that are normally budgeted for in the form of contingencies.

2.5.4. Predictive Maintenance

Predictive maintenance is about using the current deterioration condition of a facility to predict future maintenance requirements through use of a deterioration model designed within its service life According to Langivine, Allouche and Abourizk (2006) and Teo and Harikrishna (2006), the life cycle model approach for predicting maintenance requirements determines the timing of all future maintenance programmes including the scope and cost of the same. The ability to use the predictive maintenance approach to forecast maintenance workscope and budgets is significant not only for planning maintenance programmes but also formulating effective maintenance framework. Various classes of predictive maintenance models have been formulated by past researchers.

Clifton (1993) classifies various prediction methods as follows:-

1. Estimation based on experience
2. Deductions from performance of similar materials
3. Accelerated or non-accelerated testing
4. Modeling based on deterioration process
5. Application of stochastic concepts.
6. Estimation based on trending from previous cost/budget data

Each of the above methods has merits and demerits d epending on circumstances at hand calling for the need to assess applicability before employing any one of the methods.

The first approach was adopted by Sayward (1984) when testing the performance of a concrete structure through extrapolation to the future. Although this is a simple method, it does not allow for a thorough assessment and quantification and therefore might lead to in-accurate results.

The second approach was employed by Purvis *et al* (1992) to assess deterioration of a reinforced concrete structure over a period of time. This approach may only be reliable when sufficient past data is available but is not reliable when conditions under which the model was developed differs from that when it is applied.

The third approach is about service life prediction based on accelerated or non-accelerated testing procedures as provided by Masters and Brandt (1987). It has two major setbacks which include:

- Since the methodology is generic and elaborate, it requires detailed information on deterioration processes and extensive testing which could be expensive as well as time consuming.
- Reliability is dependent on whether the testing conditions simulate the actual field conditions where it is applied.

The fourth approach formed the basis of a study conducted by Roy *et al* (1996) to evaluate paint performance. This approach is effective only for monitoring deterioration and takes cognizance of all conditions to which the building element or component is exposed to. For instance, the artificial weathering test, did not give a result that is representative of the actual paint performance since it only monitored weathering due to a chemical process ignoring mechanical or biological weathering.

The fifth approach relied on collection of statistical data for the determination of deterioration at any point in time and was adopted by Shohet *et al* (2002) to develop a service life prediction method for exterior cladding component. The approach was later used by shohet and Paciuk (2004) for further detailed study of the same topic. Similarly, Lounis and Vanier (2002) modeled a multi-objective and stochastic optimization method based on Markov chain principle for use by maintenance managers to determine optimal allocation of funds and prioritization of roof maintenance, repair and replacement that simultaneously satisfy conflicting objectives of:-

- Minimization of maintenance and repair costs.
- Minimization of risk failure
- Maximization of performance or functionality.

The problem with this approach is that each value on the rating scale represents a fixed combination of different defects with differing extent of severity making it impractical to measure accurately.

The sixth approach is a prediction model based on trending from cost/budget data from previous maintenance programmes as advanced by Chiang (1984). This model is economical, simple, friendly and is based on data collected under similar conditions and because of these merits could be applied to predict maintenance costs and budgets for public office buildings.

In conclusion, an appropriate prediction method should involve non-complex methods for measurements and quantification in order for the process to be reasonably economical and non-time consuming. In addition, there should be near similarities of conditions of testing with the actual field conditions for applicability. Finally, the modeling process should be carried out individually for each defect for subsequent incorporation into a common deterioration profile.

2.5.5. Total Quality Management Principles

Total quality management principles is an emerging maintenance approach which is yet to gain substantial prominence in both the developed and developing world. The building maintenance approach is anchored in total quality management principles whose intention is meant to address concerns on ineffective maintenance systems hitherto practiced in Nigeria (Lekan, 2007). The total quality management principles propagated in this approach include:

- An organization wide commitment to quality.
- Creating appropriate climate
- Focus on customer satisfaction
- Effective communication system
- Precision
- Optimal allocation of resources
- Effective performance monitoring system
- Staff training and development.

The seven principles form a critical moment in the improvement of maintenance management systems and were developed from previous works of other researchers. There is however substantial borrowing from principles advanced by Ashworth (1994), Lanford (1990) and Rao (1988). The principles are worthy and are partly responsible for shaping up today's maintenance systems in both private and public sector as they are known to increase productivity by workers, reduce accidents, eliminate incidences of rework and wastage as well as improve quality.

2.5.6. Condition Based Maintenance

The systematic holistic approach offered by condition based maintenance is a major shift from the piecemeal concept of the past and is capable of decreasing long term maintenance costs. Langevine, Allouche and Abourizk (2006) points out that most modern maintenance systems, as condition based maintenance inclusive opposed to the classical approach are embedded with predictive maintenance concepts which involve predictions and diagnosis based in trending. The ability to predict maintenance workscope is desirable where there is need to plan and to project within certainty maintenance budget forecasts to lay strategies for financing of maintenance programmes.

According to Cardic (1999), this maintenance concept was designed for equipment maintenance but the principles could also be applicable in other areas of building maintenance. While New Zealand has received wide acceptance of condition based maintenance, the same is not true of the United States where the idea is not fully embraced and is just slowly picking up. Although this approach is yet to be fully embraced for being alien, it has a significant bearing on the future of the building maintenance profession for being systematic, comprehensive and cost effective.

2.5.7. Strategic Asset Maintenance

Strategic asset maintenance is a modern maintenance management strategy that is slowly gaining prominence in the developed world. According to Peterson (2007), strategic asset maintenance is a business oriented global management process which is hinged on consistency and execution of highest value decisions concerning use and care of assets. This model of maintenance is derived from the following principles:

- Empowered workforce
- Reliability centered maintenance
- Work management processes
- Predictive and preventive maintenance
- Self-managed work teams
- Reliability leadership and planning
- Safety, health and environment
- Continuous improvement
- Reliability modeling and equipment risk
- Root cause failure analysis
- Capacity/business objectives modeling
- Activity based management

Although this approach was coined to manage business oriented industrial assets, the above principles could go a long way in restructuring maintenance framework for public office buildings through optimization of building maintenance costs and putting in place effective maintenance strategies.

2.5.8. Facilities Management

Facilities management is another emerging approach to maintenance that is set to revolutionize maintenance systems. Facilities management (FM) concept is presumed to have originated from North America and has spread rapidly to the European and Far East Countries (Chanter and Swallow, 2007). The application of this approach to maintenance has been widespread. For instance, the growth of FM as a key service industry has been extremely rapid with an estimated United Kingdom (UK) market increase of 35% from 1998 to 2002 (Royal Institute of Chartered Surveyors, 2003). The tremendous acceptability shows how this approach has gained prominence towards the improvement of maintenance management systems in the developed world.

FM as a practice, entails three operational facets that include in-house management, contracting or outsourcing and total facilities management arising out of awareness of the need to manage the condition of the building stock more efficiently (Ashford, 1994). The management of maintenance of the building stock in the developed and developing world had been bedeviled by a myriad of challenges calling for a shift from the contemporary systems.

The short-comings of the conventional building maintenance hitherto practiced in the UK is in the form of push-pull effect and is depicted diagrammatically as shown in Figure 2.4 (Chanter and Swallow 2007). This is as a result of modern innovative thoughts about building maintenance strategies and the increasing desire by space users to work in environments that are well maintained.

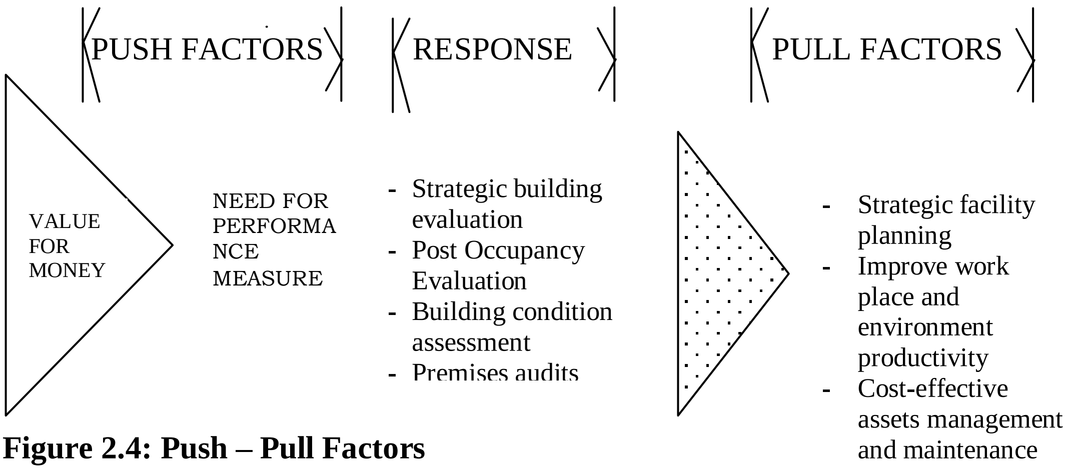


Figure 2.4: Push – Pull Factors
Source: Adapted from Chanter and Swallow (2007)

2.6 Building Maintenance Manual

Building maintenance manual is a tool for effective management of building maintenance programmes and is key to success of any maintenance framework. Okwemba (1981) defines a building maintenance manual as a reference handbook which guides the landlord, tenant and building maintenance team on procedures for executing maintenance works. According to Bastidas (1998), a building maintenance manual is a document that has information necessary for planning, budgeting and execution of maintenance programmes. On the other hand, Republic of Kenya (2011) defines a building maintenance manual as a compilation of maintenance actions and guidelines for use in maintaining building components, services and the buildings environs. A building maintenance manual can therefore be defined as a reference document that guides management of repairs and refurbishment works in a systematic way.

A good building manual should be developed right from the early stages of project planning calling for the need for maintenance experts to be part of the design team. This arrangement will go a long way in reducing design related maintenance defects (Al-hamad *et al*, 1997). A building manual therefore forms a foundation from which a building maintenance policy can be derived.

A building maintenance manual is a structured document whose ingredients are key to formulation of legal and institutional framework for building maintenance. Okwemba (1981) outlines the ingredients of a building maintenance manual as follows:

- Sources of information
- Materials incorporated in a building
- Construction techniques used

- Operating instructions
- Maintenance schedule
- Operation and maintenance precautions
- Anticipated life of the building, its elements together with electrical/mechanical installations.
- Anticipated operational and maintenance costs throughout its lifespan.
- Servicing contracts
- List of as-built drawings

A maintenance manual is therefore an important tool for setting maintenance priorities and allocating resources which include finances, equipment and labour for building maintenance. From the above structure, it is therefore evident that a building manual is specific to a particular building and is dependent on size and complexity of a building.

As argued above, a building maintenance manual is specific to each class or category of buildings. Alberta Infrastructure (2004) prepared an operational and maintenance manual to guide school trustees, administrators and consultants on maintenance programmes for schools infrastructure whose intention is to provide informed, correct decisions about maintenance workscope and budgetary strategy for financing maintenance activities. The manual whose mission is to provide guidance on maintenance, caretaking, insurance, utilities, general operations as well as health, safety and security has some features that may be applied for formulation of building maintenance manual for public office buildings but with minor modifications.

Maintenance of public buildings in Kenya have been executed haphazardly without reference to any building maintenance manual, instead public buildings maintenance programmes had in the past been executed through chapter nine of the outdated BOOM raising serious concerns on the effectiveness and credibility of the existing building maintenance systems. (Republic of Kenya, 1970)

The above scenario has however challenged maintenance policy makers to put in place plans for developing the first building manual through an initiative being spearheaded by the Ministry of Housing. The Ministry of Housing has laid out a programme for formulating a draft building maintenance manual through private consultants for institutionalization in the near future.

2.7. Building Maintenance Policy

No building maintenance management system can achieve its objectives without a policy document to give direction on how and when maintenance operations are supposed to be executed. Lee and Scott (2009) define maintenance policy as a written document that provides for a framework within which to execute maintenance programmes to meet a maintenance standard, strategy and objectives. Horner *et al* (1997) views maintenance policy as the integration of different strategic approaches, for example, corrective, preventive and condition based to be adopted individually or in appropriate combination. Other studies by Chanter and Swallow (2007), Barret (1995), Seely (1987) and Spedding (1987) define maintenance policy as a management framework that incorporates strategies to ensure facilities are maintained properly. On the other hand, maintenance policy can be defined as a document which incorporates planning, budgeting, inspections and management of maintenance programmes (Republic of Kenya, 2011). It is therefore a policy tool from which maintenance framework is anchored to provide the necessary legal and institution framework for maintenance managers to execute maintenance programmes.

To execute maintenance programmes effectively, it is necessary to lay down appropriate strategies for undertaking the assignment. Maintenance strategy is a method of carrying out maintenance operations while maintenance standard refers to acceptable maintenance level which is dependent on the funding allocation and influenced by building type or use, tenant, technical, administrative and political factors (El-Haram and Horner, 2002). The term "acceptable level" is however relative and has different interpretations among organizations as argued by Lee and Scott (2009). From the above argument, it can therefore be stated that a maintenance standard can be determined through a delicate balancing of cost of facility and maintenance resources. In addition, it is a known fact that maintenance policies and allocation of resources differ among different organizations, for example successful corporate entities have adopted higher maintenance standards than public entities that are constrained with limited budgetary allocations.

Despite the existence of various approaches to the interpretation of maintenance standards, no maintenance strategy can be properly planned and organized without setting a maintenance standard. Maintenance standard as a key fundamental element to maintenance process is influenced by building regulation, health, safety and uses (Then, 1996). An effective building maintenance framework should therefore set standards for execution of maintenance programmes. There is greater need than before for various organizations to formulate maintenance policies to guide maintenance of their portfolio of buildings and assets. A review of some building maintenance policies is considered here below.

The University of Glasgow Policy (2010) suggests establishment of strategic maintenance systems for its premises to allow financial planning, accommodate short and long term plans, maintain its premises in good condition, improve efficiency and maximize whole life asset performance. The essence is to have an effective, efficient system of executing maintenance works through an appropriate institutional framework that sets out short and long term objectives.

South Hams District Council (2006) has developed a building maintenance policy document that focuses on efficient and effective maintenance management systems. It further lays out objectives and strategic plans for executing building maintenance programmes. The intent and purpose of this policy is to provide a guide for maintenance management of the council owned building assets so that capital investment is protected, with asset life cycle and service output costs drastically optimized. The key objectives of the policy:-

- To retain the asset in a condition in which it can perform its required function.
- To prevent deterioration and failure or extend life of the asset.
- To restore to correct operation within specified parameters.
- To obtain accurate and objective knowledge of physical and operating condition, including risk and financial impact for the purpose of maintenance.
- To restore physical condition to a specified standard.
- To recover from structural and service failure
- Partial equivalent replacement of components of asset.

East Sussex County Council (2001) building maintenance policy has adopted similar objectives but focuses more on strategic maintenance concept geared towards long term benefits rather than short term gains. The council's maintenance policy sets out key objectives of maintenance programmes in addition to well defined maintenance workscope and appropriate maintenance systems.

Queensland Government (2011), has developed a maintenance management framework policy within which to maintain its entire inventory of its buildings and assets. The main objectives of the policy are:-

- Continuous improvement in asset planning, maintenance procedures and risk management.
- Ensure government buildings are adequately maintained.
- The risks to the government are well managed.
- Monitoring of maintenance condition and performance of buildings.
- Performance management, review of policies/strategies, analyse life cycle cost, assess environment impacts, plan for replacement/ upgrades and improve efficiency/ effectiveness of maintenance.

The intent and purpose of this policy is to put in structures and systems to properly maintain government buildings so that they support efficient delivery of services to the public, an aspect that is key to the topic of this study.

In Kenya, maintenance of public buildings is being executed through chapter nine of the Buildings Organization and Operationals Manual (BOOM) (Republic of Kenya, 1970) which has almost become obsolete with current globalization trends. Efforts are however being put in place to have the BOOM reviewed to be in tandem with technological advances. The Chapter nine of BOOM recognizes the Ministry of Public Works as the government's technical advisor on maintenance of public buildings. This status has since changed with the hiving off of the department of housing and elevating it to full ministerial status. In this new arrangement, the Ministry of Public works has remained with public office buildings while the mandate of maintaining public housing has been taken over by the recently established Ministry of Housing. The BOOM breaks down maintenance programmes into major, minor and essential services depending on size, complexity and costing. The mode of executing the maintenance programmes is either through direct labour or contracts. Maintenance works as defined in the BOOM are either of preventive or emergency nature and have been carried out in the past through a centralized fund controlled by the Ministry of Public Works. In the early 1990's, this scenario changed as the government decentralized funding for maintenance programmes to individual government departments and ministries disorienting the existing building maintenance structure. Most government departments and ministries are now executing maintenance programmes through minimal consultation with the Ministry of Public Works save for major, complex maintenance works.

The un-coordinated maintenance of public buildings has led to costly maintenance programmes with serious backlogging effect calling for institutionalization of appropriate building maintenance policy. The government has constituted a committee to initiate formulation of a Draft Building Maintenance Policy known as National Building Maintenance Policy. One of the key objectives of the Policy is to revitalize the existing maintenance structure by re-equipping and staffing of the in-active building maintenance depots countrywide (Republic of Kenya, 2011) The Draft Building Maintenance Policy proposes a Building Maintenance Fund equivalent to 5% of the value of the national building stock as the annual budgetary allocation for building maintenance programmes.

This proposal is rather too ambitious and it remains to be seen whether parliament will enact a piece of legislation that will over burden the already over-taxed citizens. It is a known fact that taxation level for Kenyans is the highest in East Africa.

Lee and Scott (2009) identify five major components of a building maintenance poicy which include:-

- Length of time for maintenance for present use.
- The life service requirements of the buildings, their fittings and services.
- The standard to which the building and its services are to be maintained
- The reaction time required between a defect occurring and a repair being carried out.
- Legal statutory requirements.

Although the above highlighted building maintenance policies share vision and strategies which mean well for the future of building maintenance, it remains a challenge to see how these policies can be implemented in the third world countries bedeviled by both weak legal/institutional framework and low budgetary allocations for maintenance programmes.

2.8. Building Maintenance Budgeting

Budgeting is a planning tool which is also critical for programming of maintenance activities for public office buildings. According to Business Dictionary Definition, budget is a statement on costs, revenues and resources designed to support an activity or programme over a specified period reflecting a reading of future financial conditions and goals (Cambridge University, 2011). The Business Encyclopedia defines budget as the establishment of a planned level of expenditure usually at a fairly detailed level covering a specific time frame (Entrepreneur Media, 2012).

Building maintenance as an enterprise consists of varied activities that require financing hence budgeting. In the context of building maintenance, budget is both a financial and planning tool facilitating short, medium and long term maintenance operations whether planned or unplanned (chanter and swallow, 2007). There is therefore need to link the building maintenance budgetary process to the desired policy and objectives of an organization thus adopting a system that is in-built. The implication is that budgetary systems are unique for any particular organization and cannot therefore be applied to other organizations unless modified. The medium and long term provisions is an asset that can be exploited to predict and subsequently plan for resources to cater for future maintenance needs.

The concept of budgeting is derived from work programming which embraces either planned or unplanned scope of works. Planned maintenance activities include routine maintenance as well as repair/replacement of building elements or components whose performance can be readily predicted (Chanter and Swallow, 2007 and Okwemba, 1981). For instance, elements whose life span are known and can be replaced through a cyclic maintenance process.

Cyclic maintenance can arise out of normal usage and exposure to the climatic and environmental factors. Some statutes also give direction on frequency of repairs or replacement of certain building components. On the other hand unplanned maintenance involves those of unpredictable nature and susceptible to sudden failure leading to emergencies which can only be budgeted for as a contingency and added to the overall budget (Lateef, 2010). These budgets can only be effective as long as there is no backlogging effect of defects attributed to previous under funding due to one reason or another.

The above view point is also strongly amplified by past studies from which it was concluded that it is rare for maintenance budgets for public buildings to match building maintenance needs (Tse, 2002; Lam, 2000; Lo *et al*, 2000; Shen and Lo, 1999 and Shen, 1997). Pitt (1997) also indicates that budgetary allocations have in most instances not matched the scope of maintenance works causing a dilemma to the top managers. Chanter and Swallow (1996) and Oberg (2002) reflects on the high proportion of cost of maintenance relative to the total operational costs of buildings and suggests the need for appropriate strategies for minimizing building maintenance costs. The above writers have however not indicated the appropriate strategies for reducing building maintenance costs.

The composition of a maintenance budget should be determined in order to formulate strategies to bring down budgets to optimal level. Martin (1987) identities various elements in a building maintenance budget together with their respective weighting. Figure 2.5 below shows the weighting of various components of a maintenance budget. The figure indicates that building services maintenance budget at 38% account for the major proportion of the overall maintenance budget suggesting that services is an important area to be targeted in maintenance costs minimization strategies.

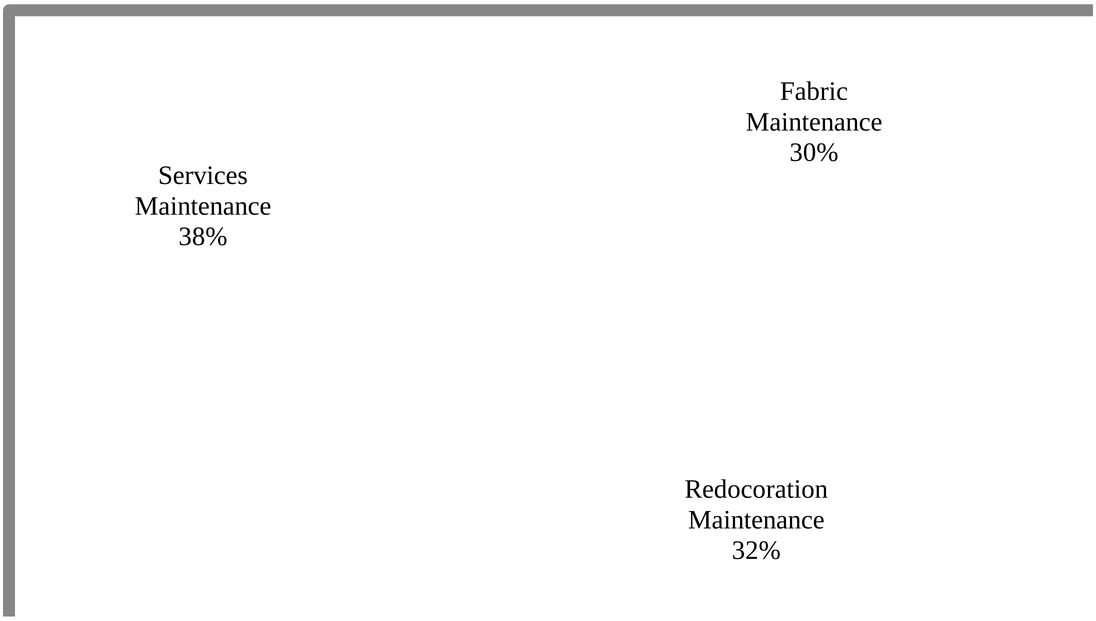


Figure 2.5: Broad weighting of Building Components in Maintenance Budget

Source: Martin (1987)

Gibson (1977) however provides a more comprehensive version of the composition of a building maintenance budget presented as Figure 2. 6. In this version of budget weighting, external decoration at 26% ranks most followed by building services at 21%. The significance of this statement is that maintenance costs minimization strategies should target the two ranked most items.

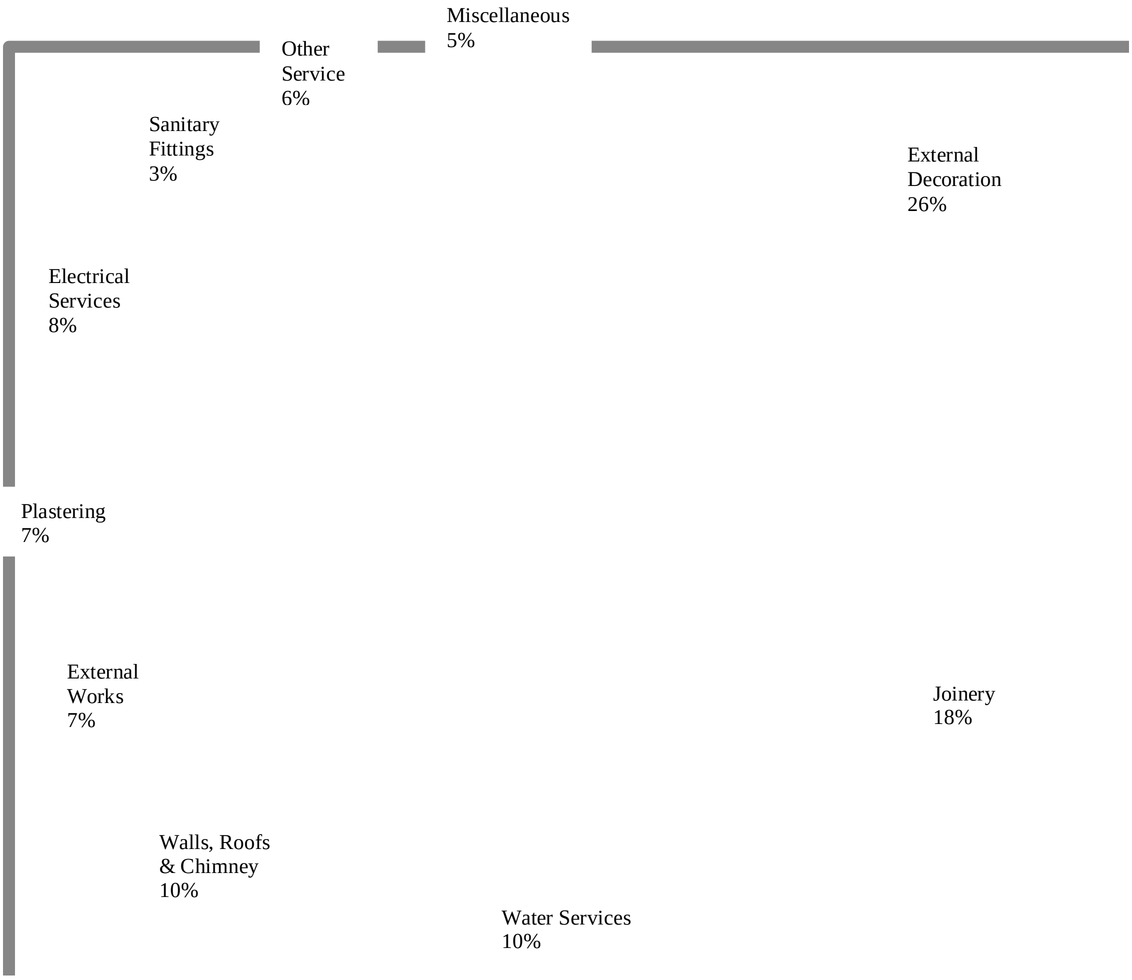


Figure 2. 6: Detailed Weighting of Building Components in Building maintenance budget.

Source: Gibson (1977)

The findings from the two studies above are specific on certain category and complexity of buildings and cannot be generalized as a guide for apportionment of costs to various building components in a maintenance budget. This could explain the variance of the building services weightings assigned by Martin (1987) at 38% and Gibson (1977) at 21%.

Cyclic maintenance is founded on the premise that building elements or components have economic life span beyond which replacements are mandatory. Okwemba (1981) advances the importance of the economic life span guide chart which is a component of a building manual as one of the tools for budgeting for building maintenance works. This tool is however useful for building components whose failure can only be predicted with certainty. The mode of maintenance of such components is thus cyclic and the frequency of which is guided by their economic life span. The researcher in his study has highlighted economic life spans of various building elements or components which could guide on frequency of repairs or replacement needed for drawing up building maintenance budgets.

The economic life spans of these elements or components are part and parcel of any building manual. The economic life is defined as the period during which a building element or component is in service and performs according to set standards (Sarja and Vesikan, 1996). Accordingly, any economic life prediction method adopted should take into account the deterioration pattern. Table 2.1 below provides a list of some common building components or elements together with their life spans.

Table 2. 1: Common Building Components or Elements Together with Life Spans

Item No.	Item Description	Economic Life Span (years)
1.	Normal External Painting	5
2.	Normal Internal Painting	2 ½
3.	Replacement of Lifts	30
4.	Replacement of Water Pipes	50
5.	Replacement of Electrical Installations	25
6.	Replacement of Electrical Mains	40
7.	Replacement of Ventilation Plant	20

Source: Okwemba (1981)

While this guide defines a moment towards prediction of future maintenance budgets, maintenance operators are cautioned that the stated economic life spans could be drastically reduced as a result of exposure to certain degradation variables such as extreme climatic conditions, overloading, high traffic, misuse and many other factors. The guide could therefore only be applicable to controlled environments where the above referred to variables remain constant. In addition, the economic life spans may also vary from one region to another according to the prevailing environmental factors ruling out global application of the guide. The essence of this argument is that data for economic life spans should be specific to a category of buildings and generated for use locally rather than being subjected to global application.

In addition, the life spans of certain building components especially fittings, machinery and equipments vary substantially from one manufacturer to another confirming limited use of the economic life cycle principle. Although Chanter and Swallow (2007) estimates the economic life of buildings at 60 years for purpose of calculating life cycle costs, this age could be higher depending on materials and technology of construction or lower depending on prevailing degradation factors. Fixing of the economic life spans of buildings at 60 years is erratic in that technology advances may come with better performing materials and technology of construction.

Past researchers have developed various approaches to building maintenance budgeting some of which are discussed below. In situations constrained by budgetary deficits, Langevine *et al* (2006) projects a maintenance strategy that adopts one or two or three of the following classes of maintenance:-

- Replacement - to bring back performance and condition to initial level
- Major Rehabilitation – to significantly improve performance and condition
- Minor Rehabilitation – to marginally improve condition

- Marginal Repairs – no noticeable improvement but however serve to preserve service life.

The requisite maintenance alternative is prioritized based on budgetary allocation analysis on the current and future condition of building components or elements. The most commonly used budget analysis technique is known as Integer Programming Formulation, a technique developed by Hudson *et al* (1997). Prioritizing maintenance workscope through this budgetary technique has the tragedy of creating maintenance backlog consequences with the likehood of causing failure in an element or component or the entire building in addition to reduced performance. The system is short lived and therefore cannot be sustained for considerable long periods but can be handy for emergencies in sudden short budgetary crises.

Peterson (1997) highlights the concept of strategic asset management where maintenance budget levels are adjusted with a view to achieving more production from plant and equipment measured on the basis of cost/benefit analysis. The essence of this strategy is to align maintenance resources to continually maximize value and minimize any variation that would lower plant/equipment production. The major setback in this initiative is that it works well in situations where there is no budgetary ceiling but would be difficult to implement where maintenance budgets are fixed.

Wordsworth and Riley (1996) approach to maintenance budgeting involves use of information from bills of quantities from completed buildings together with those collected prior to occupation for transformation into a 60 year maintenance profile. The maintenance profile in this budget includes lifespans of various building components or elements and their estimated costs and frequencies of repairs and replacements. One major challenge with this approach is that the process is un-structured and therefore left at ones discretion that might undermine its accuracy as there is no formula.

According to Teo and Harikrishna (2006), a cost effective budgetary approach to building maintenance requires a reliable prediction at the emergence and manifestation of defects. The above two researchers modeled a quantitative method for efficient maintenance of plastered and painted external facades. The budgetary cost approach that was modeled for the Singapore's public housing sector provides for optimum timing of maintenance repairs, scope of work involved and life cycle costs necessary for budgetary forecasts. The findings of the study confirm that the defects index for various common defects on plastered façade have relationships with the facade area affected. The approach however has limitations on its application due to the following:

- Finishes to external facades are varied and not just limited to plastered painted surfaces
- Weather and environment as variables have significant influence on deterioration patterns and fluctuates from place to place curtailing generalized regional applicability.
- The study was conducted in public housing without reference to whether the findings could be applicable to other classes of buildings.

Commission of Engineering and Technical Systems (1990) modeled a planning tool for maintenance managers to address challenges associated with forecasting of maintenance costs of public buildings in Chicago, United states. The prediction is based on life cycle costs of buildings and their components and is utilized to accurately forecast budgets to secure funding for public buildings. The commission identifies maintenance as the first item to be eliminated or reduced as public agencies struggle to balance their budgets which relates quite well with theme of this study.

In Kenya, the national budget is derived through a three year rolling programme known as the Medium Term Expenditure Framework (MTEF) which links budget to policy (Bird and Kerira, 2009). This is intentional to enable continuity of programmes being financed through annual budgets. Budgets for building maintenance programmes are formulated by various government ministries and departments through the expertise of technical ministries of Public Works and Housing. The estimates for formulating budgets are derived from inspections on condition survey of various public buildings and projected for the next three years in line with the MTEF budgetary requirements. The annual budgetary allocation follows a sectoral approach where a cluster of government ministries and departments are grouped together to compete for resource envelope pegged at specific ceilings (Republic of Kenya, 2007) The implication is that it can be very difficult to receive budgetary allocation according to requisition.

BOOM (Republic of Kenya, 1970) provides a guide for projecting building maintenance costs based on the fact that building maintenance costs increases with the age of the building throughout the economic life of the building. Table 2.2 shows typical percentage maintenance costs against ages of different classes of buildings.

The cost of building maintenance at a particular age is the relevant percentage of the initial cost of the structure.

Table 2. 2: Percentage Maintenance Costs against Ages of Various Classes of Buildings

Item No.	Category of Building	0-10 years	10-20 years	20-30 years	30-40 years	40-50 years	50-60 years
1.	Temporary Buildings	4%	6%	9%	13%	18%	24%
2.	Class I – low class Buildings	1%	2%	3 ½%	5 ½%	8%	11%
3.	Class II – Low class Buildings	½%	1%	1 ¾%	2 ¾%	4%	5 ½%
4.	Class III – High class Buildings	½%	1%	1 ¼%	2 ¼%	3%	4%

Source: Republic of Kenya (1970)

The table shows that building maintenance costs are lowest for newly constructed structures but rises gradually with the age of the building until it is peak at 60 years which is the end of the economic life of buildings where any maintenance activity will be un-economical. One issue that is not clear is whether any major rehabilitation or refurbishment may distort these percentages and by how much ruling out the accuracy of this model. Also, with globalization, new technologies and materials have emerged that could lengthen service life of buildings which is likely to distort these percentages. Applicability of the principle in differing climatic and environmental conditions is not feasible since climate and weather are known variables that change deterioration rate of buildings.

The Draft National Building Maintenance Policy (2011) however proposes creation of a maintenance fund equal to 5% of property value to be the basis of budgetary allocation for funding maintenance programmes for public buildings. The draft seeks to establish the National Building Maintenance Fund to operate in the manner National Hospital Insurance Fund operates. If approved and enacted by parliament this might substantially change the conditions of public buildings whose maintenance has not been effective mainly due to budgetary constraints. It remains to be seen whether the cabinet will approve the draft and pass it to parliament for the necessary legislation when the government spending priority keeps on shifting elsewhere.

2.9 Building Maintenance and Design

Some schools of thought believe that significant maintenance cost minimization can be achieved at design and construction stage by incorporating the necessary design and quality control parameters. Chohan *et al* (2011) indicates that the major proportion of maintenance workscope is attributed to quality of design, an aspect that confirms the relationship between design and maintenance. Seeley (1987) asserts that a design team that neglects consideration of maintenance strategies at project planning stage contributes immensely to increased maintenance cost and that there is therefore a greater need than before to close the gap between design and maintenance. Ramly (2006) and Ahmad (2006) supports this argument by highlighting the role of design in determining the condition of buildings after completion mainly in the scope of defects. Chohan *et al* (2011) and Ahmad (2006) have however focused in housing rather than office buildings for which this study is intended to investigate. The study by Rukwaro (1990) although is directed to office buildings, involves limited scope as it concentrates on building services which forms only a small fraction of the overall building maintenance worksscope. A big chunk of funds devoted by building owners to the rectification of defects on building facades are attributed to improper design, poor material quality, inferior worksmanship or adverse environment (Asafetal, 1995 and Briffet, 1990). Teo and Harikrishna (2005) indicate that the costs incurred to rectify these defects constitute a significant proportion of the overall building maintenance cost. The answer to closing the gap between design and maintenance calls for formulation of a maintenance manual during design stage. Consequently, project design and supervision consultants who specify construction materials and also supervise construction activities determine the level of maintenance at post-occupation stage. It has also been observed that different construction materials and technology perform differently when exposed to differing situations thereby influencing the scope and cost of maintenance activities at post-occupancy stage. Likewise, the level of quality control is a likely determinant of the scope and cost of maintenance. Ishal *et al* (2007) supports the above argument by suggesting that there is a link between design/quality control and the cost of maintenance at post-occupancy stage.

Modern architectural designs, more than before, are anchored on sustainable principles and are geared towards concepts that are responsive to environmental conservation and sustained use of renewable natural resources with a view of minimizing future maintenance and operational costs of the buildings infrastructure. The design of modern public office buildings should therefore be responsive to sustainable principles in order to minimize future maintenance and operational costs to optimize on meager allocations by the exchequer.

2.10 Research, Innovation and Technology in Building Maintenance

This section examines the concept of research and innovation and how they influence technological advancement and their relevance in promoting effective and efficient building maintenance strategies. In furthering the above objective, it looks at modern concepts in the construction industry which include sustainability, green building and information technology.

2.10.1. The Concept of Research and Innovation

In striving to facilitate knowledge in new construction materials and technology, research and innovation is set to promote effective and efficient maintenance management systems. Aziz (2006) defines research as the process of discovering and creating new knowledge and its application to solve societal problems. On the other hand, innovation is defined as the application of new knowledge to industry to generate new products through the adoption of new processes (Firth and Mellor, 1999). The importance of research and innovation in the drive for economic prosperity for world nations cannot therefore be ignored any more.

That the construction sector produces, maintains and rehabilitates 60% of all fixed capital investment assets and being a facilitator of the growth of other sectors of the economy shows its importance to world economies (Fairclough, 2002). This in essence displays the recognition given to building maintenance. Several researchers among them Syagga (2010), Gupta (2007) and Ahmad (2006) have stated the significant role research and innovation plays in enhancing construction and maintenance, some views of which have been discussed below.

A research survey conducted by Dale (2007) on perceptions of the United Kingdom residents revealed that 99.9% of respondents felt that Research and Development was important or very important to the future of the construction industry while 100% of the respondents were of the view that innovation was more important to the future of the construction industry.

According to Syagga (2010), rapid development of science, technology and innovation creates new products and services in addition to new ways of learning, researching and doing business, a view point that is also advanced by Gupta (2007). Research therefore leads to invention which eventually generates innovation necessary for generation of better performing construction materials with longer service life and hence reduction in maintenance cost.

According to Ahmad (2006), sustained research and innovation studies can be directed on existing maintenance structure and systems with a view of improving efficiency and effectiveness. Studies on user reaction surveys at post occupancy stage can be applied to monitor performance of designs and materials through a feedback mechanism in order to institute the necessary improvements on designs for future buildings so as to increase service life while at the same time, minimize maintenance costs with a view to achieving better performance at post occupancy.

2.10.2. Sustainability Principles

Globally, research and innovation has made major strides in reforming the construction industry through the invention of new construction techniques as well as modern construction materials. Walker (2007) advances the principle of sustainability which is an emerging phenomena as a powerful environmental force in the construction industry. The concept of sustainable design as expounded by Smith (2001) can go a long way in reducing operating costs of buildings. This is currently the global trend in construction and includes adoption of energy and water efficient systems. The green building which is the practice of creating structures through utilizing processes that are environmentally responsive and resource efficient is indeed a product of sustainable design (Consultants Network, 2006). The idea of the green building includes use of solar and rain water harvesting systems in addition to designs that emphasize on more utilization of natural lighting and ventilation leading to drastic reduction of cost of utilities.

A study on Australian office buildings stock supports this view point by linking cost effective refurbishments with sustainability (Wilkinson and Reed, 2006). Solomon (2005) defines sustainability principles of buildings as those that through their design, spatial orientation, choice of building components, construction and operational strategy are highly efficient and also have low operating costs, environmentally friendly and do not affect the health of their users and occupants negatively. Lekan (2009) supports this definition and proposes a paradigm shift from non-sustainable structures to sustainable ones by recommending appropriate strategies in his study. The concept of sustainability now transcends environmental sustainability to embrace both social and economic sustainability. According to Dale (2007), some of the sustainable construction systems include:

- Carbon Neutral Construction Materials and Methods.
- Renewable Energy Systems.
- Energy Efficient Heating Systems.
- Solar Powered Systems.
- Waste Management Systems.

The last four systems if incorporated in buildings will go a long way in minimizing maintenance and operational costs. Sustainability principles could therefore be applied in the maintenance of public office buildings in Kenya where maintenance budgets are constrained.

2.10.3. Green Building Concept

Just like sustainability, the green building is a modern concept in construction which is slowly gaining acceptance in both the developed and developing world. The emerging green building concept based on the principles of responsiveness to the environment and resource efficient systems is a modern approach to management of buildings and infrastructural projects (Consultants Network, 2006). Its application is modeled throughout the life cycle of an asset which includes design, construction, operation, maintenance, rehabilitation and demolition or disposal.

The principles of the green building include the following:

- Water Conservation
- Energy Conservation
- Affordability of Design Solutions
- Improved Occupant Health
- Low Operations and Maintenance Costs
- Materials Efficiency
- Siting and Structure Design
- Waste Reduction
- Indoor Environmental Quality Enhancement

For this particular study, the principles of water conservation, energy conservation, low operations/maintenance cost, materials efficiency and waste reduction ranks high in facilitating minimization of building maintenance costs.

2.10.4. Technology in Construction

Technology and development are inseparable in that no substantial development would take place without technological input. Tatum (1998) and Winch (1988) identify characteristics of constructed products as immobility, complexity, durability and costs which justifies the need to address myriad challenges that have bedeviled the construction sector as well as seeking for answers or solutions through re-inventing technology. Technologically superior materials and systems decrease replacement frequencies of building components or elements which eventually minimize building maintenance costs in the long run.

The construction industry needs to institute deliberate networks where stakeholders share ideas on new solutions for application and to strategize for further research in the technological advancement of the construction industry and in particular maintenance. Technological advancement is however known also to originate from contractors, subcontractors, materials and component manufacturers (Pries and Dore, 2005). Contractors and their networks therefore have a significant role in any maintenance cost minimization strategy.

The saying that science facilitates innovation while innovation enhances technology are processes that can be beneficial to both the construction sector and the economy at large. There is however need for a radical approach to innovation to sustain a breakthrough in science and technology with a view to transforming the characteristics of the construction industry (Slaughter, 1998). The development of technology should however not be considered in isolation but should also embrace the emerging global concepts like sustainability and the green building.

A number of studies have been conducted in the field of appropriate construction materials and technology but with less focus in building maintenance. Most world nations have however endeavored to be part of research initiative in this field of study by creating national state structures. In the United Kingdom, a Research and Development Office of National Statistics (R&D) has been established to spearhead research efforts in construction (Dale, 2007). The Australian Government has a National Research, Development and Implementation Centre (CRC) that has broad missions to deliver tools, technologies and management systems to improve the viability of the construction industry (http://www.construction-innovation info) The Government of Philippines has set up a compendium of Indigenous Building Materials and Technologies as a department of the University of Philippines Building Research Service whose mandate includes publishing and continuously updating a resource book on indigenous building materials and technologies to be stored in an electronic data base (Murray, 2008). The terms of reference for this initiative include:

- Accessibility and Maximization of Savings from Transport
- Cost Effective Materials and Technology
- Minimal Pollution to the Environment
- Recycling of Materials.

All the above ingredients of the indigenous building materials and technology initiative not only reduce the cost of construction to the citizens of Philippines but also building maintenance cost at post-occupancy stage.

In Kenya, the Ministry of Housing in partnership with Housing and Building Research Institute of the University of Nairobi (HABRI) established an Appropriate Building Materials and Technologies Programme whose sole aim is to facilitate provision of improved affordable housing in both rural and urban set ups (Republic of Kenya, 2006).

The above research initiative focuses on long term benefits to the construction industry and will not only significantly reduce costs at construction stage but also building maintenance costs at post-occupancy period.

2.10.5 Information Technology

Information technology (IT) has flourished in every sector of world economy and no processes or entities can technologically prosper without it. In this era, discussing technology in any sector would be incomplete without discussing (IT) advancement which dominates the contemporary technological change (Cole, 2000). IT has permeated in every section of the society, maintenance should therefore be no exception.

Some considerable research work has been achieved in this subject while the implementation of the findings has been a bit slow. Magolo (1994) and Tricker (1982) clarify the importance of effective information management systems towards improvement of maintenance operations and processes. The dynamic nature of construction and maintenance processes, interdependence of various participating entities and the need for team work, flexibility and a high degree of coordination expected suggest that IT has a critical role in the construction industry. Until the 1980's, the use of IT in building maintenance was limited to a few organizations calling for a standardized system for general application on a large scale (chartered Institute of Building, 1990).

The many actors and processes in building maintenance operations call such degree of efficiency that can only be achieved through IT. Okwemba (1981) discusses the relevance of IT in the management information systems for building maintenance. He asserts that the vast information and records associated with building maintenance needs to be stored safely in a data base, processed and retrieved with ease and consequently outlines the following benefits of a computerized system:

- Storage and retrieval of building particulars with ease.
- Prompt issuing of maintenance instructions through job cards

- Speedy drawing up of maintenance work programmes
- Speedy preparation of budgets (Labour and Materials) including stock control.
- Efficient management of accounting systems

Chanter and Swallow (2007) argues that the large quantity of data generated by the maintenance operations and its management makes it a complex matter and therefore calls for a really efficient information management system. Accordingly, this level of efficiency demands the adoption of a computerized maintenance system for which the writer says a host of software packages are available in the market.

Chartered Institute of Building (1990) traces the adoption of computer technology in the building maintenance sector citing its use in recording and retrieval of vast amounts of data. The application of computer technology starts from the initial components from which a building is constructed, to its place in the property portfolio, its tenants, its repair history and other aspects of its service life. The writer identifies the following aspects of maintenance where the computer can readily be applied:

- Maintaining a property data base.
- Procedures for dealing with day to day repairs.
- Systems for cyclical and planned maintenance.
- Budgetary control and financial modeling.

All the above writers agree on the relevance of the IT and its application in the management of building maintenance programmes. This is despite the fact that its benefits remain to be exploited in the public sector building maintenance. The application of IT in planning, costing and budget control is an asset where cost cutting programmes are being implemented. Although IT is set to improve the efficiency and effectiveness of maintenance operations and processes, it may be difficult to apply in unplanned maintenance as well as in emergency situations. The benefits of IT use in maintenance management however override its drawbacks.

2.11 Theorizing and Conceptualizing a Cost Effective Approach to Building Maintenance

The past findings discussed in literature review inform the appropriate theory and concept from which the subject of study is anchored. Theoretical and conceptual framework as derived from literature review is discussed here under and focuses on a cost effective approach to building maintenance.

Serious defects backlogs and costly maintenance systems are common features of most developing countries. The conventional maintenance approach adopted by most third world countries, Kenya inclusive is corrective and reactive rather than proactive and has been confirmed by previous research findings as in-effective (Idrus, *et al*, 2009). This fact therefore creates the need to shift away from the current maintenance framework and adopt modern effective approaches.

Modern maintenance approaches have emerged but the applicability depends on organizations maintenance objectives. Strategic maintenance planning is a more preferred concept in the developed world in that it determines future maintenance needs and strategies by reviewing the condition of the existing buildings and prospects for future growth and depletion (East Sussex County Council, 2001). The plan develops needs to be supported by a sound financial strategy, ensuring that buildings are adequately maintained in the long term. In addition, this concept forms a basis on which annual maintenance budgets and programmes are drawn and as well as addressing user reaction surveys as a means of improving customer satisfaction.

The subject of the study revolves around strategic maintenance planning towards effective maintenance framework which borrows a lot from the systems theory. A system is a set of related and interacting subsystems that perform functions directed at reaching a common goal (Laszlo and Krippner, 1998). In this study, strategic maintenance planning is a system while varying implementation processes, procedures, personnel and government agencies are subsystems that interact with one another to achieve the objective of minimizing costs. Figure 2.7 shows the relationship of various processes and personnel in a maintenance cycle.

This is indeed the theoretical framework from which this study is derived. The above theory is anchored on Systems Architecture of building maintenance decision support advanced by Langevine, Allouche and Abourizk (2006). The Systems Architecture has been modeled to provide a framework for prioritizing maintenance, rehabilitation and replacement projects based on financial

analysis and optimization tools that leads to maximization of benefits within limited budgetary provision.

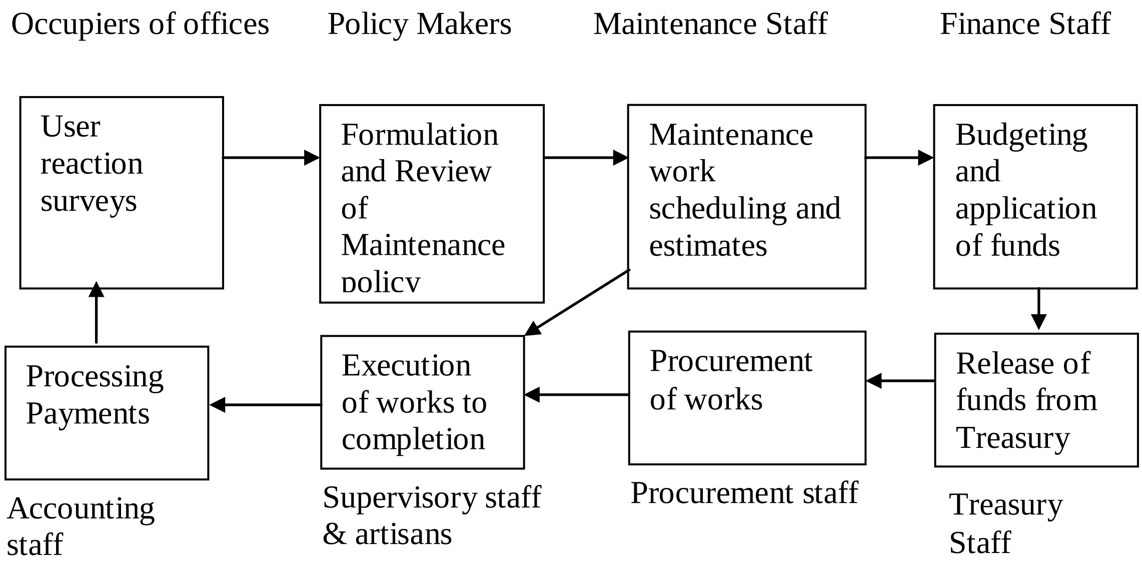


Figure 2. 7: Maintenance cycle.

Source: Adapted from Chanter and Swallow (2007)

The study focuses on strategies to increase efficiency through minimization of maintenance costs. The research design concept is derived from the relationships of different variables. There is only one dependent variable and ten independent variables listed as herein under:-

- Renewable sources of utility
- Regular periodic maintenance
- Attitude of users
- Maintenance policy and manual
- Timely adequate budgetary allocation
- Materials & technology of construction
- Design and supervision during construction
- Research & innovation
- Supervision of maintenance works
- Management systems

The dependent variable is per unit cost of maintenance programmes needed to be minimized in order to optimize on limited budgetary allocations by Treasury to public buildings. The study endeavors to establish the relationship between independent and dependent variables.

Figure 2.8 depicts the relationship between variables.

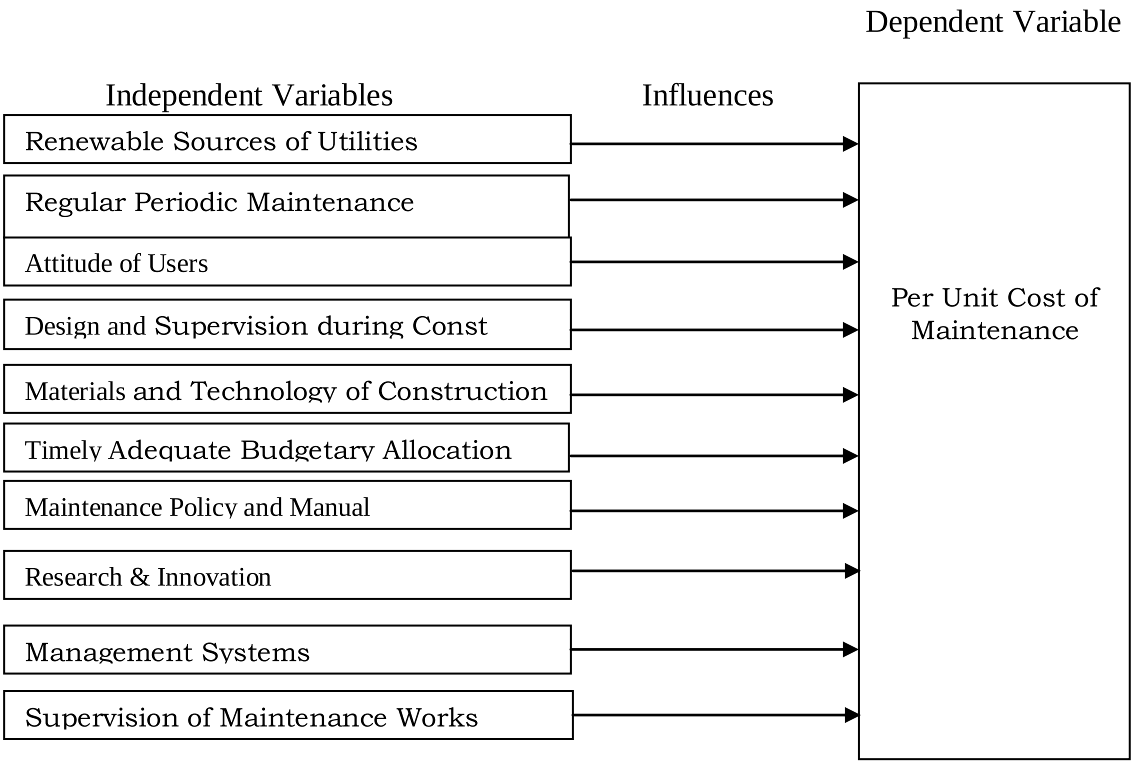


Figure 2. 8: Relationship between variables.

2.12 Conclusions

Chapter two has examined the existing knowledge in the subject of study. The existing knowledge indicate that there is still a research gap to be investigated. The next chapter, methodology outlines research design, strategy and the methods for achieving the study objectives.

CHAPTER THREE:

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This chapter details procedures of going about the study. It focuses on research strategies, design, target population, sample/sampling procedure, methods and analysis techniques and data collection tools. These procedures are necessary to guide the research process and also assist other researchers in understanding the study and particularly where there is a need to replicate research work.

3.2 Research Strategy and Design

The research strategy and design is an account of how the research problem under investigation will be executed. In this particular study, a mix of qualitative and quantitative research strategies were adopted. Qualitative research strategy was adopted to analyze descriptive data while quantitative strategy was applied to analyze numerical data. The choice of research strategy was informed by the nature of the data collected to support investigations on the study objectives. The aim and objectives of the study dictated that both descriptive and numerical data be used.

The study was a social research which focused in obtaining perceptions or opinions of the caretakers, maintenance experts and budget officers who are key in the implementation of maintenance programmes for public office buildings. According to Mugenda and Mugenda(2003) and Bryman (2008), the nature of this investigation is best undertaken through a cross sectional survey design. A survey research design was therefore applied on sampled public office buildings all based in Nairobi.

3.3 Target Population

The target population involves groups of persons, objects or events with similar observable characteristic that can form a significant basis for research data collection. Target population is the aggregate of all that conforms to a given specification (Mugenda and Mugenda, 2003). For the purpose of this research, the target population were public office buildings of four floors and above which are based in the Nairobi City. According to maintenance records for public office buildings, over 90% of the category of these buildings are concentrated in the Central Business District, Upper Hill and Industrial Areas of Nairobi City. The target population was obtained from an inventory of public buildings maintained by the government. The population of caretakers, maintenance experts and budget officers was derived from human resource records. The target population was approximately fifty two public office buildings spread in the three locations of Nairobi City, a list of which is attached as appendix 2. Research field data was collected on building maintenance activities from various public office buildings sampled from the target population. All the buildings sampled are in Nairobi, within same geographical location eliminating the influence of climate in the subject of study. This is informed by the fact that these localities have more than 90% of major Public office buildings in Nairobi City. To maintain uniformity on scope of electrical/Mechanical services, premises that were sampled were limited to at least four floors and above. This was intentional to ensure that the composition of the accessible population have same characteristics and hence homogeneous.

3.4 Sample and Sampling Procedure

Due to time and resource constraints, the study was restricted to some portion of the target population. This was an academic research programmed to be undertaken within set time frame and budget. The sample selection was guided by Mugenda and Mugenda (2003) formula which is indicated below.

$$n_f = \frac{n}{(1+n)/N}$$

Where: n_f = the desired sample size for population less than 10,000

n = the desired sample size for the population more than 10,000

N = the estimate of the population

The sample size for the public office buildings was thirty nine out of a target population of fifty two buildings located in the Central Business District (CBD), Upper Hill and Industrial Areas of Nairobi City, a list of which is attached as appendix 3. The sampe frame was derived from an inventory of public buildings maintained by the government. A stratified random sampling technique in the three designated locations of the Nairobi City was undertaken for sample selection to maintain homogeneity across the sample locations and therefore facilitate the generalization of the study findings.

The sample sizes for the various categories of Public officers who deal with maintenance were as follows:

- Caretakers: Thirty nine out of a target population of fifty two.
- Maintenance Experts: Ninety out of a target a population of one hundred and twenty.
- Budget officers: Forty five out of a target population of sixty.

The sample frame was drawn from the Human Resource Records maintained by the government. A simple random technique through use of random tables was used as basis for sample selection. A random technique ensured that the sample selection was by chance hence enhancing the representativeness of sample to the target population. The sample population in each case was 75% of the target population. A bigger sample population is more representative of the target population and hence improves validity by minimizing sampling error.

3.5 Research Methods

Research methods involve techniques that were applied to collect data. In this section types and sources of data are also detailed.

3.5.1 Data Collection Tools

In this study, data was collected through qualitative /quantitative methods. Data collection tools included:-

- Structured Questionnaire

A questionnaire with both closed and open ended questions was forwarded to appropriate persons from the sample population for response. Some questions were in Yes and No format while others are in appropriate Likert scale. Sample questionnaires were attached as appendices 4A, 4B and 4C. The questionnaires were directed to the respondents as follows:

Appendix 4A – Caretakers of sampled public office buildings

Appendix 4B – Sampled Maintenance Experts in the public sector

Appendix 4C- Budget Officers from sampled public office buildings

- Semi-structured Interview

Enquiries were made from maintenance policy makers particularly from the technical ministries or departments through direct or personal contact. The interviews were open ended and directed mainly to the experts at the level of Job group ‘Q’ and above who are policy makers in the maintenance of public buildings. The interview focus and schedule is attached as appendix 5.

- Inspection Check List

A checklist was prepared and used as a guide for investigating the phenomenon under study. A sample inspection checklist is attached as appendix 6. A digital camera was used during inspections to capture various defects and structural failure from sampled public buildings.

3.5.2. Sources of Data

Data is classified as primary or secondary. In this study primary data were sourced from the field through use of semi-structured interviews, structured questionnaires and inspection check list. Primary data was sourced from the field through questionnaires directed to caretakers, budget officers and maintenance experts. Further primary data emanated from semi-structured interviews with policy makers in addition to observations made by the researcher during inspections. Secondary data was collected through review of past works, journal articles, text books, government printer publications and records from Ministries of Housing and Public Works.

3.5.3 Study Variables

One of the main objectives for the study focuses on strategies for minimizing maintenance costs. To address the above objective, it was necessary to establish variables that influence building maintenance cost minimization. One dependent and ten independent variables were identified through literature review. The ten independent variables were rated through a mean item score to rank their influence on the dependent variable. Data on independent variables were obtained from building maintenance experts while those for the dependent variable were obtained from sampled public office buildings. The details of the study variables are shown in Table 3.1.

Table 3. 1: Study Variables.

Item No.	Name of Variable	Type of Variable	Source of Data	Unit of Measurement
1.	Renewable utilities	Independent	Maintenance experts	1 in 10 Likert scale
2.	Regular periodic *Maintenance*	Independent	Maintenance experts	1 in 10 Likert scale
3.	Altitude of users	Independent	Maintenance experts	1 in 10 Likert scale
4.	*Maintenance* policy & Manual	Independent	Maintenance experts	1 in 10 Likert scale
5.	Timely adequate budgetary allocation	Independent	Maintenance experts	1 in 10 Likert scale
6.	Materials & Tech of Construction	Independent	Maintenance experts	1 in 10 Likert scale
7.	Design & Supervision during construction	Independent	Maintenance experts	1 in 10 Likert scale
8.	Research & innovation	Independent	Maintenance experts	1 in 10 Likert scale
9.	Supervision of Maintenance works	Independent	Maintenance experts	1 in 10 Likert scale
10.	Management systems	Independent	Maintenance experts	1 in 10 Likert scale
11.	Cost of maintenance	Dependent	Sampled buildings	Kshs./m^2

Source: Author

3.5.4 Building Maintenance Cost/Budget Predication Formula

Among the key objectives of the study was to investigate the relationship between maintenance cost and budg*et* allocation and also be able to predict future building maintenance costs and budgets so as to be able to accurately plan for short and long term maintenance programmes. Various maintenance cost and budget prediction models were identified through literature review and analysed. The trending model by Chiang (1984) was adopted to predict maintenance costs and budgets for the next seven years. The prediction formula is indicated here below

$Y_t = Y_{to} (l + r)^{t - t0}$ where

a) Y_t is the indicator for Annual Predicted Maintenance Cost or Annual Predicted Budgetary

Allocation at the current year (t)

b) Y_{t0} is the indicator for Annual Predicted Maintenance Cost or Annual Predicted Budgetary

Allocation at the reference year (t_o) i.e. financial year 2009/2010

c) r is the Annual Increase Rate

The maintenance cost /budget is measured in Kshs/m^2 while time is measured in years.

3.5.5 Legal and Institutional Maintenance Framework

One of the objectives for the study was to develop an effective Legal and Institutional Framework within which to execute maintenance programmes for Public office buildings. In an effort to achieve this objective, the views of maintenance policy makers were sought in addition to references to relevant study findings and various maintenance policies identified through the review of literature. The following documents were consulted to guide the formulation of the legal and institutional framework:

- Current Constitution of Kenya
- Draft National Building Maintenance Policy for Kenya (2011)
- Maintenance Management Framework for Queensland Government (2010).
- Building Maintenance Policy for South Hams District Council (2006).
- Building Maintenance Policy for East Sussex County Council (2001).

3.6 Data Analysis

Raw data obtained from the field through interviews, questionnaires and inspection checklist were converted into a format that facilitates analysis. The raw data were categorized and tabulated prior to analysis. Data analysis involved interpretation of field data with a view to answering the research questions. Data analysis was both qualitative and quantitative. Responses from closed-ended questions were assigned numerical values and analyzed quantitatively while those from open ended questions were categorized and analyzed qualitatively. The analysis of the closed ended questions involved using mean item score, frequency count and ranking generated through use of version 17 of statistical programme for social sciences (SPSS). The open ended questions were analysed through the grounded theory whereby data collection and analysis were designed to proceed side by side.

The results of the analysis were translated into tables, pie-charts, trend curves and histograms through use of version 17 of statistical programme for social science (SPSS) for windows.

3.7 Data Validity, Reliability and Replicability

According to Mugenda and Mugenda (2003), reliability is a measure of the degree to which research instruments yields consistent results after repeated trials. Reliability of data was enhanced in carefully setting target population with appropriate qualifications and experience to enhance accuracy of responses from questionnaires and interviews. Further, interviews were conducted by one interviewer eliminating any inconsistency and therefore minimization of random error. The top level management may be conservative while responding to certain questions in the questionnaire prompting questioning of the validity of data. To check on reliability of these types of data, the researcher relied on interviewing experts and use of inspection checklist.

Kothari (2010) propagates that validity is the accuracy to which the research results represent the phenomenon under study or whether the results from the sample can be generalized to the target population. The validity of the data was enhanced by adopting a larger sample population i.e. 75% of the target population is representative enough meaning the results can be generalized to the target population. In addition, limiting the sample population in one geographical zone (Nairobi) as well as zeroing on public office buildings of at least four floors and above increases homogeneity hence more representativeness. To have data that is valid and reliable implies that the research thesis can be replicated by others as and when required.

3.8 Research Budget

A research budget was drawn immediately after approval of the Research Thesis Proposal in order to plan for financing of field data collection and report writing. The budget proposals included costs of stationery, documents reproduction/binding, transport/lunches and equipments. The research budget is attached as appendix 7.

3.9 Research Programme

The research programme details a schedule of the main research activities. The main research activities were programmed to commence from beginning of May, 2011 and be accomplished towards the end of November, 2011. The research programme is attached as appendix 8.

3.10 Research Programme Implementation Constraints

Field data collection took a total of six weeks, two weeks more than anticipated and was conducted between 15th August - 30th, September, 2011. The delay was occasioned by the initial reluctance of finance officers to release records of budget as required by appendix 4C questionnaire having been uncertain about the motives of the investigation which was however clarified later.

In addition, the budget officers took considerable time to dig into records of previous years which posed a challenge to retrieve because of poor record keeping. Budget records beyond the last three financial years were unavailable for the same reasons. There was also a delay in commencement of the field study attributed to late receipt of research permit. The research permit was received in the first week of August, 2011 whereas the field data collection was programmed to start in the first week of July, 2011 causing an overall delay of one month. Pre-testing of the questionnaires was conducted in the second week of August, 2011, analysis of which dictated that the questionnaires be modified. The respondents for the pre-test programme were not able to adequately answer all the questions listed calling for splitting of the questionnaires so that the same is directed to three different respondents, for instance, the caretakers, maintenance experts and budget officers.

To catch up with time lost, semi-structured interviews went concurrently with administering of questionnaires.

3.11 Conclusions

Chapter three has discussed the ways and means by which the study was undertaken and concludes by highlighting major constraints encountered during the exercise. The next Chapter, Building Maintenance Planning and Implementation displays, analyses, interprets and discusses data obtained from the field study with a view of addressing the aim and objectives for the study.

CHAPTER FOUR:

4.0 BUILDING MAINTENANCE PLANNING AND IMPLEMENTATION

4.1 Introduction

Chapter four begins by analyzing the preliminary items of the response and bio-data to establish adequacy, relevance and accuracy of the research findings with regard to building maintenance planning and implementation. The results and discussion section in this chapter displays analysis, interprets and discusses data obtained through questionnaires, interviews and observations with a view to drawing conclusions and making recommendations based on investigations on aspects of building maintenance planning and implementation by addressing the objectives of the study. The specific areas of interest covered in this investigation include maintenance defects, their causes and rating, major components of a maintenance workscope, maintenance framework, building maintenance cost minimization factors, budgeting for maintenance programmes and maintenance work accomplishment/ challenges. This chapter ends with a summary of the discussions.

4.2 Response

Questionnaires were sent out to caretakers, maintenance experts and budget officers and corresponding responses received as indicated in Table 4.1 below.

Table 4. 1: Tabulation of Response Rate.

	Caretakers (4A)	Experts (4B)	Budget (4C)
Sample Size	39	90	45
Total No. of questionnaires returned	34	74	39
Percentage response	87	82	87

The results indicate a response rate of between 82-87% which is quite positive for the study. Caretakers' questionnaires, appendix 4A had a response of thirty four out of thirty nine representing 87% response rate while maintenance experts' questionnaire, appendix 4B had a response of seventy four out of ninety representing a response rate of 82%. Finally, budget officers' questionnaire, appendix 4C had a response rate of 87%. Higher response rate increases representativeness of data therefore minimizing errors.

4.3 Profile of Respondents

Profile of the respondents outlines personal particulars about the respondent which for the purpose of this study was limited to designation and professional experience. Appropriate designation and professional experience of the respondent is crucial to enable them give an informed opinion on the subject of study. The information is depicted as Tables 4.2, 4.3 and 4.4. Table 4.2 shows designation and work experience for caretakers of sampled public office buildings.

Table 4. 2: Profile of Caretakers.

Designation					
Designation		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Inspector-buildings	6	17.6	17.6	17.6
	Charge hand	9	26.5	26.5	44.1
	Building surveyor	2	5.9	5.9	50.0
	Architect	1	2.9	2.9	52.9
	Engineer	2	5.9	5.9	58.8
	Others	14	41.2	41.2	100.0
	Total	34	100.0	100.0	
Work Experience					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	below 3 yrs	4	11.8	12.5	12.5
	4-7 yrs	9	26.5	28.1	40.6
	8-11 yrs	6	17.6	18.8	59.4
	12-15 yrs	7	20.6	21.9	81.3
	above 16 yrs	6	17.6	18.8	100.0
	Total	32	94.1	100.0	
Missing	System	2	5.9		
Total		34	100.0		

Twenty out of thirty four caretakers representing 58.8% from the sampled public office buildings were technically qualified and posses varied designations which include; charge hand, inspector, architect and engineer. The minimum qualification for a caretaker is a diploma in a building construction related course. While the state parastatals and corporations are financially able to employ more qualified caretakers, the same is not true of the less financially endowed conventional Government Ministries explaining the wide variance in grades of the caretakers who responded. 41% are however not qualified and are mostly clerical officers raising concerns on expertise. Only four out of thirty four caretakers were below three years in experience representing 12.5% showing that most caretakers had reasonable on job experience. Table 4.3 shows designations and work experience for sampled maintenance experts.

Table 4. 3: Profile of Maintenance Experts

Designation					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Architect	26	35.1	35.1	35.1
	Engineer	21	28.4	28.4	63.5
	Building Surveyor	1	1.4	1.4	64.9
	Quantity Surveyor	17	23.0	23.0	87.8
	Others	9	12.2	12.2	100.0
	Total	74	100.0	100.0	
Work Experience					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below 3 years	7	9.5	9.5	9.5
	4-7 years	8	10.8	10.8	20.3
	8-11 years	6	8.1	8.1	28.4
	12-15 years	10	13.5	13.5	41.9
	above 16 years	43	58.1	58.1	100.0
	Total	74	100.0	100.0	

Sixty five out of seventy four experts who responded representing 87.8% were Architects, Engineers, Quantity surveyors and Building Surveyors who are knowledgeable in the field of building maintenance enhancing the accuracy of the results obtained. The rest categorized as others form only 12.2% and include technicians who work closely with the above professionals and have expansive experience. Respondents with experience of below three years were seven out of seventy four representing 9.5% showing that the majority of the respondents are experienced enough and therefore understand well building maintenance systems and structures in public office buildings. Table 4.4 shows designations and work experience for sampled budget officers.

Table 4. 4: Profile of Budget Officers.

Designation					
Designation		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Chief Finance Officer	6	15.4	15.4	15.4
	Snr Finance Officer	4	10.3	10.3	25.6
	Finance Officer I	6	15.4	15.4	41.0
	Finance Officer II	9	23.1	23.1	64.1
	Others	14	35.9	35.9	100.0
	Total	39	100.0	100.0	
Work Experience					
Professional Experience		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	below 3 years	18	46.2	46.2	46.2
	4-7 years	10	25.6	25.6	71.8
	12-15 years	4	10.3	10.3	82.1
	above 16 years	7	17.9	17.9	100.0
	Total	39	100.0	100.0	

Twenty five out of thirty nine budget officers sampled representing 64.1% comprised finance officers from the level of Finance officer II to Chief Finance officer and are professionally qualified and knowledgeable in budgeting. The Chief Finance Officers head finance departments responsible for drawing up budgets for various Government Ministries and supported by Finance Officers of various grades in the lower cadre. Fourteen out of thirty nine representing 35.9% respondents categorized as others are majorly accountants who although do not directly deal with budgeting and are also knowledgeable in financial matters. Results further indicate that eighteen out of thirty-nine budget officers sampled representing 46.2% are below three years experience which is quite significant. This however has no impact on the accuracy of the response since the budget data is available from records.

The results indicate that the majority of budget officers and maintenance experts who responded are professionally qualified at 64.1% and 87.8% respectively enhancing the level of accuracy of responses. Almost half of the caretakers who responded are not professionally qualified, the percentage for other qualifications is 41.2% which is quite significant. A bigger proportion of qualifications listed as others in the questionnaire are designated as clerical officers raising questions on the capacity of these officers to manage building maintenance related issues. Caretakers however deal with minor maintenance activities. Maintenance experts from technical ministries handle major complex maintenance works reported to them by caretakers.

The findings indicate that the majority of caretakers and maintenance experts have experience above three years at 87.5% and 90.5% respectively. The wide experience provides the caretakers with vast knowledge in building maintenance which could be valuable in streamlining maintenance systems in public office buildings. The results further indicate that almost half of the budget officers fall within the experience bracket below three years but this does not have significant influence on the results since the majority of the expected responses are extracts from records which need minimal professional expertise. In addition, an analysis of qualifications listed as others in the budget questionnaire reveal that the majority of these groups are accountants who are also equally knowledgeable in financial matters and in charge of processing of payments for which budgeted provisions have been made. Qualifications and experience of the respondents in the topic of investigation contributes to the accuracy of the responses and therefore critical for the reliability of the study findings.

4.4 Buildings Defects

One of the objectives of the study was to investigate buildings defects, their causes and ratings with a view to recommend an effective maintenance framework for managing maintenance programmes within optimal budgetary allocation. Appropriate questionnaires were therefore administered to sampled maintenance experts and caretakers to obtain their perceptions on causes of common maintenance defects and the composition of maintenance workscope.

4.4.1 Causes of Common Buildings Defects

Sampled maintenance experts from the public service were asked to state and rank causes of common defects in public office buildings. A list of possible causes of common defects was included in the questionnaire which acted as a basis for ranking. The list included normal wear and tear, vandalism, design deficiency, negligence, natural phenomena, infestation by termites, management problems and poor supervision.

4.4.2 Rating of Causes of Common Defects

The ranking was done in order to establish causes of defects with the highest impact to be targeted for management in maintenance cost minimization. The ranking was done through computation of the mean item scores. The response is recorded as Figure 4.1.

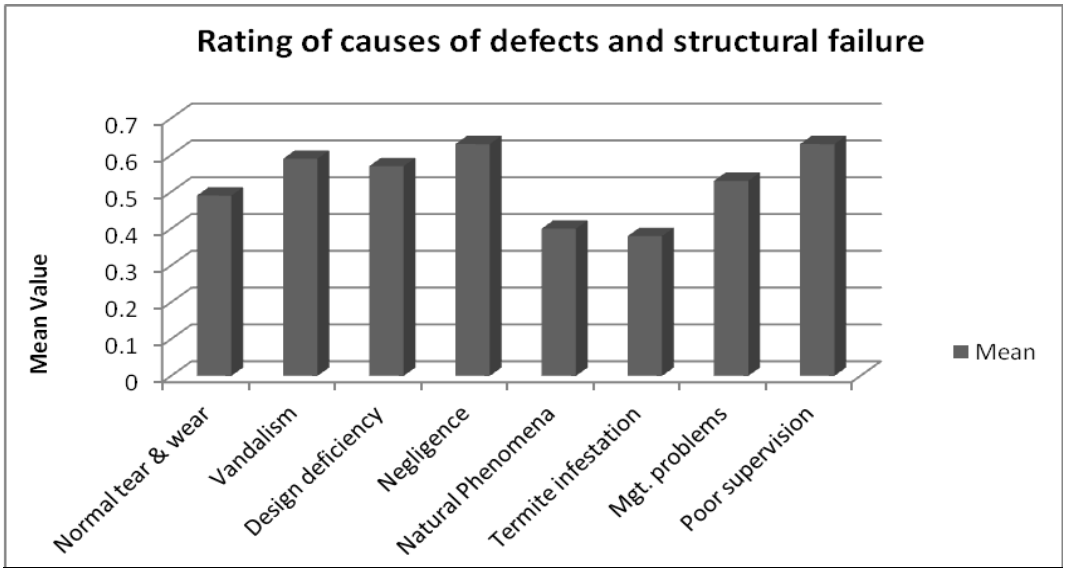


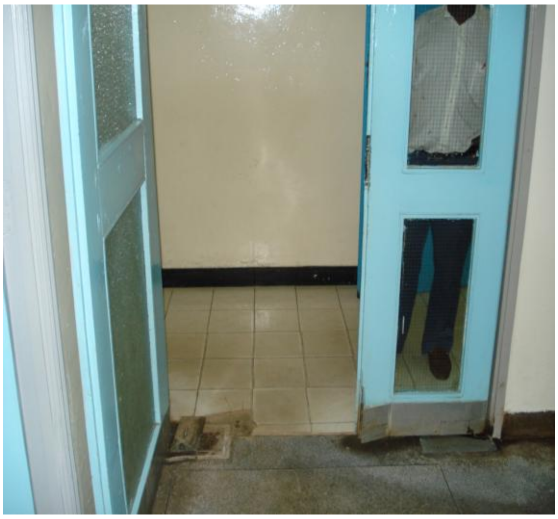
Figure 4. 1: Graphical Representation of Rating of Causes of Common Buildings Defects.

One out of seventy four respondents did not answer the question but however did not indicate any reason for declining. The seventy three experts who responded ranked various causes of common building maintenance defects in a Likert scale of 1 in 8 at different ratings. The ratings were computed in the form of mean item scores placing poor supervision and negligence on top as the most significant contributors to common buildings defects at 0.63 with natural phenomena lying last at 0.40. Appropriate management of these factors in order of prioritization is inevitable where there is greater need to minimize maintenance cost either for low budgetary provision or some other constraints. Some of the causes of defects, for instance, negligence which ranked first with poor supervision does not require any meaningful resources to manage other than change of attitude of users. Rating for other causes include vandalism at 0.59, design deficiency at 0.57, management problems at 0.53, in addition to normal wear and tear at 0.49. The rating of the causes of defects was necessary to prioritize the causes with most impact for management so as to minimize maintenance costs in the long run.

Identification of causes of common building maintenance defects with their ratings is necessary for prioritization of those with the greatest impact for management in cost minimization strategies. Observations made during inspections of sampled public office buildings shows various defects and their causes confirming the results from questionnaires.

During the inspections of the sampled premises, it was observed in sampled Public office buildings that negligence as a contributor to defects is rampant. As discussed above, this major cause of building defects can however be managed through little effort by changing the attitude of users and maintenance staff as they require negligible funding. The defects arising out of negligence observed during inspections include loose electrical/plumbing fittings, loose hinges to joinery fittings, loosely hanging glass panes/lourves, blocked storm/foul water drains, running taps and failure to switch off lighting fittings and electrical appliances when not in use. Some of these incidences were captured as photographs 4.1 - 4.6. More display of defects attributed to negligence is found in appendix 9.

Photograph 4.1: Precariously Hanging Loose Glass Louvres of Public Service Commission Building Attributed to Negligence. The defect requires negligible effort to repair.



Photograph 4.2: Double Door with Loose Hinges at the Magereza House Attributed to Negligence. The defect requires negligible effort to repair.

Photograph 4.3: Loose Electrical Power Socket at Works House Attributed to Careless Movement of Furniture or Goods. This requires negligible effort to repair.

Photograph 4.4: Loosely Hanging Flush water Cistern at Transcom House attributed to Negligence This requires negligible effort to repair.

Photograph 4.5: Loosely Hanging Fluorescent Lighting Fittings at Transcom House Attributed to Negligence.

Photograph 4.6: Blocked Storm Water Drainage Gulley Pot at Transcom Parking Attributed to Negligence.

Evidence of poor supervision which tied together with negligence was also noted during inspections as a major contributor to buildings defects. Poor supervision is linked to failure to adhere to specifications thereby encouraging use of substandard materials and un-desirable methodologies of construction as demonstrated in Photograph 4.7 and 4.8.

Photograph 4.7: Peeled off PVC Floor Finish at Treasury Attributed to Poor Supervision During Construction.

Photograph 4.8: Ceiling Board damaged by Leaking Tiled Roof at Jogoo House Attributed to Poor Supervision. Continued state of affairs might further damage more building components

Poor supervision as observed during inspections is responsible for cracks, leakages, frequent equipment breakdowns, rapid deterioration of building elements and components which eventually reduce performance of buildings. Use of substandard materials and short cuts in construction therefore reduces service life of various building components or elements and therefore is responsible for costly replacement costs. The study findings agree closely with those advanced by Asafetal (1995) and Briffet (1990). According to maintenance experts who were interviewed, poor supervision is responsible for major defects and can only be avoided through use of experienced, qualified maintenance staff.

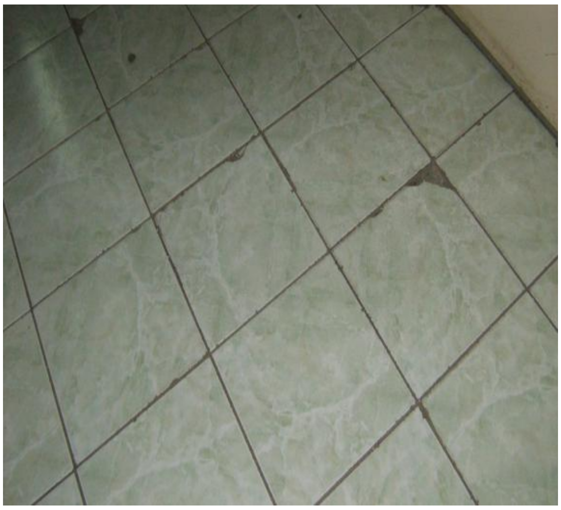
Vandalism is another major contributor to buildings defects and was observed in almost all the sampled public office buildings that were inspected. Vandalism is responsible for loss of valuable electrical/plumbing drainage fittings, electrical/mechanical equipment and joinery fittings. Maintenance experts argue that more than 50% of minor maintenance in public office buildings is attributed to vandalism. Some of the buildings defects attributed to vandalism were documented as photographs 4.9 and 4.10. More observations are in appendix 9.

Photograph 4.9: Missing Firefighting Hosereel Equipment at Jogoo House A Attributed to Vandalism.

Photograph 4.10: **Missing Manhole Cover at NSSF Building Attributed to Vandalism.**

Maintenance experts interviewed suggested the adoption of strict security surveillance as the most effective way of minimizing rampant vandalism in public office buildings. Security surveillance include installation of CCTV and enhanced security checks which have been put in place in some office buildings and is already yielding positive results as confirmed by some caretakers.

It was observed during inspections of the sampled public office buildings that a number of defects noted were attributed to deficient design. Use of deficient design were majorly noted in wrong specification of finishing materials and in-appropriate roof design. Photographs 4.11, 4.12 and 4.13 overleaf shows building failures attributed to deficient design. More observations are in appendix 9.



Photograph 4.11: Defective Ceramic Floor Finish at Sheria House Attributed to In-appropriate Specification.

Photograph 4. 12: DamagedKitchenette Timber Work Top and Peeling Paint Due to Dampness at Jogoo House A Attributed to Deficient Design.

Photograph 4. 13: Failed KICC Flat Roof Attributed to In-ability to Regularly Replace the Water Proofing Membrane Due to Budgetary Constraints.

Experts interviewed agree that deficient design is responsible for most of the defects at post-occupancy stage and therefore suggest that any serious maintenance cost minimization strategy should be in-built right from design stage, a view point that is also advance by Chohan *et al* (2011), Ishal *et al* (2007), Ramly (2006), Ahmad (2006) and

Rukwaro (1990). Okwemba (1981) argues that a building maintenance manual specific to any building should be formulated at design stage so as to close the gap between design and maintenance.

The results on incidences of defects from questionnaires and observations form part of the maintenance workscope and therefore the maintenance budget. To minimize the maintenance budget, it is necessary to strategize on the management of causes of defects. This fact was also confirmed by senior maintenance experts who were interviewed. They stated that the current maintenance framework is curative rather than preventive as the defects are attended to as they come without putting in measures to address their root causes. An effective maintenance framework should attend to defects as well as manage what triggers them in order to minimize on recurrence with a view of reducing maintenance workscope and cost.

4.5 Scope of Maintenance Works

The second objective in this study was to establish maintenance workscope for public office buildings. The scope of maintenance work was investigated by asking various caretakers of the sampled public office buildings to choose from scheduled items of minor and major maintenance activities executed in the last financial year.

4.5.1 Major maintenance workscope

Caretakers of various sampled public office buildings were asked to choose from scheduled items of major maintenance activities executed in the last financial year.

The schedule for major maintenance activities from which caretakers made a choice included the following:-

- Major Re-painting and Redecoration
- Major Re-flooring
- Major Replacement of Roofing Water Proofing Membrane
- Major Re-roofing
- Major Re-partitioning works
- Major Overhaul of Ceiling.
- Replacement of Lifts
- Replacement of PABX
- Major Overhaul of Electrical Installations
- Major Overhaul of Plumbing/Drainage Installations.

The response from the questionnaires are captured as Figure 4.2.

Figure 4.2 is a graphically representation of frequencies and percentages for components of major maintenance works.

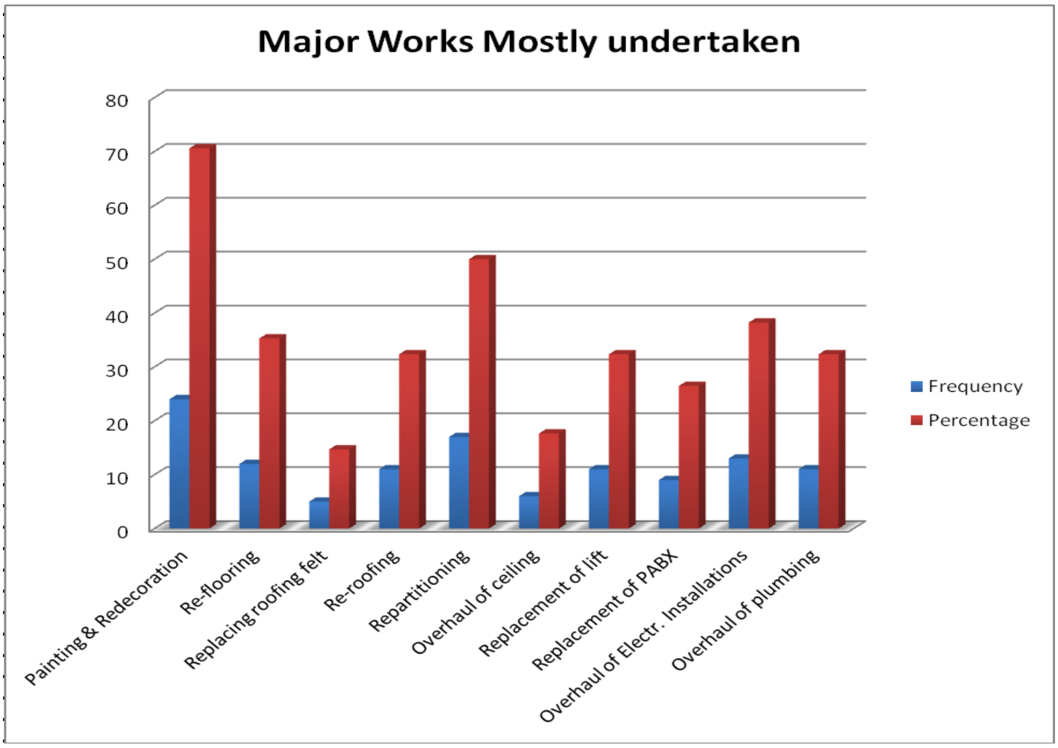


Figure 4. 2: Graphical Representation of Frequencies and Percentage

Figure 4.3 is a summary of proportions of various maintenance works.

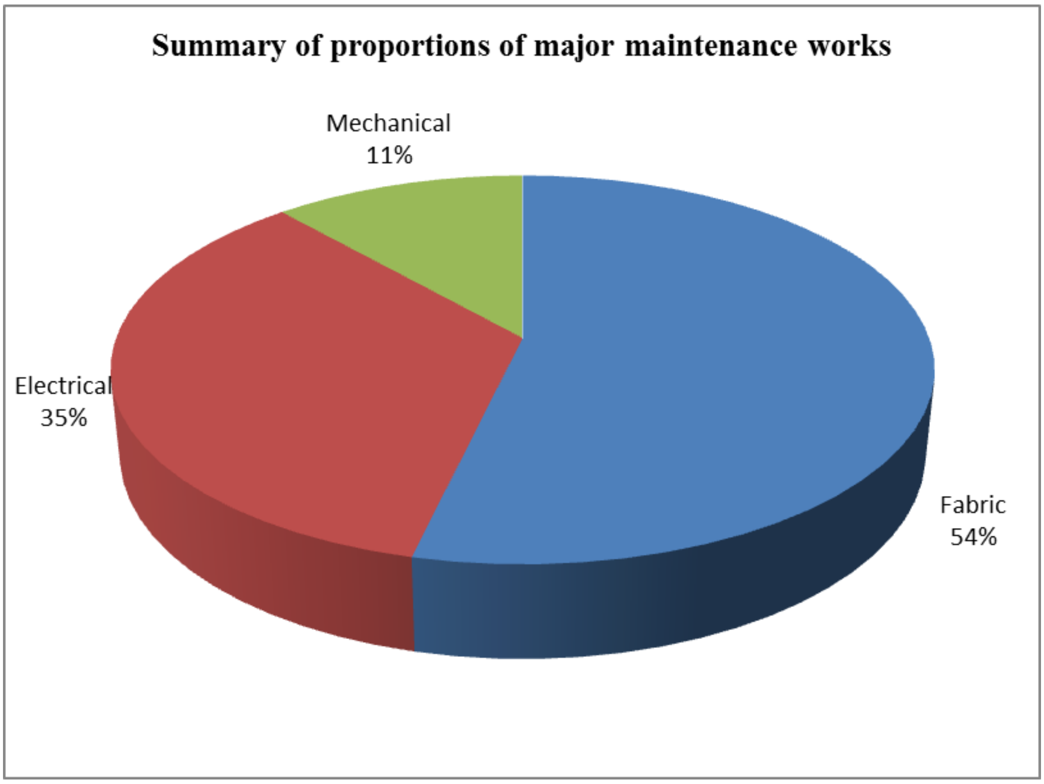


Figure 4. 3: Summary of Proportions of Various Major Maintenance Works.

The significant point in this investigation is that re-painting and re-decoration activities are most prevalent at 70.6% followed by re-partitioning works at 50% and overhaul of electrical installations at 38.2%. The reasoning behind this scenario is that painting deteriorates fast requiring frequent attention while re-partitioning is often needed to define spaces dictated by emerging functional and global trends, for instance the emerging open plan office concept is a case in point. Likewise, electrical installations are susceptible to numerous faults that more often requires overhaul. In addition, changes in office partitions dictate that electrical installations are overhauled. Summary of major maintenance works as depicted in Figure 4.3 reveals that fabric maintenance ranks first at 54% while combined electrical and mechanical services stand at 46% showing that although maintenance of building services have in the past not been given appropriate prominence, it is not far from the weighting assigned to fabric maintenance. Observations made during inspections of public office buildings established a number of defects which fall under the category of major maintenance. The findings confirm the caretakers' account of what constitutes public office buildings major maintenance workscope. The essence of the investigations was to establish common items of major maintenance which would be prioritized for cost minimization in an efficient maintenance framework.

A closer scrutiny of the sampled public office buildings indicate that over 90% as documented in the observation checklist were initially designed with flat roofs most of which have failed for the in-ability to replace the water proofing membrane regularly. This has necessitated re-roofing programmes where the initial flat roofs are being converted into pitched roofs which are associated with less maintenance costs. The on-going re-roofing of the Magereza House as indicated in Photograph 4.14 is a significant aspect of major maintenance workscope and confirms the position taken by the caretakers through questionnaire enquiries.

Photograph 4. 14 : The Ongoing Re-Roofing Works to Magereza House as a Major Maintenance Work.

Other than conversion of flat roofs into pitched roofs, re-roofing as a major maintenance workscope can also entail replacement of the worn out water proofing membrane and overhaul of pitched roof whose service life has expired. Studies by Lounis and Vanier (2002) provides a prediction model for programming roof maintenance which could be adopted to develop maintenance workscope of public buildings.

Observation checklists derived from inspections reveal that one of the predominant major maintenance workscope is painting, a fact that also confirms the view point taken by caretakers. The reasoning behind this state of events is that painting deteriorates faster and hence require frequent attention. Maintenance experts argue that painted external facades which are exposed to the environment requires attention annually thereby contributing to a significant proportion of major maintenance works. The recently refurbished Protection House as documented in photograph 4.15 below is an example of a public office building where re-painting stands out prominently.

Photograph 4. 15: Recently Re- decorated and Painted External Façade of Protection House as a Major Maintenance Work.

Roy *et al* (1996) developed a system which could be used to evaluate performance of paint as well as its scope. This approach is however only effective for monitoring deterioration when all the other prevailing conditions are taken into account.

As indicated by the caretakers of sampled public office buildings, electrical/mechanical services form the second highest proportion of a major maintenance workscope at 46% which is significant. Observation checklists reveal that these major maintenance works arise mostly from overhaul necessitated by consequences of repartition works and age factor, a scenario that was recorded as photographs 4.16, 4.17 and 4.18.

Photograph 4. 16: Newly Overhauled Partitions to the 7th Floor, Works Building Leading to Overhaul of Electrical Installation Work as a Major Maintenance Work.

Photograph 4. 17: Newly overhauled Plumbing/ Drainage in Washrooms to Kenyatta International Conference Centre Building as a Major Maintenance Work.

Photograph 4. 18: Old Out-dated Surface Wiring at Jogoo House Calling for Overhaul of Electrical Installation as a Major Maintenance Work.

According to caretakers and observations made during inspections, civil works that constitute major maintenance works include major overhaul of storm/foul water drainage, paved walkways and recarpeting of parking/access roads. Maintenance experts argue most civil works defects noted during inspections are attributed to negligence for example careless driving over paved walkways/drains as well as failure to clear blocked drains in time leading to costly repairs on other civil works components. Photograph 4.19 shows failed parking at the National Cereals and Produce Board as a major maintenance workscope.

Photograph 4. 19: Failed Parking of National Cereals and Produce Board Parking calling for Re-carpeting as a Major Maintenance Work.

The choice of finishes to floors is determined by functional requirements of spaces. According to maintenance experts, in-appropriate choice of finishes increases frequency of replacements thereby increasing scope and cost. The floor finishes observed during inspections of the sampled public office buildings, range from sand/cement screed, terrazzo and grano being the cheapest to moderately expensive ceramic tiles to expensive, aesthetically superior granito, porcelain and granite tiles. According to Okwemba (1981) various building elements have differing service lives meaning that cyclic replacements become indispensible at appropriate time. It is with this in mind that administrators of most of the sampled public office buildings are overhauling or have programmed to overhaul floor finishes of their premises, an example of which is illustrated in photograph 4.

Photograph 4. 20: Recently Laid Porcelain Tiles Floor Finish to Transom House as a Major Maintenance Work.

4.5.2 Minor Maintenance

Caretakers of various sampled public office buildings were asked to choose from scheduled items of minor maintenance activities executed in the last financial year. The schedule for minor maintenance activities from which caretakers made a choice included the following:-

- Minor Replacement of Locks
- Minor Replacement of Broken Glass Panes
- Minor Replacement of Power Sockets and Switches
- Minor Replacement of Lighting Fittings
- Minor Clearance of Blocked Drains
- Minor Replacement of Stained Ceiling Boards
- Minor Repairs to Water Tanks
- Minor Replacement of Taps
- Minor Replacement of Wash Hand Basins

- Minor Replacement of Water Closets
- Minor Replacement of Flushing Cisterns
- Minor Replacement of Leaking Roofing Sheets/Tiles
- Minor Replacement of Bottle Traps
- Minor Replacement of Ball Valves
- Minor Replacement of Joinery Fittings
- Minor Replacement of Gutters.

The response from the questionnaires are captured as Figure 4.4 in graphical representation and summarized as Figure 4.5 in Pie chart form.

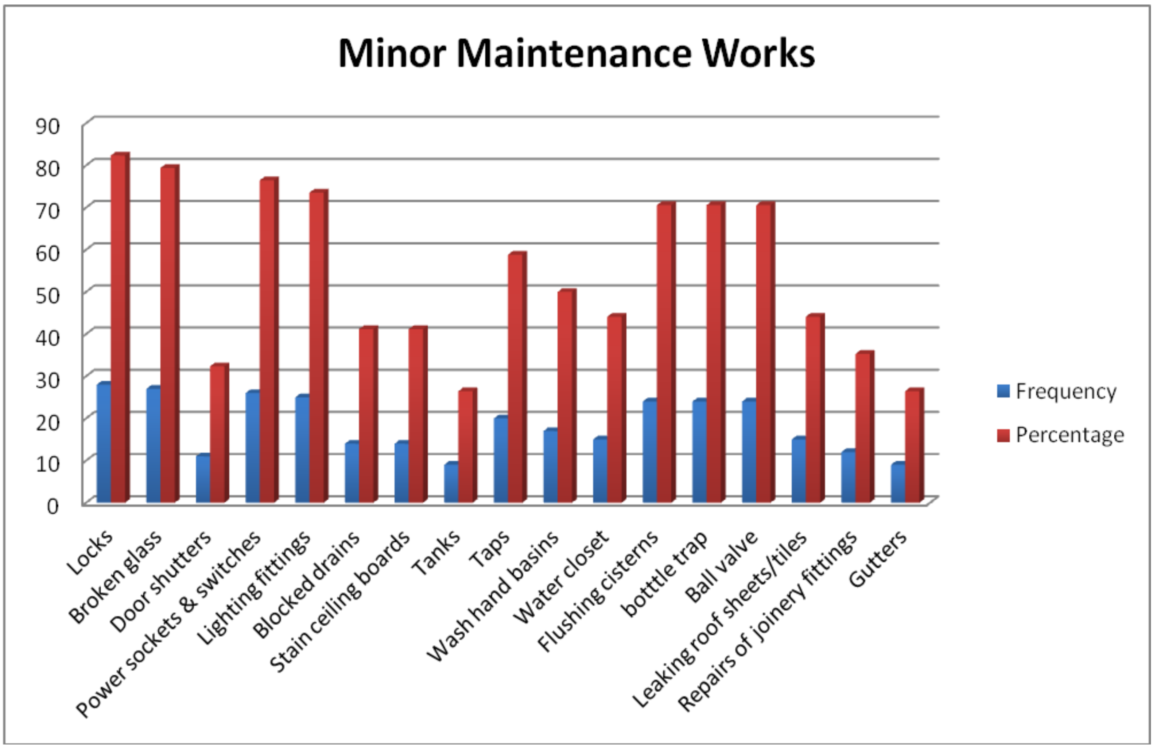


Figure 4. 4: Graphical Representation of Frequencies and Percentages on Ranking of Minor Maintenance Works

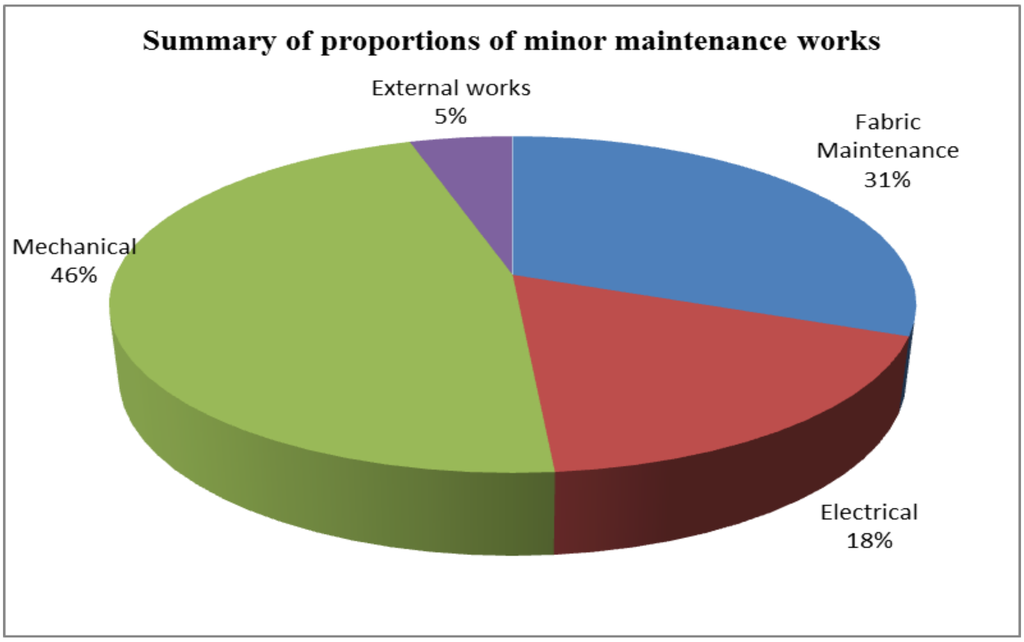


Figure 4. 5: Summary of Proportions of Various Minor Maintenance Works

An analysis of the results reveals that replacement of locks ranks high at 82.4% among the common minor maintenance activities followed by replacement of glass panes at 79.4% and replacement of power sockets and switches at 76.5%. Observations made from inspections of the sampled public office buildings established common items of minor maintenance workscope which are routine and are normally executed by maintenance managers on day to day basis. The outlining of the minor maintenance work would reveal its significant components which would be targeted for cost minimization in an efficient maintenance framework.

Glazing primarily protect buildings occupants, furnishes and equipment from adverse effects of the environment but permit entry of natural lighting to enable spaces function as designed. It is therefore important that whenever glass breakages occur, replacements need to be done immediately in order that service delivery is not interrupted. Observations made during inspections of sampled premises revealed various incidences of glass related defects which include falling off, cracking, precariously hanging and about to fall.

According to maintenance experts, the major causes of glazing related defects include banging of windows orchestrated by failure to use window stays, knocks by foreign goods or objects, putty failure and negligent usage. Precariously hanging glass lourve blades and loose glass panes from weakened putty can be salvaged through quick interventions to avoid costly replacements from breakages. Photograph 4.21 shows missing glass lourve blade which could have been salvaged before falling off.

Photograph 4. 21: Replacement of Missing Louvre Glass Blade to Public Service Commission Building as a Minor Maintenance Work.

The most common joinery related defects observed during inspections include missing/defective door, cabinet and cupboard locks, loose hinges, damaged timber worktops/frames, leakages and stained ceiling boards. Maintenance experts revealed that most joinery related defects arise from various causes which include in-appropriate handling, forced opening, roof membrane failure and exposure to dampness. Some of the joinery related defects that form a minor maintenance workscope are shown in photographs 4.22 and 4.23.

Photograph 4. 22:Re screwing of Loose Hinges to Double Door at the Magereza House as a Minor Maintenance Work.

Photograph 4. 23: Replacement of Missing Door Lock to National Social Security Fund Building as a Minor Maintenance Work.

Simple repair and replacement of electrical/mechanical fittings are major components of a minor maintenance workscope in public office buildings as advanced by the caretakers of the sampled premises and confirmed through observations during inspections. This workscope is necessitated majorly by rampant vandalism in most public office buildings. According to the caretakers and maintenance experts, the key electrical/mechanical fittings targeted by vandals include lighting fittings, power sockets, switches, circuit breakers, taps, ball valves, gate valves, flush cisterns and mirrors. Some fittings are however damaged through careless and negligent handling. Loose power socket shown on photograph 4.24 was observed during inspection of sampled public office maintenance workscope which though requires very little effort to address can have costly consequences if not addressed in time. More observations are in appendix 9.

Photograph 4. 24: Re-Screwing of Loose Electrical Power Socket and Damaged Power Switch at Works House as a Minor Maintenance.

According to maintenance experts, the incidence of minor maintenance in regard to defective/missing electrical/mechanical fittings can be minimized through incorporation of appropriate security surveillance system as well as sensitizing users on proper handling of fittings.

Blocked storm water/sewer drainage and missing manhole/inspection covers were observed during inspections of sampled public office buildings and are key components of a minor maintenance workscope. According to maintenance experts, persistent blockages of drainage systems is attributed to either negligent introduction of foreign matter or failure to regularly clean the drainage systems while missing manhole/inspection covers is as a result of vandalism. Photograph 4.25 indicates a blocked storm water drainage that only requires a cleaner to un-block.

Photograph 4. 25: Clearance of Blocked Storm Water Drainage at Jogoo House as a Minor Maintenance Work.

Continued blockage of the storm water drainage can cause eminent failure of the road surface and sub-base whose replacements can be costly. These minor maintenance works can be addressed through simple routine maintenance and appropriate security surveillance that requires minimal resources.

From inquiries with various caretakers and confirmed by observations made during inspections, the first three ranked minor maintenance items mentioned above are mainly instigated either through vandalism or negligence. The inference from this finding is that the bigger proportion of minor maintenance work is generated through vandalism and negligence. Cost minimization strategies in minor maintenance works should accordingly be directed to elimination of vandalism and change of attitude of users of public office buildings. According to Figure 4.6 which summarizes proportions of various aspects of minor maintenance works, building services are ranked first at 64% followed by fabric maintenance at 31% with external works ranking last at 5%. It can therefore reasonably be deduced that in the overall, building services stand prominent within the scope of minor maintenance works, an aspect that should not be overlooked in cost minimization strategy.

4.6 Maintenance Framework for Public Office Buildings

The third objective of this study was to assess the existing maintenance framework for public office buildings with a view to formulating an appropriate legal and institutional framework which is captured in this study as the sixth objective. Specific focus is directed on how to achieve maintenance targets within optimal budgetary provision. The key issues in regard to maintenance framework in this investigation include; approaches to maintenance, capacity of maintenance units, mode of execution of maintenance programmes, frequency of inspections/execution of planned maintenance, building maintenance policy/manual and impact of utilities on operational costs

4.6.1 Approaches to Maintenance

Sampled maintenance experts in the public service were asked to state the system practiced in the maintenance of public office buildings. The questionnaire provided for various approaches which included value based, predictive, preventive, corrective, none and others from which the respondents made choices. The response is indicated as Figure 4.6. Additional data is displayed in appendix 10.

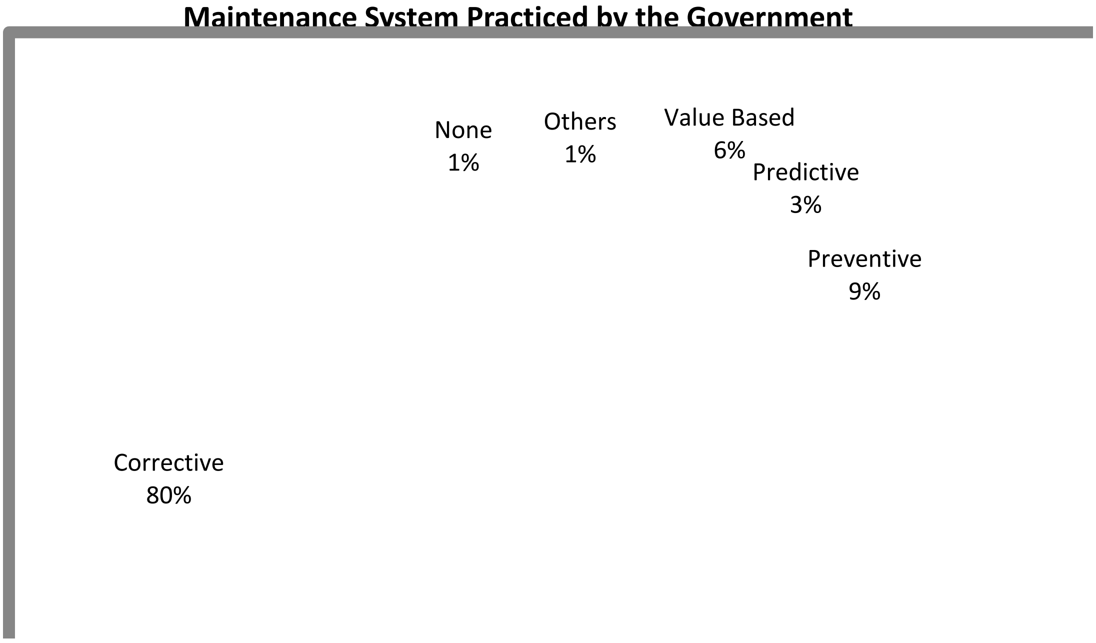


Figure 4. 6: Maintenance System Practiced by the Government

Three out of seventy four respondents did not answer the question but did not indicate any reason for declining. Fifty seven out of seventy one respondents at 80.3% rating stated that the corrective maintenance approach is the most prevalent system of maintenance in the public sector. The rating for the response on other systems of maintenance included preventive at 8.5%, value based at 5.6% and predictive at 2.8%. Maintenance systems or approaches contribute to how effective a maintenance framework is. This investigation was therefore undertaken to establish the commonly used system of maintenance in public office buildings.

Senior maintenance experts in the public sector interviewed explained that whereas corrective maintenance is predominantly used in maintaining government ministries' offices, most state corporations and parastatals have shifted to other systems of maintenance. It is surprising to note that corrective maintenance is widely practiced when the existing building organizational and operational manual (BOOM) which though has become outdated is categorical on planned preventive maintenance as the system for maintaining public sector buildings. Experts who were interviewed argue that planned preventive maintenance was practiced in the past until early 1990's when things changed after the government decided to decentralize maintenance funds to individual government ministries. Most ministries thereafter would only request for technical expertise when a major defect has occurred and caused substantial damage ruling out any initiative on planned preventive intervention. This change on government policy set the beginning of corrective maintenance which Idris *et al* (2009) argues is a non-cost effective maintenance system. According to Cane (1998), corrective maintenance is reactive and unplanned and is only taken when a breakdown or failure has taken place. It therefore follows that maintenance programmes of public office buildings are being executed through unplanned costly systems. The fact that the budgetary allocations do not match the maintenance requirements of public office buildings is a good reason to move away from this state affair to bring on board an effective maintenance framework which this study endeavors to recommend.

Rating of Cost Effectiveness of Different Approaches to Maintenance

Further enquiries were made to the sampled maintenance experts to rate the cost effectiveness of different approaches to maintenance. The list of different approaches to maintenance included value based, predictive, corrective and preventive systems of maintenance. The response is captured as figure 4.7. Additional data is displayed in appendix 10.

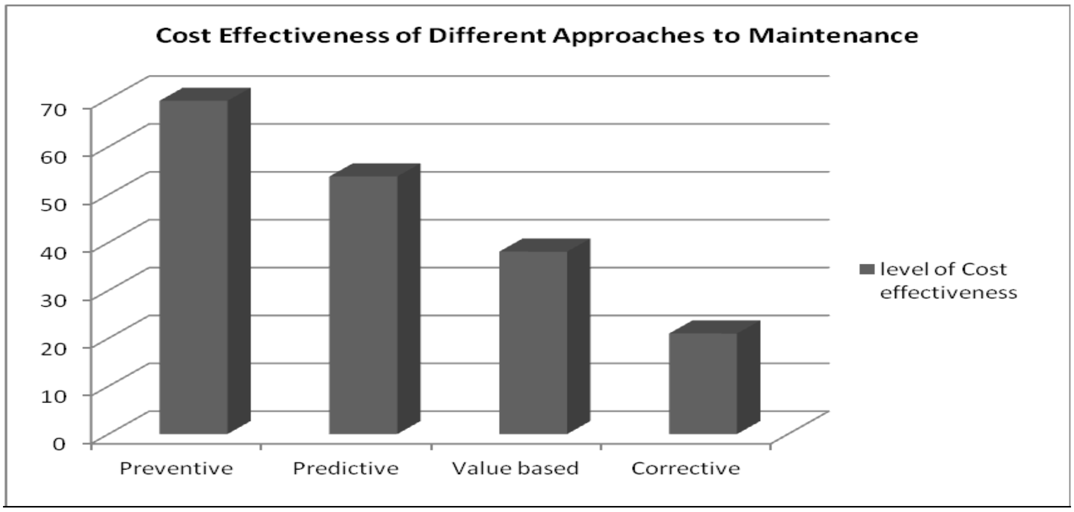


Figure 4. 7: Rating of Cost Effectiveness of Different Approaches to Maintenance

An average of nine out of seventy four experts did not respond but did not indicate any reason for declining. The response on the rating of cost effectiveness of the different approaches is ranked here below:-

1. Preventive -69.6%
2. Predictive -53.8%
3. Value based -38.1%
4. Corrective -21%

From the above, preventive maintenance system tops the ranking while corrective maintenance system is ranked last in as far as cost effectiveness is concerned. The rating of the various approaches to maintenance was undertaken to establish the most appropriate approach to be incorporated into the desirable maintenance framework.

The findings echo those of Alberta Infrastructure (2004) which indicates that preventive maintenance is proactive and is aimed at preventing unexpected equipment breakdowns or building component failure which in the long run reduces overall maintenance cost. Senior maintenance experts who were interviewed also supports this view point. Lateef (2010) however supports a value based maintenance approach as opposed to corrective maintenance which he argues is reactive and just executed on the condition of the building as revealed by inspections. The value based maintenance is however rated third by respondents whom the majority might perhaps have felt is a new emerging approach to maintenance which has not been tested locally. Even though planned preventive maintenance has been approved unanimously by respondents as an approach that can remedy the ills that have plagued maintenance programmes of public office buildings, Horner *et al* (1997) however argues that a good maintenance policy should integrate different approaches to maintenance to consolidate the different benefits. Planned preventive maintenance approach could therefore be combined with predictive maintenance rated by respondents in the second spot. This is informed by the fact that planned maintenance would provide a schedule based maintenance programme with preventive strategies for defects (East Sussex County Council, 2001) while the predictive maintenance would offer systems for predicting maintenance workscope and budgets (Langevine *et al*, 2006). The combination of the two approaches will go a long in transforming the current maintenance systems into an effective maintenance model which is planned and executed within the budgetary allocations and set time frames.

Significance of Regular Maintenance in Cost Minimization of Maintenance

Sampled maintenance experts from the public sector were asked to give their opinion on the significance of carrying out regular maintenance in a building maintenance cost minimization strategy. The rating from which the respondents made a choice included insignificant, significant and very significant. The response is tabulated as table 4.5.

Table 4. 5: Significance of Regular Maintenance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Insignificant	0	0	0	0
	Significant	12	16.2	16.2	16.2
	Very significant	62	83.8	83.8	100.0
	Total	74	100.0	100.0	

All the seventy four respondents sampled indicated that regular maintenance is either significant or very significant in minimizing maintenance cost. This investigation was undertaken to obtain the perceptions of maintenance experts on the impact regular maintenance has on cost of building maintenance.

The tragedy of the collapse of the Sun Beam Super Market in the City of Nairobi would not have taken place if regular maintenance had been effected, an event that further amplifies the significance of regular maintenance (Republic of Kenya, 1996). The Sun Beam Super Market tragedy justifies the need for regular maintenance which in effect minimizes maintenance backlog.

Non regular maintenance as explained by the senior maintenance experts who were interviewed is the cause for the sorry state of most public buildings. They argue that non-regular maintenance contributes to backlogging effect of defects and can lead to eminent equipment breakdown or building component failure as propagated by Cane (1998). It is therefore desirable that regular maintenance of public buildings is carried as this maintains their economic life in addition to reducing the costly consequences of maintenance backlog.

4.6.2 Capacity of Maintenance Units

The scope of the investigation conducted on capacity included qualifications of heads of maintenance units, levels of staffing, adequacy of tools of trade, mode of execution of works, frequencies of execution and inspections for planned maintenance and significance of supervision. Caretakers of various sampled public office buildings were asked to confirm whether their premises have an in-house maintenance unit. The question was designed to be answered in a 'YES' or 'NO' format and is captured as Table 4.6.

Table 4. 6: Availability of In-house Maintenance Units

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	4	11.8	13.8	13.8
	Yes	25	73.5	86.2	100.0
	Total	29	85.3	100.0	
Missing	System	5	14.7		
Total		34	100.0		

Five respondents did not answer this question but however did not indicate any reason as to why. Twenty five out of twenty nine respondents overwhelmingly responded in the affirmative (Yes) at a rating of 86.2% confirming that most public office buildings have in-house maintenance units. The significance of this investigation was to establish the availability of in-house maintenance units for these premises to handle maintenance work that is not referred to the Ministry of Public Works.

To establish the technical expertise of the head of these maintenance units, the same caretakers were asked to state their qualifications. The possible qualifications were suggested in the questionnaires from which to choose from. These comprised Architects, Building Surveyors, Engineers, Inspectors, Artisans and others. The response is depicted as Table 4.7

Table 4.7: Qualification of Head of Maintenance Units

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Architect	4	11.8	14.8	14.8
	Building surveyor	2	5.9	7.4	22.2
	Engineer	3	8.8	11.1	33.3
	Inspector Build, Elect/Mech	7	20.6	25.9	59.3
	Artisan	4	11.8	14.8	74.1
	Other	7	20.6	25.9	100.0
	Total	27	79.4	100.0	
Missing	System	7	20.6		
Total		34	100.0		

Seven respondents did not answer this question but however did not indicate any reason as to why. Twenty out of twenty seven respondents at 69.2% rating confirmed the qualifications of the heads of in-house maintenance units as artisans, inspectors, engineers, building surveyors and architects with the position of inspectors ranking first at 25.9%. The inspectors are Diploma / Higher Diploma graduates which the senior maintenance experts interviewed confirmed to be the minimal qualifications required for heads of in-house maintenance units. The level of qualification was investigated to establish whether the existing in-house maintenance units were being managed competently and therefore effectively.

The reasoning advanced to support this argument is drawn from the requirements of strong managerial/supervisory skills to be able to superintend over artisans who does the actual work. It should be noted that the population which is not qualified to head these maintenance units stands at 40.7% and covers artisans and others. This percentage is quite significant in that almost half of the maintenance units are headed by personnel who are not technically qualified. The situation raises concerns on capacity and capability of some of these maintenance units to manage in-house maintenance works effectively. Field data indicate that state parastatals and corporations have either well established maintenance units with highly qualified heads or have engaged private property consultants which seem to be offering effective building maintenance services. This fact was observed during inspections of sampled public office buildings. It is therefore crucial that the heads of maintenance units should have the requisite qualifications and experience to be able to offer effective maintenance services.

Staffing for In-house Maintenance Units

Caretakers of various sampled public office buildings were asked to confirm adequacy of staff for in-house maintenance activities. The response was crafted in a 'YES' or 'NO' format and is captured in Table 4.8.

Table 4.8: Adequacy of staff for In-house Maintenance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	14	41.2	53.8	53.8
	Yes	12	35.3	46.2	100.0
	Total	26	76.5	100.0	
Missing	System	8	23.5		
Total		34	100.0		

Eight out of thirty four respondents did not answer the question but however did not indicate any reason for declining. Majority of the respondents at 53.8% indicated they did not have adequate staff for in-house maintenance raising concern on capacity to deliver maintenance work on schedule. The same caretakers made a response to enquiries on the staffing capacity of the in-house maintenance units for their respective premises whose response is captured as Table 4.9.

Table 4.9: Staffing Capacity of In-house Maintenance Units

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	12	35.3	46.2	46.2
	1	1	2.9	3.8	50.0
	4	2	5.9	7.6	57.6
	5	1	2.9	3.8	61.4
	7	2	5.9	7.6	69.0
	8	1	2.9	3.8	72.8
	11	1	2.9	3.8	76.6
	12	1	2.9	3.87	80.4
	15	3	8.8	11.4	91.8
	19	1	2.9	3.8	95.6
	20	1	2.9	3.8	100.0
	Total	26	76.5	100.0	
Missing	System	8	23.5		
Total		34	100.0		

The staffing capacities for various maintenance units ranged from zero to twenty. Eight out of thirty four respondents did not answer the question but however did not indicate any reason for declining. Twelve out of twenty six representing 46.2% rating did not have any staff at all and yet most of them execute in-house maintenance activities which imply that some of them hire maintenance technicians whenever there is need. For those with staff, the capacity ranges from a single staff to twenty. Some state parastatals and corporations seem to have put in place sufficient staff covering all trades while others depends on contracting. The findings indicated that the existing in-house maintenance units are inadequately staffed. According to maintenance experts, properly staffed maintenance units should include artisans in every trade, for example, carpentry, masonry, painting, plumbing, electrical/electronics, refrigeration and welding. This is necessary to enable the maintenance units execute maintenance programmes effectively. They further stated that, where there is no existing maintenance unit and the administration is not ready to establish any, outsourcing option is equally suitable.

Tools for the In-house Maintenance Units

The same caretakers were asked to indicate whether adequate tools have been assigned to the maintenance units to enable them perform. The response was provided for in a 'YES' or 'NO' format and is captured in Table 4.10.

Table 4. 10: Adequacy of Tools of Trade

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	21	61.8	65.6	65.6
	Yes	11	32.4	44.0	100.0
	Total	32	94.1	100.0	
Missing	System	2	5.9		
Total		34	100.0		

Two out of thirty four caretakers did not answer this question but however did not indicate any reason for declining. Twenty One out of thirty two caretakers confirmed that their in-house maintenance units did not have sufficient tools of trade at 65.6% implying that the majority of in-house maintenance units are not equipped with sufficient tools of trade which would be necessary to boost capacity for execution of maintenance works

4.6.3 Mode of Execution for Maintenance Works

Caretakers of sampled public office buildings were asked to indicate the method they use to procure maintenance works. The questionnaire provided for alternative methods for executing maintenance works, for instance execution through in-house arrangement or contracting or both methods. The response is as indicated in figure 4.8. Additional data is displayed in appendix 10.

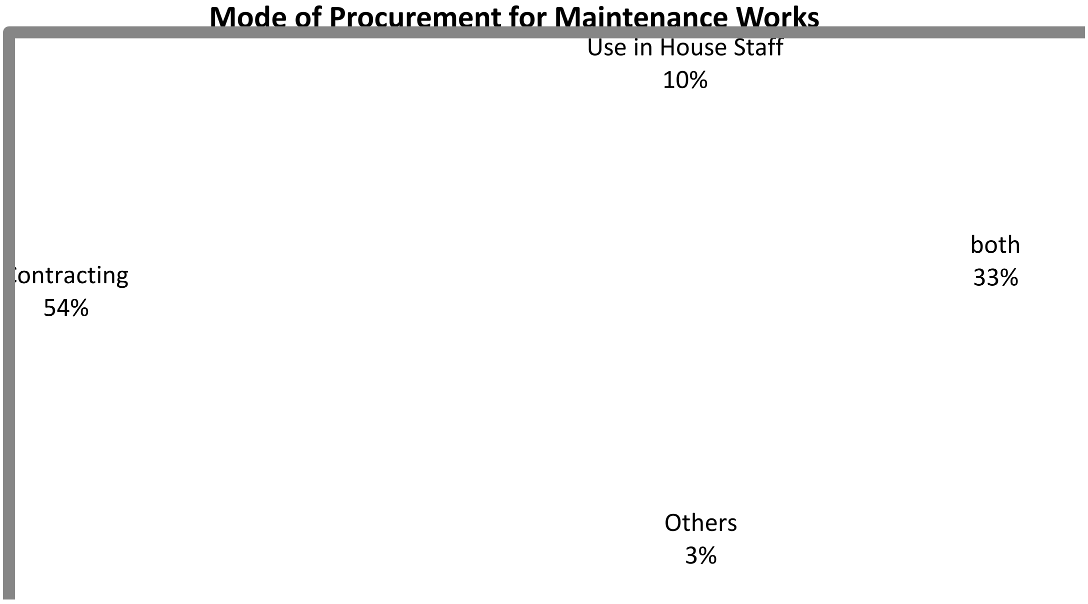


Figure 4. 8: Mode of Execution of Maintenance Works

Four out of thirty four caretakers did not answer this question but however did not indicate any reason for declining. Sixteen out of thirty respondents at a rating of 54% said that they had adopted the contracting method while three out of thirty indicated they use in-house staff at a rating of 10%. Ten out of thirty use both methods at 33.3%. The response on other methods is only 2.9% which is in-significant. The most preferred mode of executing maintenance works as established by the study is thus contracting. This revelation would help in designing a policy framework for maintenance. Senior maintenance experts interviewed said that since the era of the retrenchment programme that saw the exit of the majority of artisans from the civil service, there has been a general trend to contract maintenance works which agrees quite will with these findings. In addition, the civil service reform programme has made wide reaching recommendations which include implementation of right sizing of staff and focus in core functions strategies justifying contracting of maintenance services which are non-core (Republic of Kenya, 1998).

The same caretakers responded to enquiries on whether the execution arrangement they have chosen is cost effective as indicated in Table 4.11.

Table 4.11: Response on Whether the Method of Execution is Cost Effective

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	9	26.5	31.0	31.0
	Yes	20	58.8	69.0	100.0
	Total	29	85.3	100.0	
Missing	System	5	14.7		
Total		34	100.0		

Five out of thirty four caretakers did not answer the question but however did not indicate any reason for declining. Twenty out of twenty nine at 69% rating confirmed that the execution arrangements they are using are cost effective while nine out of twenty nine at 31% rating indicated the execution arrangements are not cost effective. The response in this question when tied with the previous one on mode of maintenance works execution indicate that whereas contracting is the most preferred mode it is also considered more cost effective. Formulation of maintenance policy would thus borrow much from these findings.

Senior maintenance experts interviewed indicated that there is a general perception that the contracting option is expensive and therefore non- cost effective which they dispute by arguing that other arrangements may look cost effective at a glance but when evaluated in monetary terms are non-cost effective. Some of those caretakers who have not approved contracting as cost effective may be part of this perception. The study confirms that both in-house maintenance and outsourcing are popular in the maintenance of public buildings. Senior maintenance experts argue that both methods are cost effective depending on value and complexity of the maintenance programmes. They suggest that in-house maintenance is effective for simple minor maintenance works while outsourcing is best for specialist and major maintenance works.

4.6.4 Frequency of Inspections and Execution of planned maintenance programmes

Inspections

Caretakers of various sampled public office buildings were asked how frequently they inspect their premises. The question was necessary to establish whether public office buildings are inspected regularly for planned preventive maintenance as provided for by the Buildings Organization and Operations Manual (BOOM). The questionnaire allowed for alternative frequencies from which the caretakers chose the appropriate frequencies applicable in their respective premises. The choices available to the caretakers included quarterly, half yearly, annually and response to defect. The response is captured as figure 4.9. Additional data displayed in appendix 10.

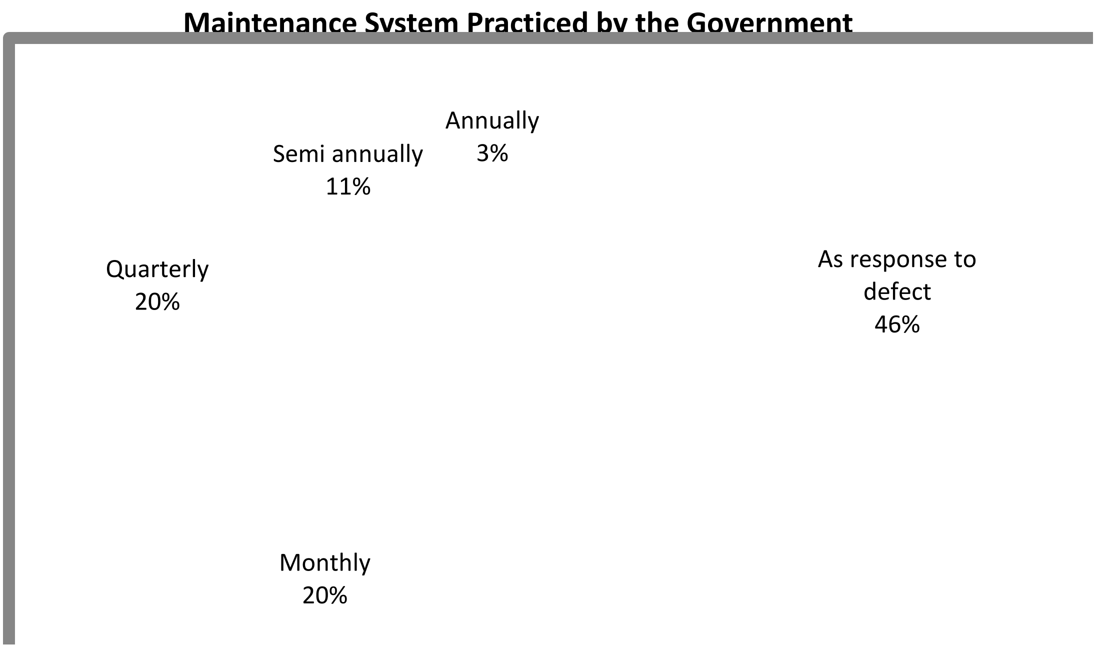


Figure 4. 9: Frequency of Inspections for Maintenance Programmes

Two caretakers did not respond to the question but however did not indicate any reason for declining. Eighteen out of thirty two respondents at 56% rating indicated inspections are carried out regularly (quarterly, half yearly, yearly and monthly) with monthly and quarterly inspections tying up in ranking at 19%. The results further indicate that inspections conducted as a response to a defect was supported by fourteen out of thirty two respondents representing 44% which is quite significant. It is therefore correct to infer that almost half of the public office buildings are not inspected regularly and therefore do not undergo planned preventive maintenance but are subjected to corrective maintenance. For maintenance systems to be effective it is necessary to have regular inspection of premises to be able to plan and forecast maintenance needs.

Planned Periodic Maintenance

Sampled maintenance experts from the public sector were asked to state the optimal period for undertaking planned periodic maintenance for public office buildings. The questionnaire provided for suggestions which included one, three, five and ten years from which respondents made choices. The response is indicated as Table 4.12.

Table 4. 12: Optimal Period for Undertaking Planned Period Maintenance

Period (Years)		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	24	32.4	32.4	32.4
	3	35	47.3	47.3	79.7
	5	13	17.6	17.6	97.3
	10	2	2.7	2.7	100.0
	Total	74	100.0	100.0	

All the seventy four respondents sampled answered the question. Thirty five out of seventy four respondents at 47.3% rating recommended three years as the optimal period. Findings indicate that the majority of maintenance experts viewed a period of three years as reasonable for executing planned periodic maintenance. Planned periodic maintenance is majorly undertaken to replace equipment and building components whose service lives have expired. According to Okwemba (1981), service lives of equipments and building components is part of the ingredients of a building manual which determine the appropriate frequency for planned period maintenance. Teo and Harikrishna (2006) supports this view point by suggesting the adoption of life cycle model approach for predicting maintenance requirements for planned periodic maintenance.

The same experts were further asked to state reasonable period for conducting inspections for planned periodic maintenance. The response is captured as Figure 4.10. Additional data is displayed in appendix 10.

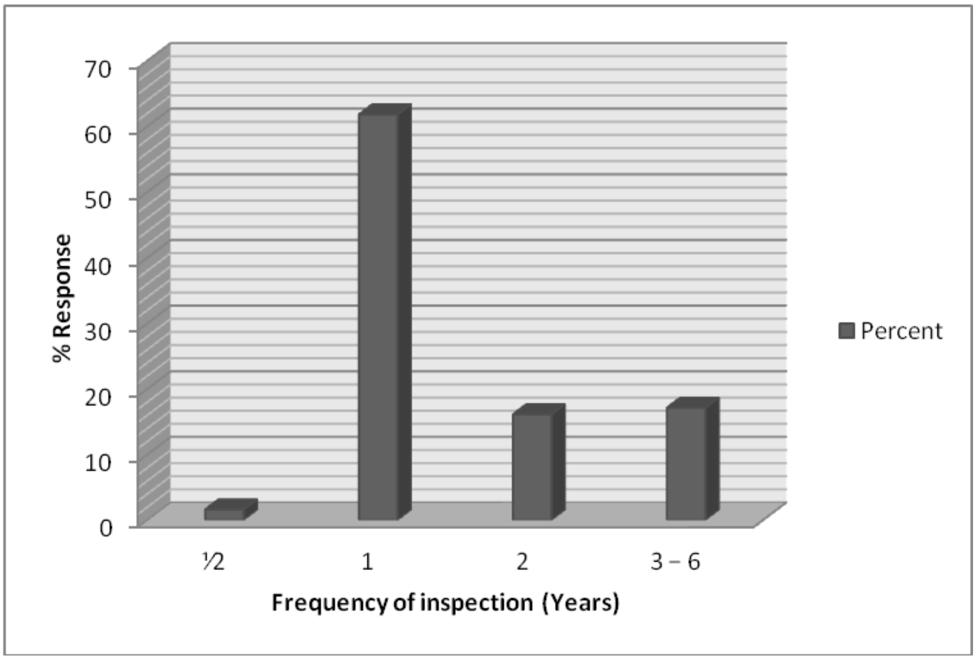


Figure 4. 10: Reasonable Period for conducting Inspection.

Twelve out of seventy four respondents did not answer this question but did not indicate any reason for declining. Thirty eight out of sixty two at 61.3% rating felt that annual inspections for planned period maintenance is adequately reasonable while ten out of sixty two at 16.1% rating felt that a period of two years is reasonable.

Only one out of sixty two respondents at 1.6% rating felt the inspection period should be half yearly while the rest of the respondents at 17.1% rating approved various inspection periods ranging from three to six years. The frequency of inspections period of one year was therefore proposed by the majority of the respondents. Okwemba (1981) and Republic of Kenya (1974) together with the senior maintenance experts who were interviewed agree with this finding. It should also be noted that yearly inspections would tie well with the budget cycle and therefore would provide inputs for formulation of annual maintenance budgets. An effective maintenance system should therefore incorporate annual inspection of premises with planned period maintenance being executed every three years.

Supervision of Maintenance Works

Sampled maintenance experts from the public sector were asked to indicate whether supervision enhances value for money in the maintenance of public buildings. The question was designed to be responded to in a 'YES' or 'NO' format. The response is captured as Table 4.13 below:-

Table 4. 13: Whether Supervision Enhances Value for Money in the Maintenance of Public Buildings

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	73	98.6	100.0	100.0
Missing	System	1	1.4		
Total		74	100.0		

One out of seventy four respondents did not answer the question but did not indicate any reason as to why. All the seventy three respondents unanimously agreed that supervision is key to achieving value for money in the maintenance of public buildings. Frequent and quality supervision by qualified maintenance staff would ensure that maintenance works are carried out in accordance with specifications thereby increasing service life of the equipments or building components. By increasing service life, the frequency of future repairs or replacements would be decreased which in the long run minimizes maintenance costs.

The same sampled maintenance experts were again asked to indicate the extent to which supervision enhances value for money in the maintenance of public buildings. The question provided for various degrees of significance which included insignificant, significant and very significant. The response is indicated as Figure 4.11. Additional data is displayed in appendix 10.

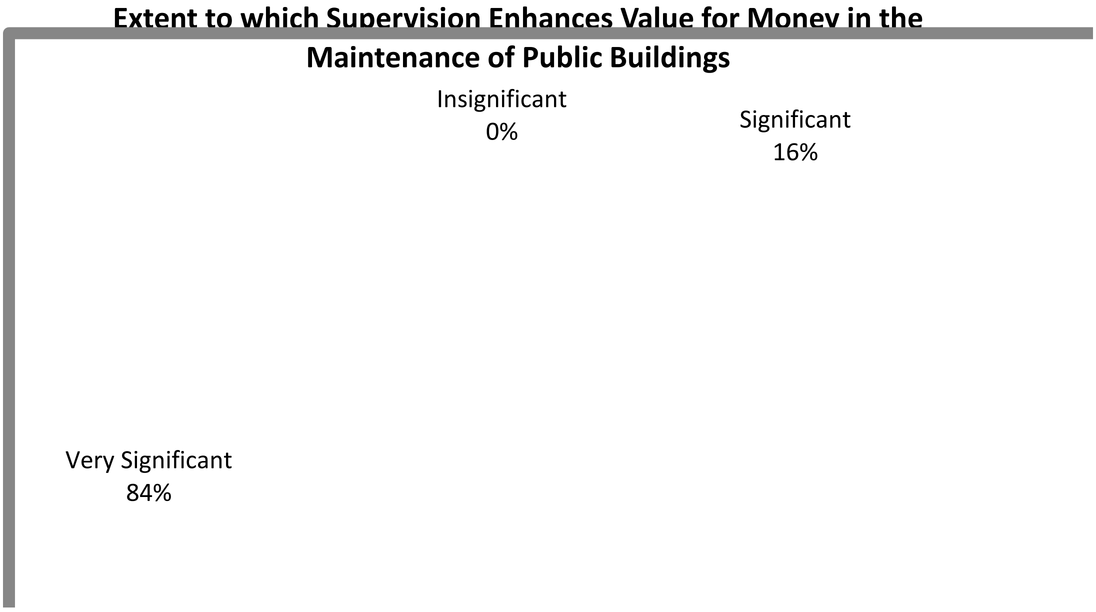


Figure 4. 11: Extent to which Supervision Enhances Value for Money in the Maintenance of Public Buildings

One out of seventy four respondents did not answer the question but did not however indicate any reason for declining. All the seventy three experts who responded overwhelmingly indicated that supervision significantly or very significantly enhances value for money in the maintenance of public buildings. No doubt, supervision is therefore a very important tool in enhancing quality of maintenance works thereby reducing frequency of repairs and replacements. This in the long run minimizes maintenance costs. An effective maintenance system and structure should therefore provide appropriate infrastructure to enhance supervision.

4.6.5 Legal and Institutional Framework

Legal and institutional framework lays a foundation for effective execution of maintenance programmes. It provides legal and institutional leverage for building maintenance policy. The building maintenance manual is however a document that forms a basis for formulation of a maintenance policy.

Caretakers of various sampled Public office buildings were asked to answer in a Yes/No format whether they have an in-house building manual/policy in the absence of a national one. They responded as indicated in table 4.14.

Table 4.14: Response on Availability of an In-house Building Policy/Manual

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	12	35.3	37.5	37.5
	Yes	20	58.8	62.5	100.0
	Total	32	94.1	100.0	
Missing	System	2	5.9		
Total		34	100.0		

Two caretakers did not answer the question but did not indicate any reason for declining. Twelve out of thirty two stated ‘NO’ to the question at 37.5% while twenty out of thirty two said ‘YES’ at 62.5%. This perception contradicts the view point advanced by senior maintenance experts interviewed that apart from the out-dated buildings organizational and operational manual (BOOM) there is no other known building maintenance manual/policy. In fact, the process for formulating a building maintenance manual/policy has just been initiated (Republic of Kenya, 2011).

Maintenance experts who were interviewed argued that maintenance of public office buildings is being managed through fragmented pieces of statutes and institutions. This fact shows that the maintenance programmes are being executed haphazardly without clearly defined legal and institutional framework resulting to costly in-effective systems, processes and operations. This is also supported by Republic of Kenya (2011). There is therefore no maintenance policy/manual for use in maintaining public office buildings.

Further enquiries were made to the same caretakers to indicate their perception on how effective a building maintenance manual/policy would improve maintenance systems. The response was designed in a 1 in 4 Likert scale including below average, average, good and excellent. The response is expressed as table 4.15.

Table 4.15 : Response on Effectiveness of Building Maintenance Policy/Manual

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below average	1	2.9	0.03	0.03
	Average	9	26.5	28.1	45.5
	Good	15	29.4	46.9	46.9
	Excellent	7	5.9	21.9	21.9
	Total	22	64.7	100.0	
Missing	System	2	35.3		
Total		34	100.0		

Twenty two out of thirty two caretakers returned a combined verdict of good and excellent recording their affirmative perception about the effectiveness of the building maintenance manual/policy at 68.8%. Two caretakers however did not answer the question and did not indicate any reason for declining. Majority of the respondents therefore indicated a positive response on effectiveness of building maintenance policy/manual. According to Republic of Kenya (2011) the absence of a building maintenance manual/policy for maintenance of public sector buildings has rendered maintenance activities being handled in adhoc manner leading to costly ineffective systems. The haphazard manner within which maintenance is carried out implies that no organized system for storing and retrieving maintenance records has been institutionalized encouraging inefficiency.

The caretakers were thereafter asked whether the organizations they are representing are in the process of developing an in-house maintenance manual/policy. The responses were provided in a Yes/No format and is captured as Table 4.16.

Table 4.16: Response on whether Organizations are in the Process of Developing an In-house Maintenance Policy and Manual

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	23	32.4	74.1	74.1
	Yes	8	20..6	25	25
					100
	Total	19	55.9	100.0	
Missing	System	3	44.1		
Total		34	100.0		

Three out of thirty four did not answer the question but did not indicate any reason for declining. Twenty three out of thirty one returned a ‘No’ verdict as their organizations were not in the process of developing an in-house maintenance manual/policy at 74.1% rating. Eight out of thirty one returned a ‘Yes’ verdict at 25% as their organizations were in the process of developing a building maintenance manual/policy. These were mainly parastatals and corporations who have their own independent maintenance units headed by professionally qualified personnel like Architects, Quantity Surveyors, Engineers and Building Surveyors.

Caretakers in sampled public office buildings were again asked to rank the importance of building maintenance manual and policy in a Likert scale of I in 4. The Likert ranking scale comprised moderately important, important, very important and not at all. The response is captured in Figure 4.12. Additional data is displayed in appendix 10.

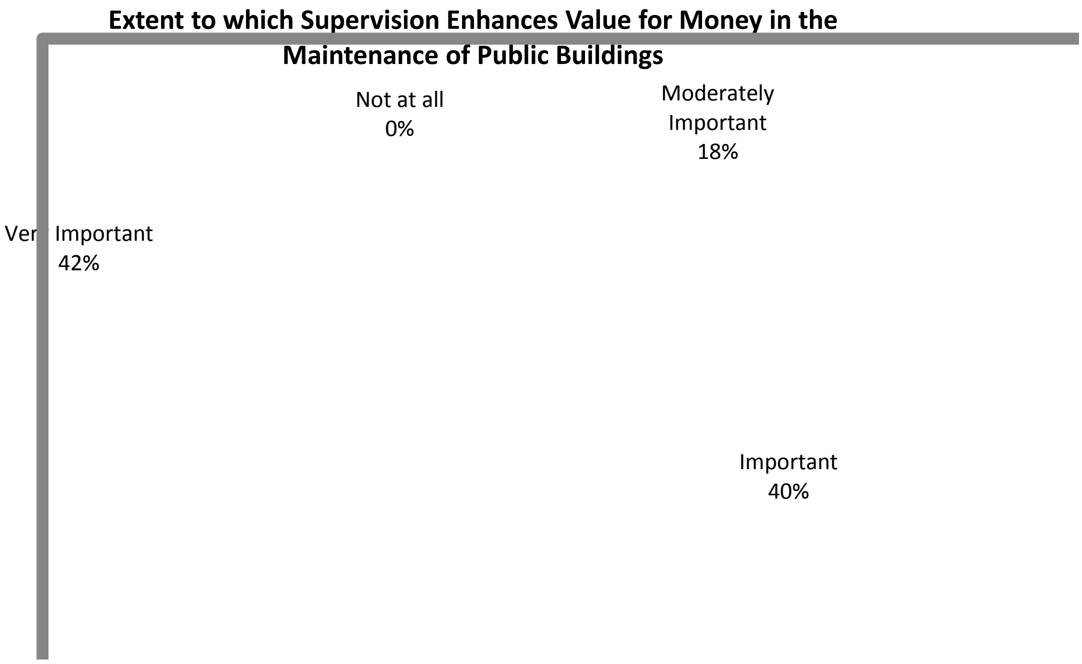


Figure 4. 12: Perception on Importance of Building Maintenance Policy/Manual

One respondent neither answered the question nor indicated any reason for declining. All the seventy three respondents confirmed the importance of building maintenance manual/policy at different ratings while none said the building maintenance manual is not important at all. Accordingly, the importance of a building maintenance manual towards revitalization of maintenance systems of public office buildings cannot therefore be over emphasized. An effective maintenance structure and system should therefore be guided by appropriate maintenance policy and manual.

4.6.6 Impact of Consumption of Utilities on Operational Costs

Caretakers of various sampled public office buildings were asked to rate the impact of consumption of water and electricity on operational costs. The rating was designed in 1 in 4 Likert scale and took the form of very low, low, high and very high. The response is summarized as Figure 4.13. Additional data is displayed in appendix 10.

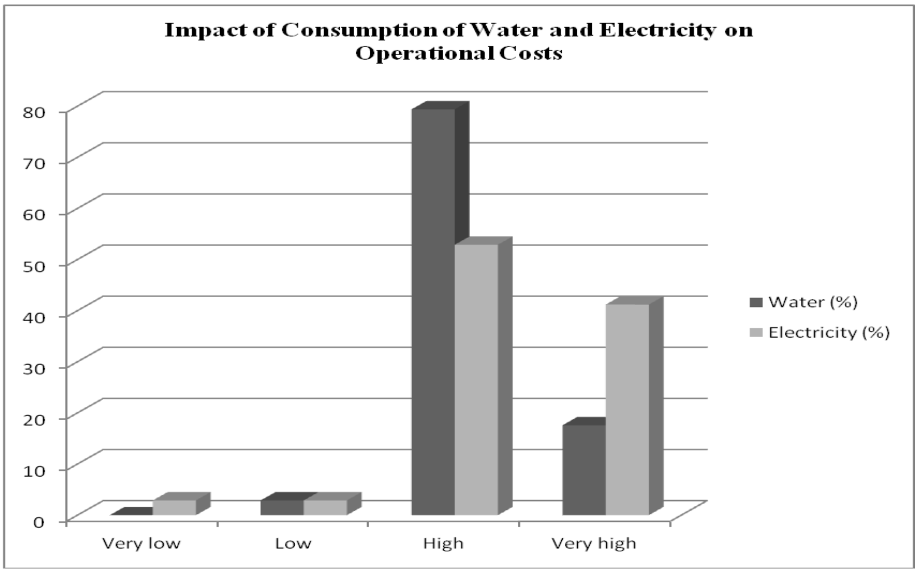


Figure 4.13: Impact of Consumption of Water and Electricity on Operational Costs

In the case of water consumption, thirty three out of thirty four equivalent to 97.0% rated its impact as either high or very high. Thirty two out of thirty four respondents representing 94.1% rated electricity consumption as either high or very high. According to maintenance experts and inspections conducted on sampled premises, the high cost of charges from undertakers of water and electricity supply has challenged maintenance managers to invest in renewable sources of utilities for example solar, borehole and roof water catchment to minimize consumption of metered utilities mains. This initiative supports the green building concept which is anchored on energy efficiency and water conservation principles (Consultants Network, 2006). Any savings realized from these alternative sources of utility can be re-directed to other needy areas of maintenance.

Measures Put in Place to Minimize Consumption of Water and Electricity

Caretakers of various Public Office buildings were asked to respond as to whether their organizations have put in place measures to minimize consumption of water and electricity.

The response was designed in a 'YES'/ 'NO' format and is recorded in Table 4.17.

Table 4.17: Measures Put in Place to Minimize Consumption of Water & Electricity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	6	17.6	18.2	18.2
	Yes	27	79.4	81.8	100.0
	Total	33	97.1	100.0	
Missing	System	1	2.9		
Total		34	100.0		

One caretaker did not answer this question but did not however indicate any reason for not responding. Twenty seven out of thirty three caretakers confirmed the existence of measures put in place to minimize consumption of water and electricity. The rating translates to 81.8% which shows that the majority of the administrators of public offices are conscious of the need to control consumption of utilities and therefore minimize costs.

The same caretakers were asked to indicate measures instituted by their organizations to minimize consumption of water and electricity in their respective premises. Several possible alternative measures were included in the questionnaire from which each caretaker was required to make choices from the possible alternative measures put in place to minimize consumption of water and electricity included:-

- Sustained use of natural lighting and ventilation;
- Adoption of energy saving electrical fittings;

- Use of sensor type plumbing fittings;
- Sensitization of users;
- Adoption of water saving taps

The responses are displayed as Figure 4.14. Additional data displayed in appendix 10.

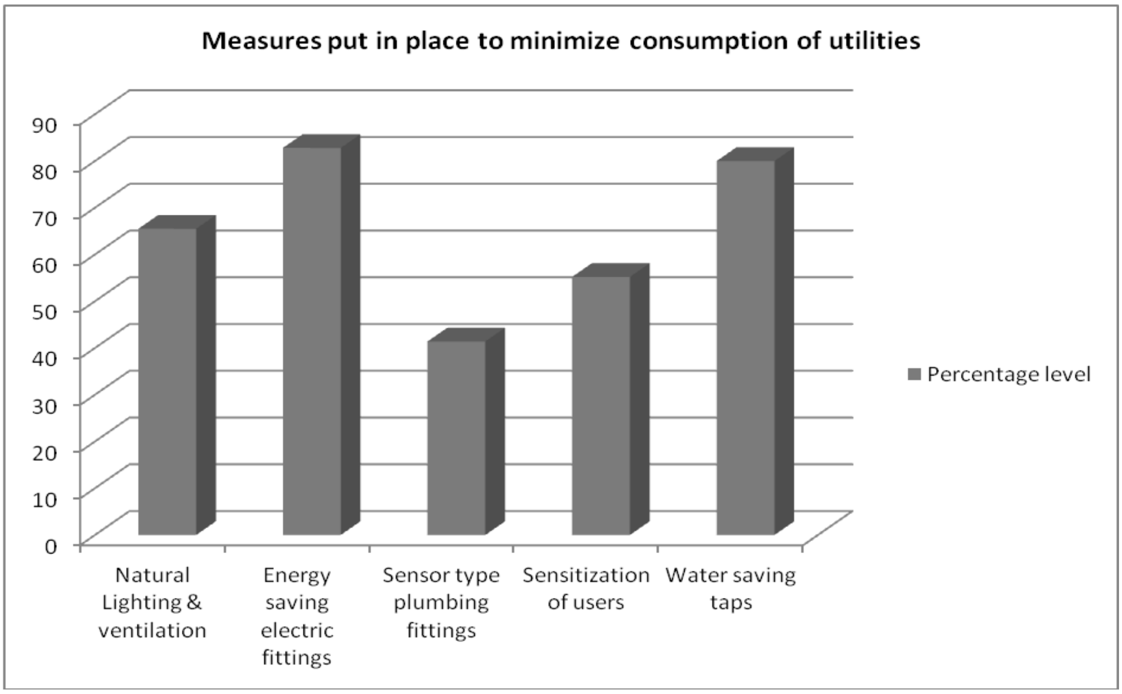


Figure 4.14: Response on Measures Put in Place to Minimize Consumption Of Utilities

Five caretakers did not respond to the question but did not indicate for whatever reason. Use of energy saving fittings and water saving taps are the most preferred measures for minimization of consumption of water and electricity at 82.8% and 80.0% respectively.

This is followed by sustained use of natural lighting and ventilation at 65.5%, sensitization of users at 55.2% with use of sensor type plumbing fittings being the most unpopular. Maintenance experts argue that, sufficient natural lighting and ventilation once provided for at design/construction is maintenance free as they are natural resources. This aspect is not directly under control of users but can only be influenced at design stage.

Sensitization requires minimal resources and can be programmed to take place during project commissioning. The rest of the measures involve fittings whose replacements will be inevitable at the expiry of service lives calling for regular budgetary allocation of the requisite funds as opposed to provision of natural lighting/ventilation and sensitization of users which just depends only on the initial cost. In circumstances where design parameters cannot allow for adequate natural lighting and ventilation, sensor type or energy saving fittings which become indispensable as real savings can be actualized as opposed to normal fittings. An effective maintenance system should incorporate appropriate structures to reduce the consumption of utilities in order that maintenance and operational costs of public office buildings are appropriately minimized.

4.6.7 Maintenance Work Accomplishment

It is generally in the public domain that the conditions of most public office buildings are in a sorry state due to a number of challenges. One of the draw backs that has seriously undermined the maintenance of public office buildings in Kenya is failure to accomplish maintenance targets which is one of the major inefficiencies of the current maintenance framework that the study investigated (Republic of Kenya, 2011). Failure to accomplish maintenance targets causes backlog of defects which if not addressed in good time might facilitate equipment breakdown or building component/element failure.

Maintenance Work Accomplishment in the Last Financial Year (2010/2011)

Caretakers of various sampled Public office buildings were asked to indicate whether programmed maintenance work was accomplished. The choice of response was in the YES/NO format. The response is as indicated in Table 4.18 below.

Table 4.18: Accomplishment of Maintenance Works Programme

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	21	61.8	63.6	63.6
	Yes	12	35.3	36.4	100.0
	Total	33	97.1	100.0	
Missing	System	1	2.9		
Total		34	100.0		

One respondent did not answer the question but did not give any reason for declining. Twelve out of thirty three responded in the affirmative (yes) translating to 36.4% while twenty one out of thirty three responded in the negative representing 63.6%. Therefore, it is revealed that programmed maintenance works in various public office buildings were not accomplished in most instances.

Further enquiries were made from the caretakers to indicate whether the un-accomplished work is less or more than 50%. The response is captured in Table 4.19 below.

Table 4.19: Percentage of the Un-accomplished Maintenance Work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 50%	18	52.9	66.7	66.7
	More than 50%	9	26.5	33.3	100.0
	Total	27	79.4	100.0	
Missing	System	7	20.6		
Total		34	100.0		

Seven respondents did not answer the question but did not indicate any reason for declining. Eighteen out of twenty seven respondents stated that less than 50% of maintenance works programmed for their premises was un-accomplished translating to 66.7% while nine out of twenty seven indicated that more than 50% of programmed maintenance work was un-accomplished translating to 33.3%. The backlogging effect with time can introduce most costly defects even to the extent of failure as witnessed in the collapse of Sun Beam Super Market tragedy (Republic of Kenya, 1996). It can therefore be safely concluded that programmed maintenance work is never completed and that a backlog of programmed annual maintenance work scope of less 50% is prevalent in most Public office buildings and can result to costly consequences.

Challenges Impacting on Completion of Scheduled Maintenance Work Programmes

Caretakers of various sampled Public Office Buildings were further asked to state challenges for non-completion of scheduled maintenance work scope. Four challenges among them in-

adequate funding, delays in execution, delays in procurement and under-staffing were listed in the questionnaires from which to choose from. Some respondents checked more than one item. The responses are highlighted in figure 4.15.

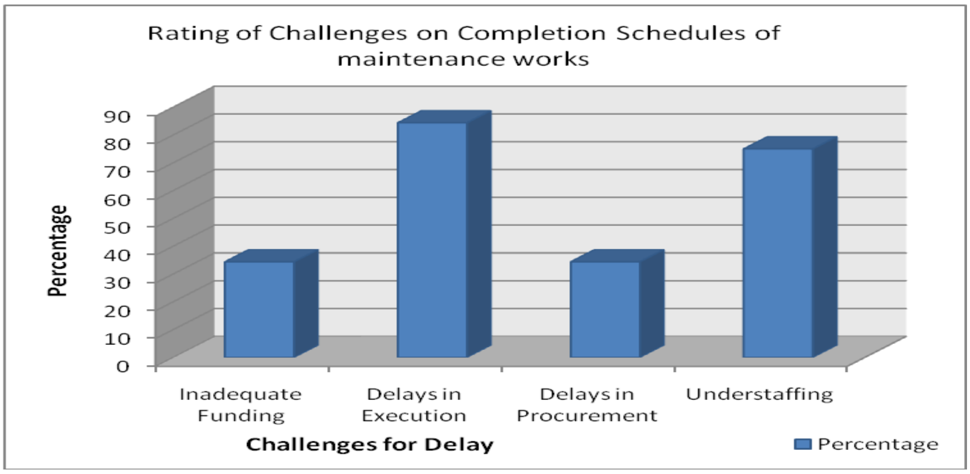


Figure 4. 15: Rating of Challenges Impacting on Completion of Schedules of Maintenance Works Programmes.

Summary of the responses are as follows:-

Inadequate Funding

Eleven out of thirty two indicated that in-adequate funding is a challenge representing at 34.4% while twenty one out of thirty three did not approve of in-adequate funding as a challenge translating to 65.6%. This item was jointly ranked last with delays in procurement. This perception contradicts the view point of budget officers. One can easily conclude that caretakers are not involved in the formulation of building maintenance budgets and may not therefore be privy to budgeting information on maintenance.

Bureaucratic Delays in Execution

Twenty seven out of thirty two stated that delays in execution is a contributor to non-accomplishment of maintenance tasks representing 84.4% while only five out of thirty two confirmed that delays in execution is not a factor at 15.6%. This item ranks first as a major contributor to non-accomplishment of maintenance programmes. Mode of execution of work is determined by the prevailing administrative and managerial systems which may need to be reformed in order that efficient/effective systems are put in place.

Procurement Process

Eleven out of thirty two stated that delays in the procurement process is a challenge at 34.4% while twenty one out of thirty two said delays in the procurement process is not a contributor to non-accomplishment of building maintenance at 65.6% an aspect that contradicts the stand taken by senior maintenance experts in the public service who view the current Procurement Act as an impediment to faster delivery of maintenance projects, a fact also confirmed by Republic of Kenya (2011). The Public Procurement Act requires that certain threshold of value of projects should be advertised for a period of 21 days and at the same time undergo 14 days appeals/complaints period after tender award contributing to a total of 35 days delays in project execution (Republic of Kenya, 2005). It is apparent that caretakers are not involved in the procurement process and therefore might not be knowledgeable on how the processes are being carried out.

Understaffing

Twenty four out of thirty two indicated that under-staffing is a major impediment to accomplishment of building maintenance programmes at 75% while eight out of thirty two at 25% did not approve under-staffing as a major challenge.

This item ranks second to delays in execution in order of prominence. Senior maintenance experts in the Public Service interviewed explained this scenario by arguing that the government lost a sizeable number of maintenance staff which included inspector-buildings and artisans in various trades through the staff retrenchment and rationalization programme executed in the late 1990's and early 2000's (Republic of Kenya, 1998). This exercise robbed building maintenance units of key maintenance staff needed for in-house maintenance programmes.

Considering the response from caretakers and budget officers together with the view point of senior maintenance experts from the public service, it can be concluded that all the four items contribute in one way or another to non-accomplishment of maintenance programmes with the leading challenge being delays in execution and understaffing. Reducing the impacts of these obstacles would reduce maintenance backlogs and therefore in the long run minimize cost in maintenance. It is a known fact that the backlogging effect has the ability of instigating more severe defects which can lead even to the extent of total failure.

4.7 Building Costs and Budgets

Findings in this study indicate that the majority of maintenance experts have strongly recommended the concept of planned maintenance system as opposed to the conventionally practiced corrective maintenance system. To be able to programme for planned maintenance it is necessary to forecast maintenance budgets with certainty in order that appropriate resources are set aside. The life cycle costing approach is suitable for planned maintenance while contingencies would be set aside to take care of emergencies that cannot be planned. This sub-chapter looks at age and floor areas as variables that influence maintenance costs and budgets. It further examines the relationship between the cost of maintenance requirements and the actual allocations.

4.7.1 Age and Floor Areas as Determinants of Building Maintenance Costs and Budgets

Ages and floor areas of sampled public office buildings were extracted from government records. The need for data on age and floor area is informed by past findings in literature review which indicate that they influence costs hence budgets. The extent to which age influences cost will be examined in the later stages of this document. Data on age of the various sampled public office buildings is captured as Table 4.20.

Table 4. 20: Age of Various Sampled Public Office Buildings.

Age (Years)		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	9	2	5.1	5.1	5.1
	11	1	2.6	2.6	7.7
	14	3	7.7	7.7	15.4
	16	1	2.6	2.6	17.9
	25	1	2.6	2.6	20.5
	28	2	5.1	5.1	25.6
	30	2	5.1	5.1	30.8
	31	6	15.4	15.4	46.2
	32	2	5.1	5.1	51.3
	33	4	10.3	10.3	61.5
	35	2	5.1	5.1	66.7
	36	1	2.6	2.6	69.2
	37	1	2.6	2.6	71.8
	38	2	5.1	5.1	76.9
	42	1	2.6	2.6	79.5
	43	1	2.6	2.6	82.1
	44	2	5.1	5.1	87.2
	45	1	2.6	2.6	89.7
	46	1	2.6	2.6	92.3
	54	2	5.1	5.1	97.4
	55	1	2.6	2.6	100.0
Total	1,255.8	39	100.0	100.0	

Mean – 32.2 years
Standard Deviation -11.84 years

The above table shows that the age of the 39 sampled public buildings range from 9 to 55 years with a mean of 32.2 and a standard deviation of 11.84. Records show 69.2% of the public office buildings sampled are old and therefore costly to maintain. Previous study by Rukwaro (1990) also confirms this theory that age as a variable influences building maintenance cost. Similarly, Republic of Kenya (1970) also recognizes the effect of aging on cost of building maintenance by providing a guide on how to factor age on cost of building maintenance. One issue that is not clear from the above guide is how to factor the effect of any major rehabilitation or refurbishment and whether the emergence of better performing materials may distort the percentages for computations. The floor areas for specific government organizations housed in sampled public office buildings were extracted from records. Some of the sampled public office buildings housed two or more government organizations. The floor areas are detailed in table 4.21.

Table 4.21: Floor Areas of Sampled Public Office Buildings

Floor Area (m^2)		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	700	1	2.6	2.6	2.6
	792	1	2.6	2.6	5.1
	900	1	2.6	2.6	7.7
	917	1	2.6	2.6	10.3
	933	1	2.6	2.6	12.8
	1168	1	2.6	2.6	15.4
	1185	1	2.6	2.6	17.9
	1280	1	2.6	2.6	20.5
	1288	1	2.6	2.6	23.1
	1400	1	2.6	2.6	25.6
	1500	1	2.6	2.6	28.2
	1530	1	2.6	2.6	30.8
	1560	1	2.6	2.6	33.3
	1883	1	2.6	2.6	35.9
	1950	1	2.6	2.6	38.5
	2100	1	2.6	2.6	41.0
	2250	1	2.6	2.6	43.6
	2496	1	2.6	2.6	46.2
	2688	1	2.6	2.6	48.7
	2776	1	2.6	2.6	51.3
	2800	1	2.6	2.6	53.8
	3485	1	2.6	2.6	56.4
	3500	1	2.6	2.6	59.0
	3600	1	2.6	2.6	61.5
	3611	1	2.6	2.6	64.1
	3800	1	2.6	2.6	66.7
	3900	1	2.6	2.6	69.2
	3920	1	2.6	2.6	71.8
	4000	1	2.6	2.6	74.4
	4200	1	2.6	2.6	76.9
	4554	1	2.6	2.6	79.5
	4992	1	2.6	2.6	82.1
	5220	1	2.6	2.6	84.6
	5284	1	2.6	2.6	87.2
	5500	1	2.6	2.6	89.7
	7303	1	2.6	2.6	92.3
	8480	1	2.6	2.6	94.9
	9000	1	2.6	2.6	97.4
	15600	1	2.6	2.6	100.0
Total	134043	39	100.0	100.0	

Mean – 3437m^2, Standard Deviation – 2872.4m^2

The floor areas for the 39 sampled public office buildings ranged from $700m^2$, the smallest public organization to $15600m^2$, the largest public organization with a mean of $3437m^2$ and a standard deviation of $2872.4m^2$. The total floor area for the sampled public buildings is $134043m^2$. The floor areas were necessary to compute unit costs for annual cost of maintenance and the respective annual budgetary allocations which were later applied to generate annual maintenance and budgetary allocation prediction model which could aid strategic planning for maintenance programmes. The maintenance cost and budgetary cost prediction model is discussed in detail in Chapter Five.

4.7.2 Relationship Between Cost of Annual Maintenance Requirements and the Actual Budgetary Allocations

Questionnaire enquiries were made from 39 budget officers of the sampled Public office buildings to obtain the annual budgetary requisitions and allocations for maintenance programmes in the last three years. (2009/2010, 2010/2011, 2011/2012).

The study findings as shown in the appendix 11 indicated that the mean annual budgetary requisition ranged from Kshs. 46,047, 576.05 to Kshs. 64,479,134.92 while the mean annual actual budgetary allocation ranged from Kshs. 36,949,987.37 to Kshs. 49,630,289.03. This illustrates that the budgetary support for maintenance programmes in the last three years does not match the cost of the maintenance requirements over the same period explaining the serious maintenance backlog that has characterized public office buildings in Kenya.

The findings of the investigation mirror those from Commission of Engineering Systems (1990) which also established that government funding for public buildings in Chicago, United States does not match maintenance requirements causing defects backlog. It is in this light that Republic of Kenya (2011) has proposed a maintenance fund levy equal to 5% of the property value to form a basis for financing maintenance programmes. It however remains to be seen whether this proposal can be enacted by parliament in a Country where taxation is one of the highest in the region. The backlogging effect of defects can have serious repercussions to the extent of costly equipment break down or building component/element failure thereby disrupting services (Cane, 1998). It therefore becomes necessary that a maintenance cost minimization strategy is generated to close the gap between cost of annual maintenance requirements and optimal budgetary allocations. The maintenance cost minimization strategy is discussed in detail hereunder.

4.8 Factors Influencing Maintenance Cost/Budget

This sub-chapter involves identification and rating of various factors that influence maintenance cost minimization in public office buildings. It further examines cost effectiveness of various construction materials for finishing exteriors and interiors of public office buildings by rating their performance. The essence of this study was to investigate maintenance variables that have the greatest impact on cost minimization for targeting in a cost minimization strategy.

4.8.1 Rating of Factors Influencing Building Maintenance Cost

One of the main objectives for this study was to investigate factors that influence cost minimization of public office buildings. Independent variables that could possibly influence cost minimization of building maintenance were identified through literature review.

The identified independent variables included:-

a) Renewable sources of utilities

b) Regular preventive maintenance

c) Positive attitude of users

d) Appropriate maintenance policy and manual

e) Timely adequate budgetary allocation

f) Appropriateness of materials and technology of construction

g) Appropriateness of design and effective supervision

h) Effective supervision of maintenance works

i) Regular research and innovation of maintenance systems

j) Effective management structure of maintenance units

Questionnaires were administered to sampled maintenance experts from the public sector to rank the ten identified independent variables in a scale of 1 in 10 in order to obtain their degree of influence on cost minimization of building maintenance works. The response is captured as Figure 4.16.

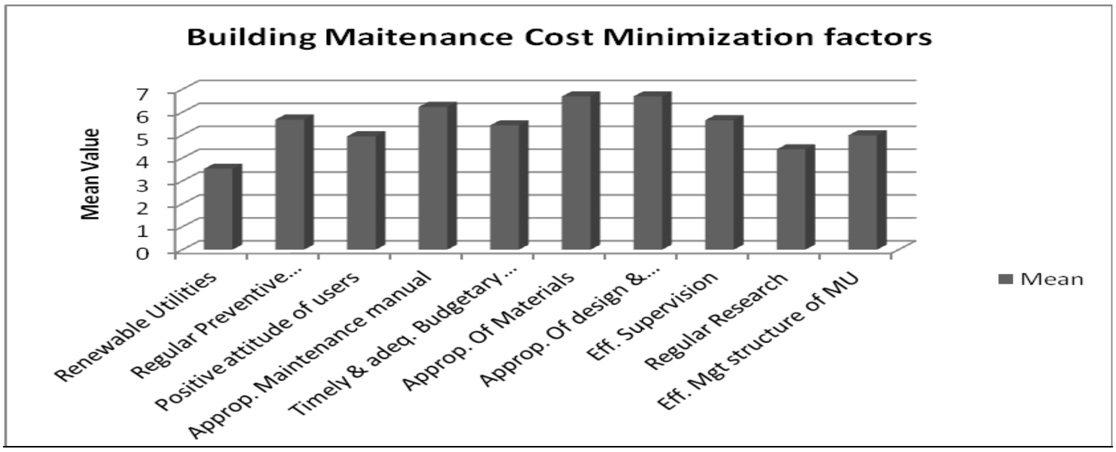
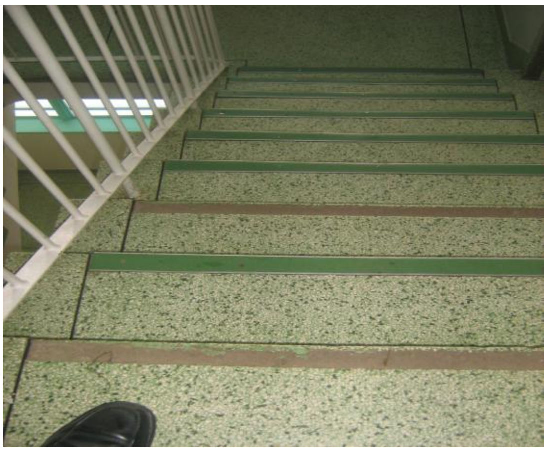


Figure 4. 16: Graphical Representation of Rating of Factors Influencing Minimization of Building Maintenance Cost

One out of seventy-four respondents did not answer the question but however did not state any reason for declining. All the 73 out of 74 experts who responded ranked the various independent variables identified from the literature review in a Likert scale of 1 in 10 by assigning varying rating of influence on the dependent variable which in this study is building maintenance cost. The rating of influence was computed in the form of mean item scores showing appropriateness of materials and appropriateness of design/supervision both ranked first as the most influential factors in maintenance cost minimization at 6.69. This is followed by appropriateness of maintenance manual/policy at 6.23, regular preventive maintenance at 5.68, effective supervision of maintenance works at 5.65, timely and adequate budgetary allocation at 5.43, effective maintenance structure of maintenance units at 4.99, positive attitude of users at 4.95, regular research in maintenance at 4.38 with renewable utilities being the least rated at 3.53. The first three most ranked factors are appropriateness of materials, appropriateness of design/supervision and appropriateness of building manual/policy and three other factors that follow are all above a theoretical mean item score of 5.0 showing their significance in maintenance cost minimization. Ishal *et al* (2007) argues in support of the existence of a strong link between design/quality control and the cost of maintenance at post-occupancy stage, Lee and Scott (2009) consider the building maintenance manual and policy as an important document that provides for legal and institutional framework within which to execute maintenance programmes to meet a maintenance standard, strategy and objectives. The findings of this study therefore echo those from past studies. Some of these variables for example design/supervision, renewable utilities and building maintenance manual are brought into play right from design/construction stage and needs to be controlled at this stage in order that future maintenance cost are minimized. The others except regular research which is a continuous process appear in the post-occupancy stage from which they can be manipulated to generate the desired results.

The research established some concepts of design through observations made during inspections of sampled public office buildings that significantly influence cost of maintenance. As discussed earlier, design determines choice of materials which has a bearing on frequency of replacement and ultimately influence maintenance costs in the long run. According to maintenance experts, an efficient design ensures that appropriate materials are specified in relevant spaces to be able to withstand tear and wear relative to their functional impacts. For example, hard wearing finishes like terrazzo and granite are suitable in heavy traffic areas while water resistant finishes like ceramic tiles are appropriate in finishing the wet cores. Equally, meeting rooms should be finished in materials with acceptable acoustic characteristics like carpet and timber parquet while external facades which are exposed require finishes that are resistant to the impacts of the environment. In a cost minimization strategy which forms one of the main objective of this investigation, the assessment of appropriateness of materials is anchored on functionality, cost and durability in line by the value management principles expressed by Bateman and Smell (2009) and Lateef (2010). As indicated by maintenance experts and confirmed by observations during inspection, numerous deficiencies in the design of the premises that were sampled were established which make some buildings expensive to maintain. Cases where in-appropriate design and choice of materials have been adopted are documented in Photographs 4.26, 4.27, 4.28, and 4.29.

Photograph 4. 26: In-appropriate Choice of Parquet as Floor Finish to NCPB House. Parquet cannot withstand wear and tear subjected from space use impacts.



Photograph 4. 27: In-appropriate Use of Stairs to Works House. as a Design Deficiency. The stairs anti-slip has been ripped off through movement of goods which could have ferried through a goods lift.

Photograph 4. 28: Painted External Facades of the National Cereals and Produce Board Headquarters, a Non-Cost Effective Finish and a Case of In-Appropriate Design.

Photograph 4. 29: In-appropriate Choice of PVC Floor Finish to NCPB House. The PVC finish cannot withstand the degree of wear and tear to which it has been subjected.

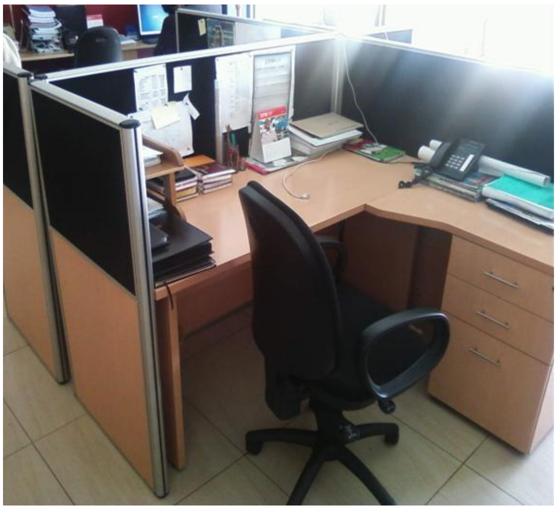
Maintenance experts argue that the deterioration levels of buildings facades are faster on the exterior due to exposure to environmental impacts like weather, pollution and other degradation factors. The degree of deterioration depends on the severity of the environment which differs from region to region. Appropriate choice of materials for external façade is therefore necessary in situations where maintenance cost minimization is key, for instance the maintenance of public office buildings where budgets are constrained. Observations made on facades of sampled pubic office buildings some of which are cost effective are illustrated in photographs 4.30 and 4.31.

Photograph 4. 30: Fair Faced and Glazed External Façade of the Kenyatta International Conference Centre, a Cost Effective and a Case of Appropriate Design.

Photograph 4. 31: External Façade of NHIF Finished in Glass and Alucobond as a Response to Modern Architecture and also a Cost Effective Design Option.

Maintenance experts argue that the design specifications for interior wall partitions influence future maintenance costs, a scenario that is also advanced by Teo and Harikrishna (2005). The manner in which the enclosing partition walls are organized determine surface areas and the level of electrical/mechanical services to be maintained and therefore has a bearing on the future maintenance costs. The emerging open plan and glass partitions concept in public office buildings is an attempt to reduce maintenance costs due to budgetary constraints. The government of Kenya has since issued circulars to ministries and state parastatals/corporation to have the concept implemented in a period of five years. During inspections of the sampled public office buildings, it was observed that some ministries and state parastatals/corporation have already started implementing the directive as shown on photographs 4.32 and 4.33. More observations were recorded in appendix 9.

Photograph 4.32: Glass Partitions to the7th Floor, Works Building, a Design Concept with Minimal Maintenance Costs.



Photograph 4.33: Open Plan Office Space for Insurance Regulatory Authority at Zep-Re Place, a Design Concept with Minimal Maintenance Costs.

For designs other than open plan, it was explained by maintenance experts that the choice of internal cladding materials do not only depend on the cost but also on other design parameters. Some state parastatals and corporations who are financially endowed have however given aesthetic and functional requirements more weighting relative to cost parameter. In the matter of the maintenance of Public office buildings whose maintenance budgets are constrained, the cost aspect should outweigh other design parameters. Photograph 4.34 shows adoption of appropriate internal wall cladding material in a boardroom. Other observations are included in appendix 9.

Photograph 4.34: Adoption of Timber Panels in the Chief Architect's Boardroom, 12th Floor, Works House, a Wall Cladding Material with Minimal Maintenance

Observations made during inspections indicate that the majority of the public office buildings that were sampled were originally designed with flat roofs, 90% of which have been converted into pitched roofs. Maintenance experts explain that the designs did not anticipate that the prevailing climatic conditions would require costly frequent replacement of the water proofing membrane calling for change of roofing style to reduce maintenance costs. Photograph 4.35 is a case where a flat roof has failed prompting erection of a pitched roof.

Photograph 4.35: Re-roofing to Foreign Affairs (Old Treasury) House, a Design Solution for Flat Roofing Challenges. Most public organizations are un-able to afford the frequent replacement costs of the water proofing membrane.

Riapan (1986), a local researcher responded to this phenomenon by conducting a study on the problems associated with flat roofs as a major concern in the maintenance of Public buildings. The study findings culminated into a major re-roofing programme for Public buildings in Kenya.

4.8.2 Ranking of the performance of various exterior/interior finishes

Sampled experts were asked to rate the performance of various exterior and interior finishing materials. This was important since the deterioration of building elements starts manifesting itself from the external/interior skin envelope provided by finishes. Various alternative finishing materials were listed in the questionnaire and grouped as either exterior or interior from which respondents ranked their performances in a Likert scale of 1 in 7. The rankings were done through computations of the mean item scores. The response on ranking of exterior finishes is recorded as Figure 4.17. The external finishes ranked included keyed masonry, granite tiles, ceramic tiles, wall master, plastered painted, brick facing and fair faced finish.

Figure 4.17 shows graphical representation of the ranking of various exterior finishes.

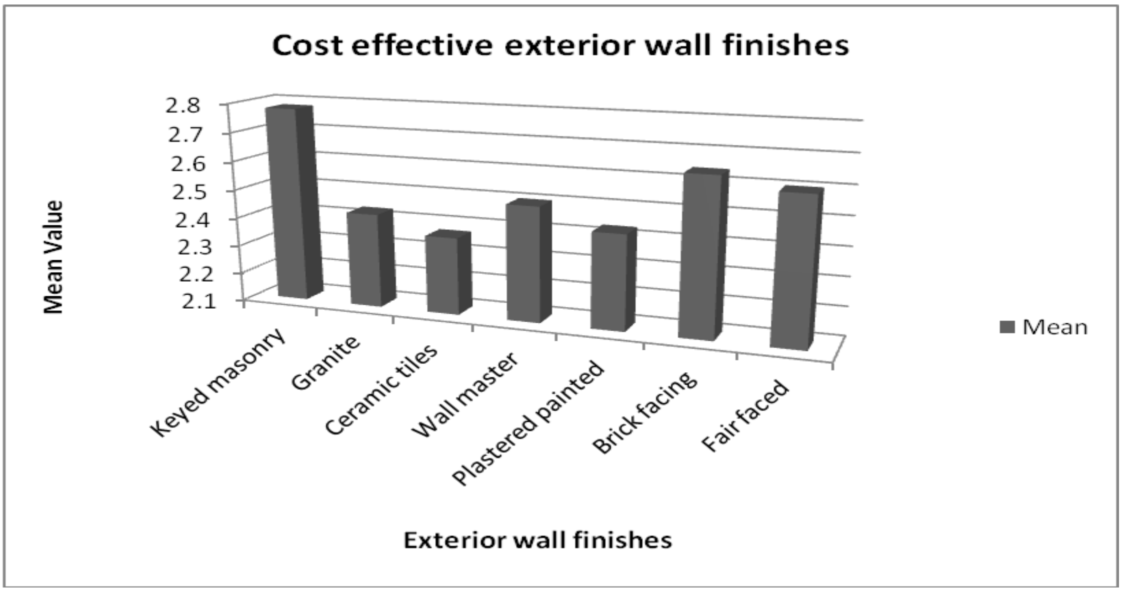


Figure 4.17: Graphical Representation of the Ranking of various Exterior Finishes

6 out of 74 respondents did not answer the question but however did not indicate any reason for declining. 68 out of 74 respondents ranked the cost effectiveness of various exterior finishes at different ratings. The ratings were computed in the form of mean item scores which indicate keyed mansory ranking first at 2.78 followed by brick facing at 2.64, fair faced at 2.60, wall master at 2.50, granite and paint tying at 2.43 while ceramic tiles lies at the bottom of the ranking at 2.37. The cost effectiveness is a combination of the initial cost and durability. While keyed masonry which was ranked first is associated with reasonable initial cost and long life, it is rated low where aesthetics and modernity is a major consideration and serves quite well where cost reduction is a major consideration. It is thus important to balance the initial cost with durability and aesthetics in order to strike a balance. Observations made on exterior finishes that influence maintenance cost are illustrated in photographs 4.36, 4.37, 4.38 and 4.39.

Photograph 4. 36:Fair Faced External Façade of the Afya House with Limited Painted Surfaces, a Cost Effective Finish

Photograph 4. 37: Keyed Masonry External Façade of Madini House with Fair Faced Beams. Madini House is mainly in keyed masonry which only requires wire brushing and cleaning at minimal cost.

Photograph 4. 38: Tyrolene Finished External Façade of Jogoo House A, a Cost Effective Finish .Jogoo House A is finished in tyrolene finish which although dull provides a cost effective maintenance solution.

Photograph 4. 39: Painted External Façade of Protection House, a Non-cost Effective Finish. The external façade of Protection House is finished mainly in plaster/paint which requires frequent repainting and hence costly to maintain.

The interior finishes included PVC tiles, ceramic tiles, wood parquette, cement/sand screed, carpet, granite tiles and granito tiles. Response on ranking of the performance of interior finishes was recorded represented as Figure 4.18.

Figure 4.19 is a graphical representation of the performance of various interior finishes.

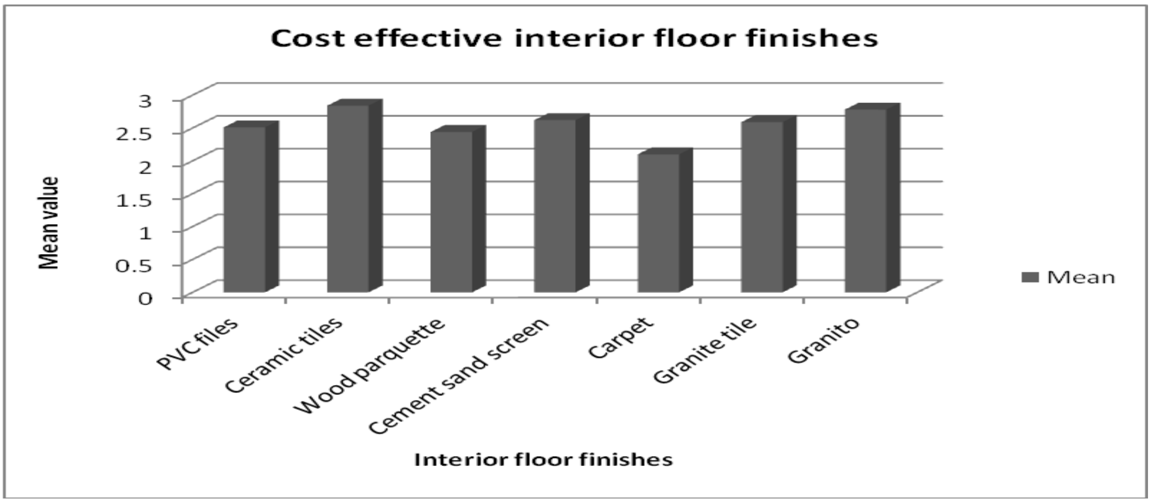


Figure 4.19: Graphical Representation of the Performance of Various Interior Finishes

Four out of seventy four respondents did not answer the question but however did not indicate any reason for declining. Sixty nine out of seventy four respondents ranked the cost effectiveness of various interior finishes at different ratings. The ratings were computed in the form of mean item scores showing ceramic tiles leading the ranking at 2.84 followed by granite tiles at 2.78, cement sand screed at 2.62, granite tiles at 2.59, PVC tiles at 2.51 with carpet at 2.10 lying at the bottom of ranking. As argued for the exterior finishes, the major overriding consideration in cost effectiveness is the initial cost and durability. Similarly, when required to make a choice, other factors for example aesthetics, modernity and class of building also comes into play. Observations made during inspections of sampled public office buildings on various interior finishes that influence maintenance cost are indicated in photographs 4.40 - 4.43.

Photograph 4. 40:Use of Ceramic Tiles to Washrooms to Jogoo House A, a Cost Effective Internal Cladding Material. Ceramic tiles are water proof and therefore suitable in wet areas like washrooms and Kitchenettes. Cost in use is very low but higher initial cost than paint.

Photograph 4. 41: Quality Terrazo Floor Finish to Works House. Terrazzo is durable as well as not too costly and can withstand wetness and heavy traffic. Cost in use is very low but less appealing compared to tiles.

Photograph 4. 42:Quality Granito Tiles at Lift Lobby to 8th Floor, Works House. Granito tiles are more expensive than ceramic tiles but durable and can stand high impact. Cost in use is very low.

Photograph 4. 43:Quality Granite Tiles in the Modernized Lift Lobby to 2nd Floor (Executive) Works House. Initially expensive but cost effective in the long run.

4.9. Conclusions

The first objective of this study was to determine defects, their causes and ratings. On the other hand identification of their causes would enable maintenance managers strategize on how to effectively manage them with a view to minimizing maintenance costs within the optimal budget. Finding of this study identified eight possible causes of common defects in sampled public office buildings and rated them. Poor supervision and negligence top the list followed by vandalism. The other factors in descending order were; design deficiency, management problems, normal wear/tear, natural phenomena with termite infestation lying at the bottom as the most insignificant cause of maintenance defects in public office buildings. These factors can be incorporated in the desirable maintenance model to minimize maintenance costs in the long run.

The second specific objective of this study was to establish maintenance workscope in public buildings. Maintenance workscope was categorized either as major or minor. The findings indicate that fabric constituted the largest proportion in major maintenance workscope while mechanical/electrical services stood more prominently in minor maintenance workscope.The rationale behind it being that maintenance workscope is necessary in planning and drawing up maintenance budgets. It is also the basis for prioritization for major items for cost minimization.

The third specific objective was to assess the existing maintenance framework with a view to formulating an appropriate legal and institutional framework for maintaining public office buildings. This research finding revealed that corrective maintenance is widely employed in the maintenance of public office buildings. However, response from the experts interviewed overwhelmingly supported the adoption of preventive maintenance as the most cost effective approach in managing maintenance of public office buildings followed by predictive maintenance thus outdoing the other options of value based maintenance, and corrective maintenance being the least preferred.

The findings also established that most public offices do not have sufficient capacity to undertake maintenance activities through in-house maintenance units. It however observes that some of the semi-autonomous state corporations and parastatals endowed with better financial resources have more established in-house maintenance units with desirable staffing level and adequate tools of trade and have therefore provided effective, efficient maintenance services giving rise to better maintained premises. Others have engaged private property managers who oversee maintenance programmes for their premises and have equally succeeded in maintaining them properly. The sampled maintenance experts appreciated the fact that regular maintenance is either significant or very significance as this reduces maintenance backlog.

The study findings emphasizes on the importance of building maintenance policy/manual in the management of building maintenance programmes. In additional, maintenance managers must devise ways to tackle the challenge of high impact of utilities consumption on operational cost. The study findings reveal an overwhelming impact of consumption of water and electricity on operational costs. However, a substantial number of public office buildings as the findings suggest have put in place various measures to minimize on consumption of the conventional utilities with water saving taps and energy saving fittings as among the most preferred measures. It is therefore necessary that the maintenance policies, standards and strategies as established in this study are incorporated into the desirable effective maintenance framework.

The fourth specific objective was to derive maintenance costs/budgets and factors that influence them in public office buildings. The main focus here was to derive maintenance costs/budget and the most influencing factors with the greatest impact on maintenance cost minimization. The maintenance cost/budget data of sampled premises were obtained from Finance Officers through questionnaire (Appendix 4C). The data covered the last three Financial Years 2009/2010, 2010/2011 and 2011/2012. The mean annual budgetary requisition (maintenance cost) ranged from Kshs. 46,047,576.05 to Kshs. 64,479,134.92 while the mean annual actual budgetary allocation ranged from 36,949,987.37 to Kshs. 49,630,289.03. The implication of this finding is that the budgetary allocations for maintaining public office buildings is never adequate. The desires by maintenance managers to have the gap between maintenance cost and the actual budgetary allocations reduced justifies the need to investigate cost minimization factors. Further results of the study established that in the rating order, design/supervision, materials specification and the building maintenance policy/manual have the greatest impact and should therefore be prioritized to minimize maintenance cost especially in the maintenance programmes of public office buildings where maintenance budgets are constrained.

The fifth objective of this study was to develop a maintenance cost/budget prediction model. In fulfilling this objective, a growth/trend curve fitting projected from cost/budget data for the last three financial years was employed to predict future unit costs of annual maintenance requirements and budgetary allocations to be able to plan for the requirements of future maintenance programmes. The trend curve illustrates a continued widening gap that exist in resource need and the actual resource allocation for maintenance hence calling for appropriate cost minimization factors to be put in place to close the gap between maintenance costs and budgetary allocations. The prediction model is based on Chiang (1984) and is discussed in detail in Chapter five. The implication of this finding is that future maintenance costs/budgets can be accurately predicted with certainty for effective planning of maintenance programmes.

The sixth objective of this study was to formulate a legal and institutional framework to provide leverage within which to execute maintenance programmes. The guidelines, standards, policies and strategies established through the first five objectives and reviews of existing maintenance policies and frameworks formed a basis for formulation of the legal and institutional framework. The Ministry of Public Works, National Building Maintenance Authority, County and Depot structures were identified as the appropriate institutions through which maintenance programmes would be executed. The formulation of legal and institutional framework is discussed into detail in Chapter five. The institutional and legal framework is expected to provide a firm foundation for improvement of the efficiency and effectiveness of the existing maintenance framework in delivery of timely, quality and cost-effective maintenance services to satisfy the users' expectations.

Chapter four displayed, analysed, interpreted and discussed data obtained from the field with a view of addressing the aim of the study. The discussions zeros in on the need for a cost/budget prediction model and a legal/institutional framework for effective maintenance. The next chapter therefore looks at the cost/budget prediction model and a legal/institutional framework to be adopted for the maintenance of public office buildings.

CHAPTER FIVE:

5.0 MAINTENANCE COST PREDICTION MODEL AND LEGAL/ INSTITUTIONAL FRAMEWORK

5.1 Introduction

Field investigations established that the current maintenance framework is in-effective and that a combination of planned preventive and predictive building maintenance system is the best approach to manage challenges that have bedeviled maintenance of public office buildings in Kenya. Planning for maintenance programmes for public office buildings requires that maintenance costs and budgets are predicted with utmost precision calling for generation of a prediction model. The study further revealed that maintenance programmes for public office buildings are being executed haphazardly without reference to any policy guidelines. It therefore becomes indispensable that an appropriate legal and institutional framework to give leverage the positive findings of this study is formulated.

This chapter therefore discusses the adoption of an appropriate cost/budget prediction model to guide planning for maintenance programmes. It also looks at formulation of an appropriate legal and institutional framework to provide a platform from which to execute maintenance programmes

5.2 Maintenance Cost/Budgetary Allocation Prediction Trend

This study employs a growth/trend curve fitting model to be able to predict the maintenance cost and government budgetary allocations for building maintenance programmes. Based on the trend analysis, the formula for computing the Annual Predicted

Maintenance Cost (APMC) and Annual Predicted Budgetary Allocation (APBA) can be written into an exponential expression with base (1+r) as shown in the equation below:

$$Y_t = Y_{t0}(1 + r)^{t-t_0}$$

This is the solution to a homogenous differential equation (Chiang, 1984) where Y_t is the indicator for Annual Predicted Maintenance Cost (APMC) or Annual Predicted Budgetary Allocation (APBA) at the current year (t), r is the annual increase rate and Y_{t0} is the indicator for APMC or APBA at the reference period (t_0), financial year 2009/2010. In order to calculate the annual increase rate given the number of years and the values of the average maintenance cost and average budgetary allocation at both initial and current periods, the above equation can be re-written as:

$r = Exp\left[\frac{lnY_{t/Y_{t0}}}{t-t0}\right] - 1$ where *ln* is the natural logarithm ($\log_{10}$)

The above prediction model was adopted through a critical review of previous research work on various cost/budget prediction models. This is useful in predicting the annual average maintenance cost and budgetary allocation for maintenance given any base period. The data on budget requisition (cost of maintenance) and allocation for the last three financial years was obtained by administering appropriate questionnaires to budget officers from sampled public offices. The budget officers extracted the data from their respective financial records and which have been annexed as Appendix 11. Unit costs for the annual maintenance cost and budgetary allocations for the past three years were computed and presented as Table 5.1 and are the basis for prediction.

Table 5.1:Unit Cost for Annual Maintenance and Budgetary Allocation

Item No.	Item Description	Unit Cost (Ksh/m^2) 2009/2010 F/Y	Unit Cost (Kshs/m^2) 2010/2011	Unit Cost (Kshs/m^2) 2011/2012
1.	Annual Budgetary Requisition (Maintenance Cost)	3,144	3,445	3,976
2.	Annual Budgetary Allocation	2,373	2,451	2,992
3.	Budgetary Shortfall	771	994	984

The results indicate that the budgetary allocations do not match with budgetary requisitions. This study therefore endeavors to bridge the gap between budgetary allocations and requisitions by identifying appropriate maintenance cost minimization factors.

To calculate the values the maintenance cost and budget allocations will assume in the coming financial years through use of the formulas mentioned earlier, the data is first described in terms of geometric means to minimize the effect of outliers given that the cost data varies across the sample population.

The formula for calculating the geometric mean is indicated below:-

$Mg = \sqrt[n]{X_1 X_2 \text{---------} X_n}$ where X_1, X_2 and X_n are variables with Mg as the geometric mean and n as the total number of variables.

The results as displayed in Table 5.2 and Figure 5.1 overleaf show a continued widening gap in resource need and resource availability for maintenance of public office buildings. Maintenance cost continues to increase at a higher rate whereas the financial resources availed for the same by the government appreciates at dismal rates. The desirable budgetary allocation should be at the level where the trend curves touches each other. Therefore, the aim should be to minimize cost such that the maintenance cost trend-curve shifts down to be at same level with that of budget allocation. The cost minimization option can be achieved by identifying those factors in the maintenance system that can be manipulated to reduce the maintenance cost implication. Ten cost minimization factors were identified and rated as shown in section 4.8 and form part of a cost minimization strategy.

Table 5.2 shows predicted annual maintenance unit costs and budgetary allocations.

Table 5. 2: Predicted Annual Maintenance Unit Costs and Budgetary Allocations (Shs/m^2)

Financial Year	Predicted APMC	Predicted APBA
2009/10	3,144	2,373
2010/11	3,445	2,451
2011/12	3,976	2,992
2012/13	4,300	3,232
2013/14	4,650	3,492
2014/15	5,029	3,773
2015/16	5,438	4,076
2016/17	5,881	4,403
2017/18	6,360	4,757
2018/19	6,877	5,139

Figure 5.1 shows the trend curve for maintenance costs and budgetary allocation in government buildings.

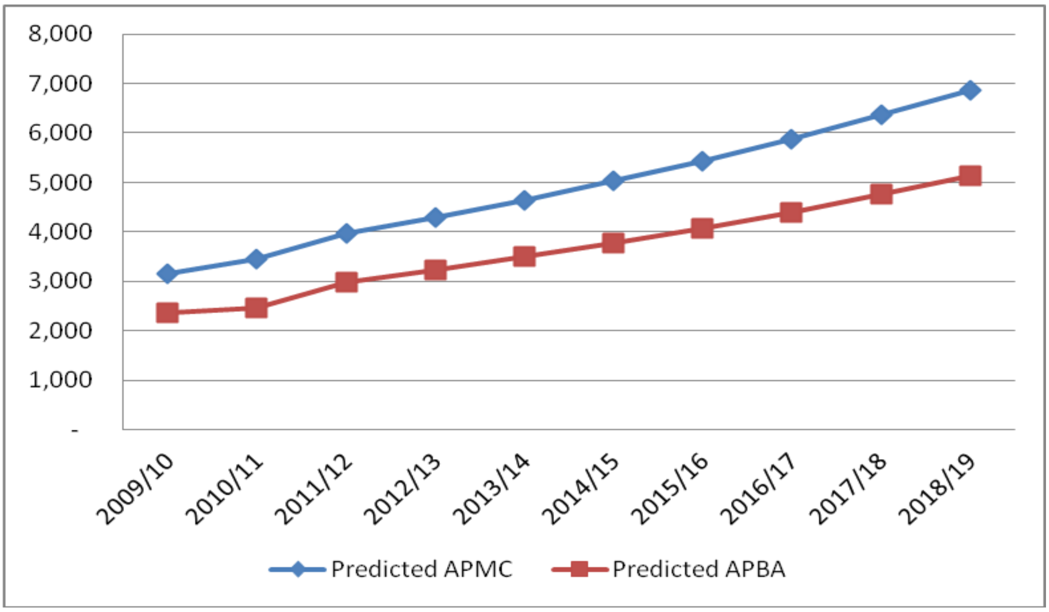


Figure 5.1: Trend in Government Buildings Maintenance Cost and the Actual Budgetary Allocation for Maintenance

As displayed in the above figure, there is a continued widening gap in resource need and resource availability for maintenance cost. Maintenance cost continues to increase at a higher rate whereas the financial resources availed for the same by the government appreciates at dismal rates. Cost minimization is thus prudent to close the gap between the two trend curves.

According to Granger (1980), though the trend-curve fitting can provide useful forecasts, at least for the middle-run, it is basically unsatisfactory in that it is essentially based on an assumption that things will keep on moving in the same trend that they followed in the past. Although this could often be the case, policy changes and adjustments could limit the growth in certain directions. This thus calls for the need to control for other factors that affect maintenance cost, which could be made possible by using a cost minimization regression analysis.

Findings from past studies enumerate various building maintenance prediction models which however are not holistic but specific to certain building components or elements.

Sayward, (1984) and Purvis *et al* (1992) projects a model which is limited to the performance of concrete structure through extrapolation to the future. Although this is a simple model, it does not allow for a thorough assessment and quantification and therefore can lead to in-accurate results. Roy *et al* (1996) modeled an approach for monitoring deterioration of painted surfaces. The problem with this model is that the approach is only effective when all conditions to which a component or element is exposed are considered and is therefore likely to provide non-accurate results. Shohet *et al* (2002) developed a model based on service life prediction for forecasting exterior cladding materials. The main drawback for this model is that a wide range of cladding materials are available in the market with varying degrees of performance eliminating global application of the model. Lounis and Vanier (2002) modeled a stochastic optimization method for budgeting of roof maintenance. Just like for exterior cladding, the roof structure and covering is available in varying quality making it difficult to generalize the application of this model. The difficulty within which to harmonise the elemental models cited above calls for a unified approach for which this study is designed. The Chiang (1984) prediction model can be applied on all elements/components of buildings and is therefore is the most appropriate for prediction of maintenance costs/budgets for public office buildings.

5.3 Developing a Legal and Institutional Framework for Maintenance

5.3.1 Introduction

This section examines the shortfalls of the existing maintenance framework with a view to offering an alternative effective framework within which to execute maintenance of public office buildings. It proceeds to formulate appropriate legal and institutional framework that would assist maintenance managers in implementing maintenance programmes in the public sector. The Legal and Institutional Framework was formulated by taking into account the following:-

- The findings of the study as derived from objectives one, two, three, four and five.
- Maintenance Management Framework for Queensland Government (2010)
- Building Maintenance Policy for South Hams District Council (2006).
- Building Maintenance Policy for East Sussex County Council (2001).
- Draft National Building Maintenance Policy for Kenya (2011).

Due care was taken to align the new framework with the provisions of the current constitution of the Kenya Government to avoid any conflict.

5.3.2 Existing Maintenance Framework

Legal and Institutional Framework lays down a foundation for the effective execution of maintenance programmes. The Draft Building Maintenance Policy (Republic of Kenya, 2011) and findings of this study confirms that maintenance of public office buildings are carried out haphazardly without regulation as no proper legal and institutional framework exists. The absence of clear legal and institutional framework as established by the study findings has contributed to non-accomplishment of maintenance targets mainly due to low budgetary allocations, in-sufficient capacities of maintenance units coupled with in-effective maintenance approaches and systems. This has led to the costly, ineffective maintenance systems and structure whose overhaul is inevitable.

A comprehensive legal and institutional framework is in no doubt key to addressing the challenges of the existing framework for maintaining public office buildings. The study findings indicate that any serious maintenance strategy should not only encompass maintenance issues at post-occupancy but also at design and construction stages. The results of the findings are depicted schematically as figure 5.2. An effective maintenance strategy should thus address maintenance issues right from design stage.

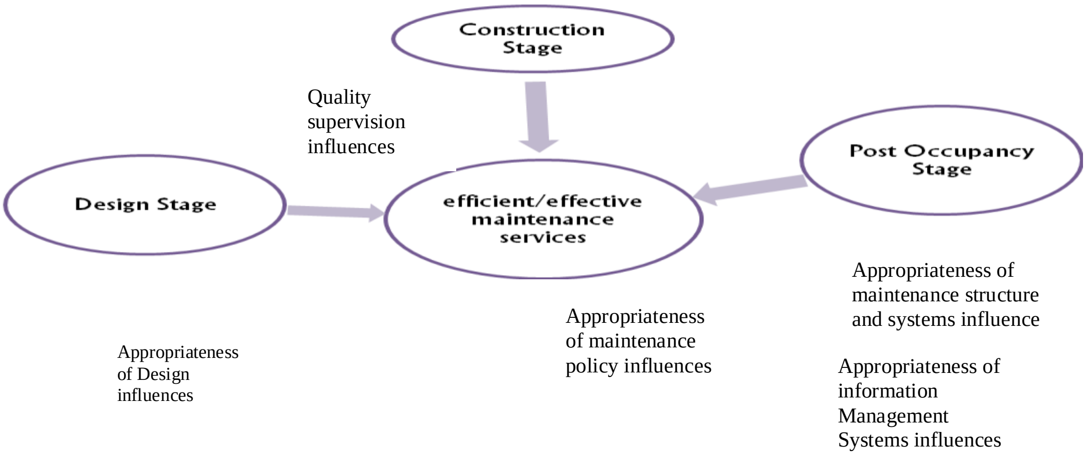


Figure 5. 2: Maintenance Strategy of Public Office Buildings

Source: Adapted from Queensland Government (2010)

5.3.4 Aims and Objectives

The aim of this framework is to provide guidelines for the effective implementation of maintenance programmes of public office buildings within optimal budgets by ensuring that these buildings are maintained within set standards for continuity in usage as well as address safety, health and comfort concerns by users.

Specific objectives are aligned with the study objectives and include:-

a) Establish guidelines for the efficient management of routine, periodic and emergency maintenance.

b) Ensure that buildings are adequately maintained through prioritization of maintenance activities.

c) Inculcate a maintenance culture in the users of facilities to reduce rampant vandalism and negligence.

d) Address environmental health and safety concerns in buildings as part of statutory requirements.

e) Enhance capacity of the building maintenance management through provision of adequate staffing, equipment/transport and budgetary support.

f) Introduce building maintenance cost minimization strategies to align maintenance costs with optimal budgets.

g) Identify common buildings defects, causes and strategies for minimizing or eliminating them.

h) Put in place a systematic way of predicting maintenance costs and budgets for planning.

i) Establish an appropriate regulatory and operational framework.

j) Review and harmonise relevant existing legislation and regulation on building maintenance scattered in various statutes.

k) Establish appropriate information management system for records, monitoring and evaluation of maintenance operations, processes and systems.

l) Incorporate maintenance requirements right from design stage of proposed public office buildings..

m) Establish appropriate user reaction surveys on newly completed public office buildings to act as a feedback mechanism on review of designs for future buildings.

5.3.5 Legal Framework

Appropriate legislation is paramount in providing legal anchorage for implementing the recommendations of this study through creation of a conducive environment. Republic of Kenya (2011) and maintenance experts argue that maintenance has been undertaken haphazardly due to the in-adequacy of the uncoordinated numerous fragmented policies and institutions. There is therefore need to review, harmonize, coordinate and consolidate existing fragmented legislation and institutions.

When formulating a building maintenance legal and institutional framework, it is necessary to understand the processes that maintenance undergoes. Queensland Government (2010) identifies four key processes as indicated in Figure 5.3.

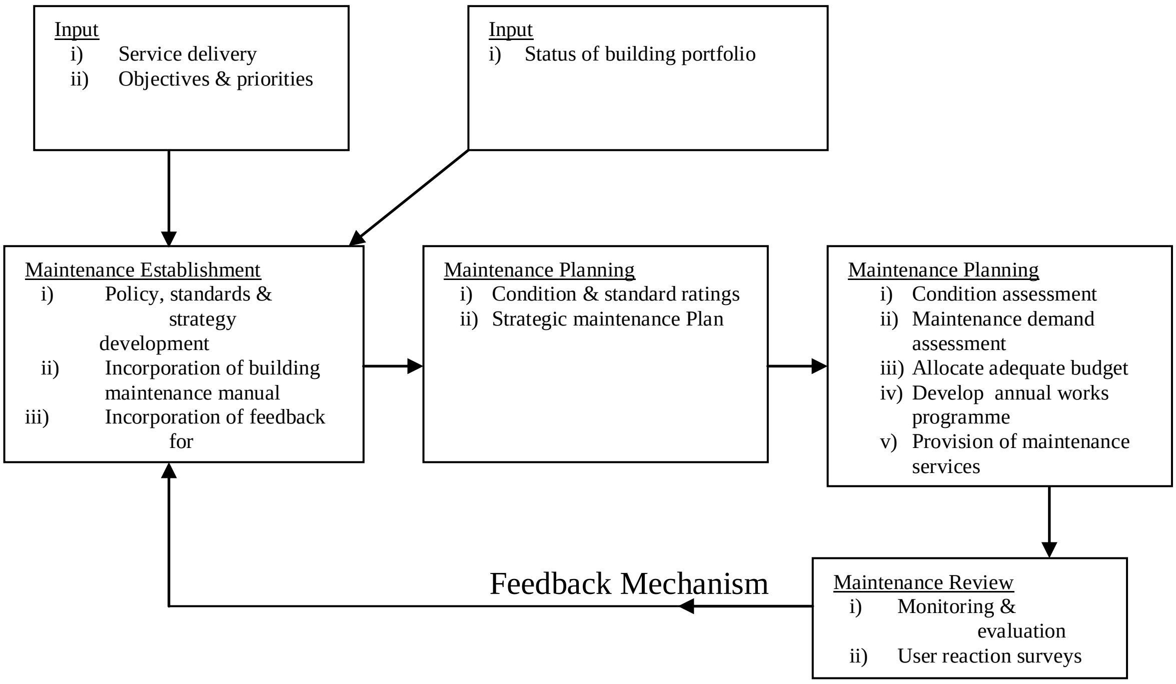


Figure 5. 3: Maintenance Management Processes

Source: Adapted from Queensland Government (2011)

The four processes i.e. maintenance establishment, planning, implementation and review form a basis for formulation of an effective maintenance framework since shortcomings in the processes can be identified for elimination or minimization through appropriate strategic actions.

A legal framework is meant to provide the leverage through which to execute maintenance programmes effectively. The proposed legal framework is guided by the findings of this study but within the provisions of the current constitution of Kenya. It provides for legislation for the entrenchment of the maintenance guidelines, policies and standards. It thus provides for the following:

a) Legislation

- To review and amalgamate the fragmented pieces of legislation and regularise as building maintenance policy act.
- To provide legal leverage for the setting up of the National Building Maintenance Authority with oversight authority over implementation of building maintenance programmes.
- To enact specific laws for the regulation of building maintenance.
- To enact specific laws for the entrenchment of guidelines and standards for effective building maintenance management.

b) **Guidelines and Standards for Maintenance of Public Buildings**

- To prepare annual maintenance budgets through building condition survey but projected for the next three years in line with Medium term expenditure framework. Chiang (1984) prediction model to be adopted for trending of budgets.

- To provide quality supervisory services to oversee the implementation of maintenance programmes by recruiting experienced and qualified supervisory staff.
- Capacity building of the existing maintenance units through provision of training, adequate staff and equipment/tools.
- Annual inspections of buildings to guarantee safety and health of users.
- Annual inspections for formulation of maintenance programmes and budgets.
- Carrying out major maintenance works every 3 years, minor maintenance routinely on daily basis and emergency maintenance as they arise. Emergency maintenance should be provided for as 5% of the overall maintenance budget.
- Adopt Planned, preventive and predictive maintenance approaches in line with study findings.
- Procurement of maintenance works should be in line with prevailing procurement act, Kenya Government. Minor maintenance works of a threshold of Kshs. 300,000.00 should be executed by use of in-house maintenance units while any works above this threshold should be contracted through competitive bidding.
- Disposal of buildings or asset whose service life has expired to be executed in line with the procurement act and treasury guidelines.
- Every building must have a building maintenance manual. Building maintenance manuals should be formulated at design stage.
- Inventory of all public office buildings be prepared and maintained by the National Building Maintenance Authority.
- Put in place appropriate information management system.
- Maintenance aspects be captured right from design stage.

- Provide for periodic campaigns on awareness and public education on building maintenance new policies and guidelines at least every year.
- Periodic review of maintenance guidelines and policies in line with global trends.

5.3.6 Institutional Framework

Institutional framework provides specific agency or agencies the mandate to implement maintenance programmes. The outdated buildings organisation and operational manual (Republic of Kenya, 1974) recognises the Ministry of Public Works with its provincial, District and Depot maintenance infrastructure as the institution charged with managing maintenance of all public buildings in Kenya. According to maintenance experts, this state of events changed in the early 1990s when the allocation of maintenance funds were decentralised to various ministries who then make decisions on prioritization of maintenance programmes.

This has made it difficult for the Ministry of Public Works to guide implementation of maintenance programmes as the Ministry's mandate is not backed by any institutional framework. Currently, the mandate of maintenance of public buildings is divided between the ministries of Public Works and Housing but with no clearly defined institutional framework encouraging other ministries and state corporations/parastatal to engage directly with maintenance operations without reference to any institution (presidential circular, 2008 and Republic of Kenya, 2011). It is therefore necessary to consolidate the institutions that manage maintenance into one body so as to streamline maintenance operations for efficiency and effectiveness.

It is therefore recommended that a National Building Maintenance Authority be established under an act of parliament to provide advisory and oversight authority over maintenance of public buildings. The act should give recognition of the ministry of public works as the line Ministry whose role is limited to procvison of policy and legislation. The existing county and depot infrastructure will be reviewed to form part of the institutional frmework. Figure 5.4 is an organograph for the recommended institutional framework.

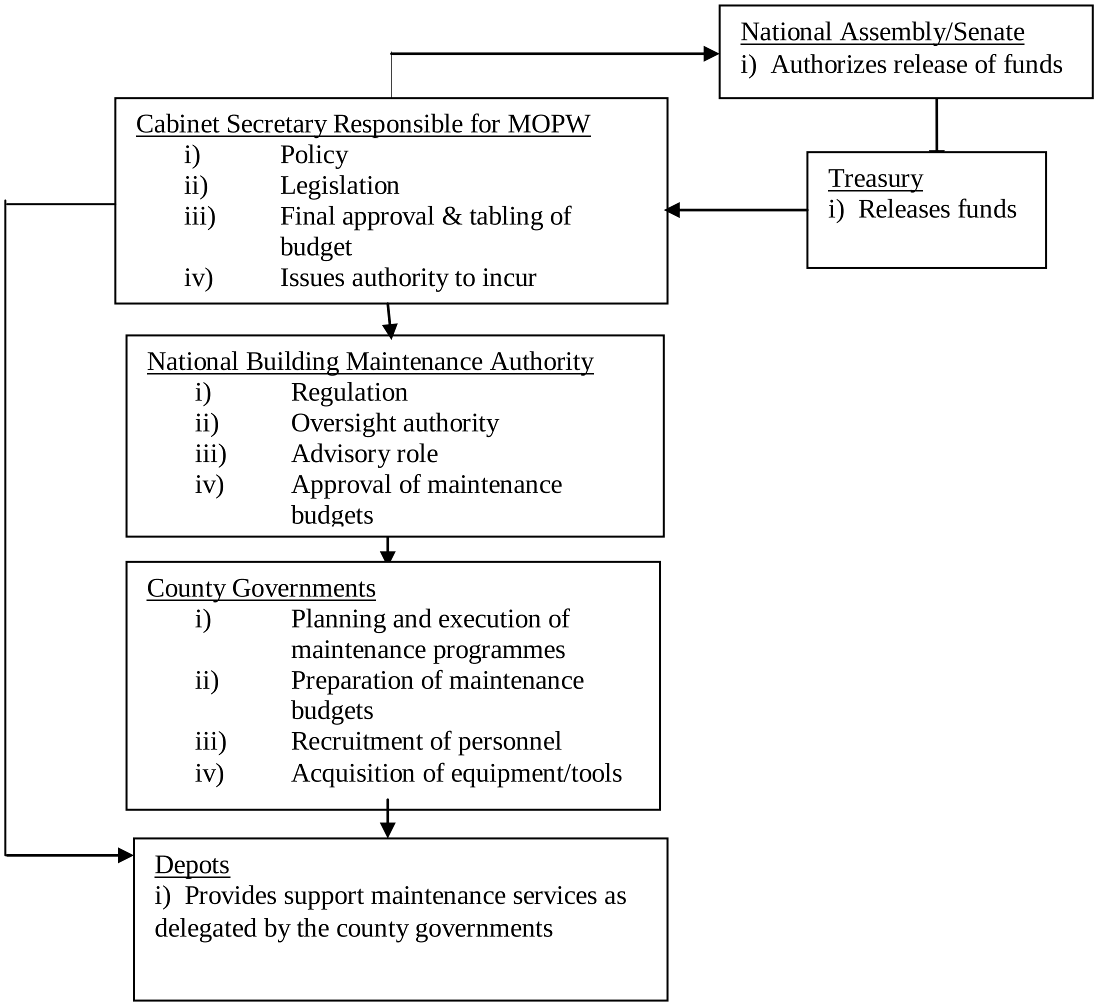


Figure 5. 4: Organograph for Institutional Framework

Source: Adapted from Republic of Kenya (2011)

5.3.7 Conclusions

This chapter concludes on the structure of the legal and institutional framework to be adopted for effective maintenance of public office buildings. The next chapter looks at the overall conclusion on the subject of study together with a summary of the findings and recommendations. This is supposed to build on the existing knowledge in building maintenance as well as open further opportunities to research on.

CHAPTER SIX:

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

In Kenya, the budgetary support for the maintenance of public office buildings is way below the annual maintenance requirements creating a serious maintenance backlog and thus leading to the sorry state of these premises (Republic of Kenya, 2011). This fact is confirmed by budgetary allocations and requisitions data as reflected in the 2011/2012, 2010/2011 and 2009/2010 fiscal years which is attached as appendix 11. Further findings from this study also confirm that maintenance of public buildings is being undertaken haphazardly and ineffectively for lack of any guiding policy framework. This study therefore endeavors to address these challenges through an investigation into various strategies necessary to streamline maintenance processes and operations for efficiency and effectiveness. To achieve this mission, the investigation attempted to narrow down to set study objectives in a bid to answer the corresponding research questions.

In an effort to address the study research questions, this chapter therefore concludes and recommends on the following key areas of investigations with regard to the improvement of the effectiveness of the existing maintenance framework for public office building in Kenya.

- Building defects, causes and ratings.
- Key components of maintenance workscope for prioritizing in a maintenance cost minimization strategy
- Assessment of the existing maintenance framework with a view to making it efficient and effective.

- Maintenance costs/budgets and rating of factors that influence them.
- Development of a model for generating current and future optimal maintenance budgets for strategic planning of maintenance programmes
- Formulation of appropriate legal and institutional framework.

6.2 Findings and Discussions

The findings responded to the study objectives which included buildings defects, causes and ratings, components of maintenance workscope, maintenance framework, maintenance cost/budget prediction and legal/institutional framework.

6.2.1 Buildings Defects, Causes and Ratings

Objective one was to determine buildings defects, causes and ratings in public office buildings. To be able to minimize workscope and cost of maintenance programmes, the study identified various causes of common defects from which the building maintenance workscope is derived. The study subjected the causes of common defects to a mean item rating scale which confirmed poor supervision and negligence tying at 0.63 as the most significant causes of common defects followed by vandalism at 0.59, management problems at 0.53 and normal wear/tear at 0.49. Natural phenomena and termite infestation were however established to have an insignificant impact. A cost effective maintenance framework should therefore incorporate policies and strategies that manage the impacts of the highly ranked causes of defects i.e. poor supervision and negligence.

6.2.2 Components of Maintenance Workscope for Public Office Buildings

Objective two was to establish key components of a maintenance workscope in public office buildings. In order to execute maintenance programmes effectively, it was necessary to understand the composition of the maintenance workscope for public office buildings so that the major components can be identified and targeted for minimization in scope and cost. The study categorized the maintenance workscope for public office buildings as either major or minor. The investigation reveals that the most frequently attended to major maintenance works in order of ranking include re-painting/re-decoration, overhaul of internal partitions, overhaul of electrical installation, overhaul of plumbing/drainage installations, replacement of lifts and re-roofing. In a summarized version, fabric maintenance at 54% takes a significant proportion of a major maintenance workscope for public office buildings followed closely by electrical/mechanical services at 46%. The investigation further reveals the most prevalent minor maintenance workscope for public office building in order of significance as replacement of locks, broken glass panes, power sockets/switches, lighting fittings, flushing cisterns, bottle traps and ball valves. As opposed to major maintenance, electrical/mechanical services workscope is at 64% in a minor maintenance programme which is much higher than fabric maintenance workscope at 31%. The implication of the findings is that fabric maintenance stands out significantly in a major maintenance workscope while electrical/mechanical works are prominent in a minor maintenance workscope.

6.2.3 Appropriate Maintenance Framework

Objective three was to assess the existing maintenance framework for maintaining public office buildings. Having established the major causes of common buildings defects, the study went further to investigate the existing maintenance framework. The study findings revealed that the major challenges to the implementation of building maintenance programmes for public office buildings in Kenya is lack of a building maintenance policy, inadequate budgetary allocations, in-effective procurement systems, under staffing, in sufficient tools/equipment and in-efficient maintenance approaches and structure leading to high cost of maintenance costs and delays in implementation of maintenance programmes.

This scenario has resulted to costly unplanned maintenance programmes where maintenance targets cannot be achieved. An effective maintenance framework for public office buildings should therefore incorporate the following:-

6.2.3.1 Clearly Defined Maintenance Approach

A clear defined maintenance approach for short and long term strategies is the way to effectively maintain public office buildings. A planned preventive building maintenance approach integrated with predictive maintenance is the best option as informed by the findings of this study. 69% of the respondents preferred planned preventive maintenance followed by predictive maintenance at 53.8%. The planned preventive maintenance approach is aimed at preventing un-expected costly equipment breakdown or component failure while the predictive version of maintenance would offer prediction models necessary for preparation of maintenance workscope and budgetary forecast. The approach combines viewpoints advanced by Lateef (2010) on predictive maintenance and East Sussex County Council (2001) on planned preventive maintenance.

6.2.3.2 Systematic Execution of Maintenance Programmes

The study findings indicate that a systematic way of executing maintenance programmes where planned periodic maintenance as a major maintenance programme is key to streamlining maintenance operations and is carried out every three (3) years in addition to minor routine maintenance works which are attended to on day to day basis. The majority of the experts at 51% recommended three years as the reasonable period for executing planned periodic maintenance but felt that emergency maintenance which sometimes can have costly consequences if not addressed immediately can be factored in the maintenance budgets as contingencies, at between 5% - 10%. Republic of Kenya (2011) however indicates a period of five (5) years as reasonable. This may not be practical since the life of some major building elements or components are known to expire before the end of five years. The findings further indicated that yearly inspections are also necessary to be able to plan for cyclic maintenance as well as formulation of annual maintenance budgets. This agrees quite well with the Republic of Kenya (2011) and (1974). All respondents confirmed that regular maintenance is significant in minimizing maintenance cost. It is therefore essential that inspections and execution of maintenance programmes are planned and undertaken regularly within the set intervals.

6.2.3.3 Quality Supervision

Timely and quality supervision to be provided by well trained maintenance staff as confirmed by the study findings is necessary for the achievement of quality workmanship and therefore lowers frequencies of replacement of building components or elements. All respondent confirmed that supervision enhances value for money in the maintenance of public buildings. This is also confirmed by Chohan *et al* (2011), Ramly (2006), Ahmad (2006) and Rukwaro (1990). Supervision is therefore key to achieving value for money as established by the study findings. The qualifications of the supervisory staff must atleast be an ordinary diploma in any building construction related discipline with at least three years post qualification experience. Any lower qualifications or experience is likely to undermine the level of supervision and therefore quality of workmanship.

6.2.3.4 Structured Maintenance Units

Establishment of in-house maintenance units with optimal staffing capacity, tools and infrastructure is a sure way of making them effective in delivery of maintenance services. The study findings indicate that one of the major challenges the current maintenance system has faced is the lack of capacity of the existing maintenance units, a fact confirmed by 100% of the respondents and Republic of Kenya (2011). It is intended that the in-house maintenance units should have adequate staff in all trades that include masonry, carpentry /joinery, painting, welding, electrical/electronics, plumbing/drainage and refrigeration/air conditioning. The smallest maintenance unit should have at least two artisans and two sub-staff in each trade. Craft III qualifications should be taken as minimum grade for the artisans while the minimum qualifications for an in-charge who may also double as a caretaker is a diploma in any building construction related disciplines. The in-house maintenance units should be backed with one set of tools in all trades and at least a pick up to be able to discharge their mandate as minimum requirements. The respondents confirmed use of both or either of in-house maintenance units and contracting for implementing maintenance programmes. Where the in-house maintenance units lack capacity, for example complex or major works, maintenance services should be out-sourced but supervised by the Ministry of Public Works.

6.2.3.5 Utility Cost Minimization

The high cost of charges from undertakers of electricity and water supply has forced the majority of maintenance managers to institute appropriate cost cutting measures. The study findings rated the impacts of water and electricity consumption at 97.0% and 94.1% respectively showing the magnitude of the effect of utilities on the operational cost of public office buildings. This agrees with the view points of Chanter and Swallow (2007) and maintenance experts who were interviewed. In order to lower the consumption of utilities, it is necessary to put in place appropriate measures so that the savings realized can be used to finance other needy items of maintenance. The utility consumption reducing strategies as established by the study include;

- Factoring at design stage increased use of natural lighting and ventilation, energy saving fittings, sensor type plumbing fittings and water saving taps
- Sensitization of users on the need to use utilities in a prudent manner by turning off taps, switching off lighting and electrical appliances when not in use

The respondents gave their perceptions on various strategies for minimizing consumption of utilities .Adoption of energy saving fittings at 82.0%, water saving taps at 80.0% and natural ventilation/lighting at 65.5% were the most preferred measures. It is therefore important that these measures are captured as part of strategies for minimizing operational costs.

6.2.3.6 Research and Innovation

An effective maintenance structure and system should have an in-built appropriate research infrastructure to be able to meet the challenges posed by globalization. In an effort to minimize building maintenance cost, regular research needs to focus on investigations of existing and emerging building materials that are less costly but have longer service lives. 100% of the respondents admitted that research and innovations is key in the advancement of maintenance. This view point is also advanced by Dale (2007), Ahmad (2006), Fairclough (2002) and Fifth and Mellor (1999). Research resources should also be directed towards user reaction surveys as a feedback mechanism to improve on designs for future buildings for enhanced functionality and cost effectiveness. It should also be directed to investigations towards best maintenance practices as well as enquiries on cost effective building technology and materials.

6.2.3.7 Information Technology

The large data generated by maintenance operations, processes, systems and management demands an efficient information management system, thus confirming the significant role information technology can play to make building maintenance structure and systems more efficient. The response from the majority of the maintenance experts cite the significance of Information Technology (IT) in enhancing the efficiency and effectiveness of maintenance systems, processes and operations. Magolo (1994), Chartered Institute of Building (1990) and Tricker (1982) also clarify the importance of effective information management systems towards improvement of maintenance operations and processes. Maintenance experts interviewed argue that computerized maintenance can be applied for efficient storage/retrieval of building particulars, prompt issue of maintenance instructions, speedy drawing up of maintenance programmes and budgets, efficient management of maintenance accounting systems and effective monitoring of maintenance programmes. An effective maintenance framework should therefore incorporate the use of IT in its systems, processes and operations.

6.2.4 Maintenance Costs/Budgets and Factors that influence them

Data obtained for the last three financial years; 2009/2010, 2010/2011 and 2011/2012 indicate that there is a wide gap between the cost of maintenance requirements and the corresponding budgetary allocations. The scenario calls for the need to seek for an appropriate maintenance cost minimization strategy.

The study findings established that materials/technology of construction and design/ supervision were jointly rated highest at a mean item score of 6.69 as variables influencing maintenance cost minimization. Other significant factors included maintenance policy/manual at 6.23, regular preventive maintenance at 5.68 and timely, adequate budgetary allocation at 5.43. The strong link between cost minimization and design/supervision together with materials specifications is also propagated by Chohan *et al* (2011), Ishal *et al* (2007), Ramly (2006) and Ahmad *et al* (2006). This shows the significant role of design/supervision in influencing maintenance costs.

Further findings established that the most cost effective interior finishing material is ceramic tiles at a mean item score of 2.84 followed by granito tiles at 2.78, cement sand screed at 2.62, granite tiles at 2.59 and PVC tiles at 2.51. It was further revealed that keyed masonry finish is the most cost effective exterior finishing material with a mean item score of 2.78 followed by brick facing at 2.64, fair faced finish at 2.60 and wall master at 2.50. Teo *et al* (2006), Al- Hamad (1997) and Briffet (1990) is in support of the significant role appropriate exterior/interior finishes play in influencing maintenance costs. Therefore, an appropriate material specification for exterior/interior finishes is key in minimizing maintenance cost in the long run.

6.2.5 Prediction of Maintenance Costs and Budgets

The study through objective three recommends a planned preventive maintenance approach integrated with the predictive system which provides maintenance managers with the ability to forecast maintenance costs and budgets for public office buildings with certainty. This is necessary for allocating resources for the government's short and long term maintenance objectives which in the past have been disbursed haphazardly. The study employed a growth/trend curve fitting model to arrive at Annual Predicted Maintenance Cost (APMC) and Annual Predicted Budgetary Allocation (APBA) based on an exponential equation by Chiang (1984). The adopted equation is thus

$$Y_t = Y_{to} (1 + r)^{t - to}$$

Where Y_t is the indicator for APMC or APBA at the current year (t) , r is the annual increase rate and Yto is the indicator for APMC or APBA at the reference period (to) i.e. financial year 2009/2010. In order to calculate the annual increase rate given the number of years and values of the average maintenance cost and average allocation at both initial and current periods, we can apply the simplified equation below.

$$r = E \times P \left(\frac{L_n Y_t / Y_{to}}{t - t_0} \right) - 1$$

where L_n is the natural logarithm or Log_{10}

Budget data for the last three years were utilized to predict future APMC and APBA which were used to generate a trend curve. This formula can therefore form a good basis for predicting maintenance costs and budgets for strategic planning of maintenance in public office buildings in Kenya. This methodology however differs significantly from the cost/budgetary prediction model developed by Republic of Kenya (1970) that provides for a sliding scale where percentage increase in maintenance cost is just pegged on the age of the buildings without any idea on how other factors would influence maintenance costs. Republic of Kenya (2011) which is a draft building maintenance policy proposes a building levy which is 5% of the initial property value which is only appropriate for determining maintenance budgets of newly constructed buildings.

The trend curve for public office buildings allocations does not match that for budgetary requisitions an aspect that mirrors the study undertaken by the Commission of

Engineering and Technical Systems (1990). Bridging the gap between the budgetary allocations and requisitions requires an appropriate cost minimization strategy to arrive at optimal budgets where the two trend curves touches each other. The cost minimization strategy can be achieved by identifying those factors in the maintenance system that can be manipulated to reduce the maintenance cost implication.

6.2.6 Appropriate Legal and Institutional Frame

Appropriate legal and institutional framework provides for anchorage for implementation of maintenance programmes effectively. The study established that the current maintenance framework is in-effective as it is not anchored on any legal and institutional framework. The study further established various maintenance guidelines, policies, standards and strategies that should form part of the institutional and legal framework. The legal and institutional framework was developed by incorporating these study findings as well as borrowing from maintenance policies from other organizations. This included the following:

- Maintenance policy for East Sussex County Council (2001)
- Maintenance policy for South Hams District Council (2006)
- Maintenance Management Framework for Queensland Government (2010)
- Draft National Maintenance Policy for Kenya (2011)

a) Legal Framework

The current constitution of Kenya was also consulted to ensure there is no conflict. The major highlights of the legal and institutional frame is summarized here below:-

- Harmonization, coordination and consolidation of existing fragmented legislation and institutions.

- Incorporation of maintenance guidelines, policies, standards and strategies established from the study
- Enactment of the National Building Maintenance Policy and legalizing institutions that implement maintenance programmes.

b) Institutions

The following institutions are proposed to be entrenched in the act to implement maintenance programmes.

- Ministry of Public Works
- National Building Maintenance Authority
- County Structures
- Depots

6.3 Summary of Main Findings

The aim of the study was to develop a model framework for effective maintenance of public office buildings with the purpose of minimizing costs in the long run.. The main findings are therefore those that will facilitate effectiveness of the maintenance framework and responds to the six objectives of the study.

6.3.1 Ratings of Defects

Poor supervision and negligence both at 0.63 mean item score were the highest rated causes of common defects closely followed by vandalism at 0.59.

6.3.2 Components of Maintenance Workscope

1) In a major maintenance workscope, fabric maintenance ranks first at 54% followed by electrical/mechanical services at 46%.
2) In a minor maintenance workscope electrical/mechanical services ranks first at 64% followed by fabric maintenance at 31%.

6.3.3 Maintenance Framework

1) The existing maintenance framework is not supported by any building maintenance policy or manual causing maintenance programmes to be executed haphazardly.

2) There is no clear legal and institutional framework for executing maintenance.

3) No maintenance guidelines and standards are in place to guide maintenance. For instance:-

- Different approaches to maintenance are in place with corrective maintenance most prevalent at 80%.
- No defined periods for conducting inspections and executing planned periodic maintenance
- Maintenance is both carried out in-house or through contracting without specific criteria.
- Procurement process is cumbersome as indicated by most experts.
- No effective supervisory services.
- Maintenance issues not factored at design stage
- Cost of utilities high, only a few organizations have put in place strategies to reduce their consumption.
- No user reaction survey and feed back mechanism is in place.
- In-house maintenance units do not have adequate capacity

4) Major challenges affecting accomplishment of maintenance targets.

- Delays in execution at 84.4% rating.
- In-adequate funding at 65%, understaffing at 75% rating, and procurement process at 65% rating.

5) The following guidelines and standards were obtained from the study:-

- Inspections for planned periodic maintenance every year at 61.4% approved rating.
- Executions for planned periodic maintenance every three years at 47.3% approval rating.
- Hybrid of planned preventive and predictive maintenance approaches at approval ratings of 69.9% and 53.8% respectively.
- Minimum size of in-house maintenance unit to consist of the head with minimum ordinary diploma in any of the built environment professions and at least one artisan with Craft III as minimum qualifications from every trade.
- Effective supervisory services at 100% approval rating in enhancing service life of buildings or components/elements.
- Effectiveness of the building maintenance policy/manual at 68.8% indicating its significance in enhancing effectiveness of maintenance framework..
- Energy saving electric fittings and water saving taps at 82.8% and 80.0% ratings respectively as key strategies for reducing consumption of utilities.

6.3.4 Maintenance Costs/Budgets

Maintenance allocation do not match the cost of maintenance requirements. The cost of maintenance requirements for the past three years ranged from Kshs. 46,047,576.05 to Kshs. 64,479,134.92 while the actual allocations ranged from Kshs. 36,949,987.37 to Kshs 49,630,289.03 calling for cost minimization strategies to close the gap between budgets and actual allocations.

6.3.5 Maintenance Cost Minimization

1) The cost minimization factors with the most impact through mean item scores are materials specifications and design/supervision both at 6.69, appropriateness of

maintenance policy/manual at 6.23, regular preventive maintenance at 5.68, effective supervision at post-occupancy at 5.65 and adequate budgetary allocation at 5.43.

2) The most rated cost effective exterior finishing materials through mean item scores are keyed masonry at 2.78, brick facing at 2.64, fair faced finish at 2.60 and wall master at 2.50.

3) The most rated cost effective interior finishing materials through mean item scores are ceramic tiles at 2.84, granito tiles at 2.78, cement sand screed at 2.62, granite tiles at 2.59 and PVC tiles at 2.51.

6.3.6 Maintenance Costs/Budgets Prediction Model

There is no systematic method for formulating and predicting maintenance costs and budgets calling for development of an appropriate maintenance cost/budget prediction model. The budget/cost prediction is based on a model crafted by Chiang (1984).

6.3.7 Legal and Institutional Framework

Maintenance programmes are being executed haphazardly necessitating formulation of an appropriate legal and institutional framework as there is no maintenance policy in place.

The study findings paint a gloom picture in the manner within which maintenance of public office buildings are being executed. The study findings indicate that some maintenance structures, systems and institutions are either non-existence or not effective at all leading to un-desirable costly consequences including non-accomplishment of maintenance targets. This scenario needs to be reversed in time before eminent failures or breakdown of building components, services and equipment occur through adoption of an appropriate maintenance model framework.

6.4 Conclusion to the Study

Maintenance services are currently being executed without due regard to guidelines, standards and policies. The findings indicate that no maintenance policy has ever been formulated to guide maintenance in addition to buildings being maintained without reference to any manual confirming the haphazard manner within which maintenance processes and operations are being executed. The maintenance approach in use is corrective in nature whereby defects are only being attended to whenever they arise or caused damage inferring that there is no long term strategic planning for maintenance of public office buildings. It was noted from study findings that in-house maintenance units do not have adequate capacity to execute their mandate necessitating re-staffing and re-equipping. The findings further revealed that maintenance budgets do not match the cost of maintenance requirements enforcing the need to put in place efficient and effective strategies that would minimize maintenance costs to optimal budgets. Appropriate cost minimization factors were established from the study and should form part of the maintenance cost minimization strategy. Guidelines, standards, policies and strategies that were established from the study should form part of the maintenance model framework to facilitate effectiveness and efficiency.

Last but not least, the existing maintenance framework was not founded on any clearly defined legal and institutional leverage making it difficult to execute maintenance programmes professionally. According to the study findings, maintenance of public office buildings is being managed by various institutions some of which lack the required capacity.

The findings further indicate that maintenance of public buildings is governed by various scattered statutes which have proved to be in-effective.

In order to alter the current scenario, it is necessary that an appropriate legal and institutional framework is developed to provide the necessary leverage required by the maintenance framework to make it effective and efficient. The guidelines, standards, strategies and policies established in the study should therefore be incorporated with the purpose of making the existing maintenance framework effective and efficient with the aim of minimizing maintenance costs in the long run.

A model of maintenance framework for public office buildings must therefore incorporate:-

- Strategies for managing defects
- Established components of maintenance workscope.
- Effective and efficient maintenance framework.
- Robust cost minimization strategies.
- Systematic means of formulating and predicting maintenance costs and budgets.
- Appropriate legal and institutional framework.

Last but not least, the study findings conclude that maintenance issues should not only be addressed at post occupancy stage but also be factored at design and construction stage. The desired model framework for maintenance must therefore capture maintenance issues at design, construction and post occupancy stages.

Figure 6.1 is a graphical representation of the model framework developed from the study findings that would be applied for effective maintenance of public office building in Kenya.

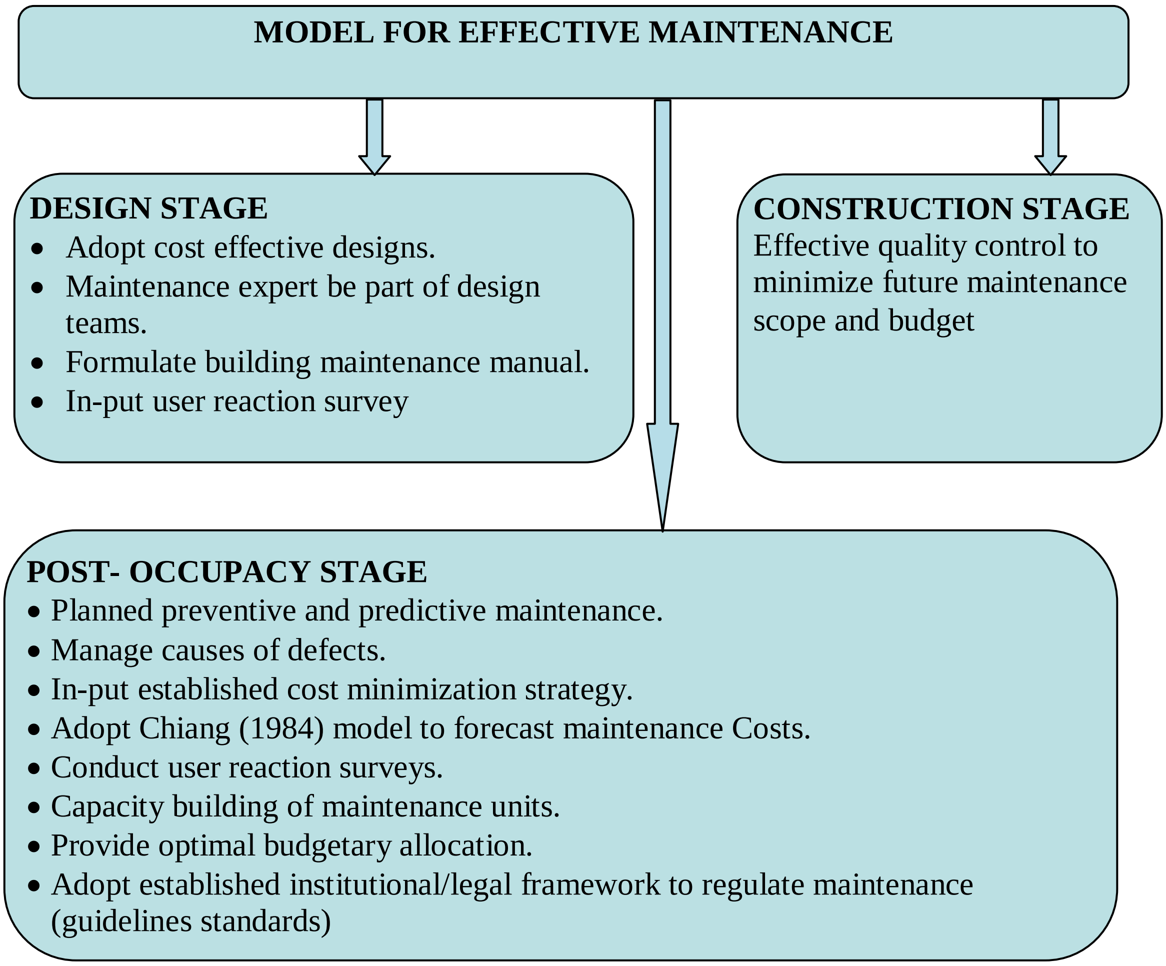


Figure 6.1: Models for Effective Maintenance

6.5 Contribution to Knowledge

The major achievement of this study is the establishment of model of a maintenance for use in maintaining office buildings in Kenya. The model framework expected to provide for an effective framework for achieving maintenance targets within set timeliness and optimal budgets. It therefore contributes significantly towards reducing the gap of knowledge in the field of building maintenance.

Item No.	Recommendation	Finding	Section Found
1	Administrators for public offices to provide appropriate security surveillance systems/sensitise users to curb vandalism and negligence as major causes of common defects	Negligence was rated first at a mean item score of 0.63 while vandalism was rated third at 0.59	Item No. 4.4
2.	Maintenance managers should enhance capacities of maintenance units to provide effective supervision	Poor supervision was rated first through a mean item score of 0.63	Item No. 4.5
3.	Maintenance managers should target electrical/mechanical services and fabric related defects for minimization.	Fabric related defects formed the largest proportion of a major maintenance at 54% while electrical/mechanical services defects were the most significant at 64% in minor maintenance.	Item No. 4.6
4.	The Government to make the existing maintenance framework more effective through institutionalization of guidelines, standards, policies and strategies established from the study findings.	Existing maintenance framework not effective as it is practiced with no defined policies or manual	Item No. 4.6
5	The Government to provide regular, timely and adequate budgetary allocation to eliminate maintenance backlogs	Budgetary requisitions and allocations for the last three financial years, 2009/2010,2010/2011 and 2011/2012 shows that there is a huge gap between the cost of maintenance requirements and the actual budgetary allocations	Item No. 4.7

6.	Maintenance managers to incorporate appropriate cost minimization strategies to reduce the gap between cost of maintenance requirements and actual allocations.	• Design/supervision rated first at 6.69 • Maintenance policy/manual at 6.23. • Regular preventive maintenance at 5.68 • Energy saving fittings and water saving taps were most preferred measures for reducing cost of utilities at 82.8% and 80.0% respectively. • Keyed masonry at 2.78, brick facing at 2.64 and fair faced finishes are the most cost effective exterior finishes. • Ceramic tiles at 2.84, granite tiles at 2.78 and sand cement screed at 2.62 are the most cost effective interior finishes.	Item Nos 4.8 / 5.2
7.	The Government to institutionalize the maintenance prediction model developed from Chiang (1984) to be adopted for maintenance cost/budget forecasts	There is no clearly defined method for formulating and forecasting budgets	Item No. 4.8 / 5.2
8.	The Government to harmonize, coordinate and consolidate existing fragmented legislation and institutions for effective maintenance.	There are various scattered scattered pieces of legislations and institutions that manage maintenance	Item No. 4.6 / 5.3
9.	The Government to in-built the legal and institutional framework into a building maintenance policy	There is no existing legal and institutional frame as there is no clearly defined maintenance policy or manual.	Item No. 4.6 / 5.3
10.	The Government to bring on board maintenance experts to be part of design teams so that maintenance issues are captured right from design stage.	• Design plays a significant role in determining the scope and cost of maintenance. • Design/supervision topped the cost minimization factors at a mean item score of 6.69.	Item No. 4.8

6.6 Recommendations

The study recommends formulation and enactment of an appropriate building maintenance policy so as to implement maintenance programmes effectively and efficiently within optimal budgetary provision. In a bid to achieve the above objectives, recommendations arising from the study findings need to be embedded in the proposed building maintenance policy. The study recommendations are hereby outlined as table 6.1.

Table 6.1: Recommendations

6.7 Areas of Further Study

This study was confined to multi-storeyed public office buildings of four or more floors located in the Nairobi City. This was necessary to control variations in quality of finishes and scope of electrical/mechanical services to maintain homogeneity and therefore reliability of the research. Public office buildings below four floors are so varied in construction to the extent of some having been constructed as timber or iron sheets prefabricated structures. These category of buildings are mainly found in the country side away from major cities. Further research should therefore be directed to these categories of buildings to establish the most appropriate model of framework for maintaining them.

REFERENCES

Abraham DM and Wirahadikusumah R (1999),“ Report on Development of prediction Model for Sewer Deterioration presented to 8th Conference of the Durability of Building Materials and Components”, National Research Council, Ottawa, Canada

Adegoke A (2003) “Maintenance Policies”, Centre for Management Development, University Press Ltd, Shangisha, Nigeria.

Adenuga OA, Odusami KI and Faremi JO (2007), “Conference Paper on Assessment of Factors Affecting Maintenance Management of Public Hospital Buildings in Lagos State, Nigeria presented to the Royal Institution of Chartered Surveyors held between 6th -7th September, 2007 at Georgia Tech. Atlanta, United States of America.

Ahmad G (2004) “Understanding Common Building Defects”, MaJalah Akitek, Vol 16, Issue No. 1, First Quarter, 2004, pp 19-21.

Ahmad R, Nur AA, Nur HI (2006) “The Effects of Design on the Maintenance of Public Housing Buildings in Malaysia” Journal of Buildings Engineer, April, 2006 Issue, Rualar Kualar Lumpur, Malaysia

Alberta Infrastructure (2004) “Operations and Maintenance Manual: A Guide for School Trustees, Administrators and Consultants”, Learning Facilities Branch, Edmonto, Canada.

Al- Hammad A, Assaf S and Al – Shhah M (1997), “The Effect of Faulty Design on Building Maintenance”, Journal of Quality in Maintenance Engineering, Vol 3(I), pp 29 – 39.

Al-Khatam JA (2003) “Building Maintenance Cost,” Masters of Engineering Report, Department of Construction Engineering and Management, King Fahd University of Petroleum and Minerals, Dhahram, Saud Arabia

Ashford JC (1994) “The Management of Quality in Construction”, E & FN SPON Publishers Ltd, Cornwall, United Kingdom.

Ashworth AC (1994) “Cost Studies of Buildings”, Longman Scientific and Technical Company Ltd, London, United Kingdom.

Australian Government (2007) “Sustainable Building Policy”, Queensland Government Accommodation Office, Queensland, Australia

Aziz K (2006), “What is a Research University?” LUMS,SSE, Islamabad, Pakistan.

Bastidas P (1998), “Maintenance Manual for School Buildings”, Organization of American States General Secretariat, United States of America.

Bateman TS and Smell SA (2009), “Management: Leading and Collaborating in the Competitive World”, McGraw Hill, New York, United States of America.

Briffet C (1990), “Building Design and Maintenance Issues”, Building Maintenance and Modernization Worldwide, Vol 2, Longman, Singapore pp. 97 – 105

Bowles G, Dagpunar JS, and Gow H (1997), “Financial Management of Planned Maintenance for Housing Associations,” Construction Management and Economics, VOL 15 No. 4

Bullen PS (2003), “A Handbook of Means and their Inequalities”, Kluwer Academic Publishers, Dordrecht, Netherlands.

Bryman A (2008), “Social Research Methods”, Oxford University Press, London, United Kingdom.

Chanter B and Swallow P (2007), “Building Maintenance Management”, Blackwell publishing, Oxford, London, United Kingdom.

Chanter B and Swallow P (1996), “Maintenance Organisation in Building Maintenance Management,” Blackwell Publishing, Oxford, London, United Kingdom.

Cadick J (1999), “Condition Based Maintenance”, Cardic Corporations, Cleveland, United States of America.

Cambridge University (2011), “Business Dictionary Definition of Budget” cited at http://www.business dictionary.com/definition/budget.html on 22nd August, 2011.

Cane D, Morrison A and Ireland J (1998), “Maintenance and service costs of commercial Buildings”, ASHRAE Transactions, Ontario, Canada.

Chartered Institute of Building (1990), "Maintenance Management", Chartered Institute of Building, Berkshire, United Kingdom.

Chew ML, Wong CW and Kang LH (1999), "Building Facades: A Guide to Common Defects in Tropical Conditions", World Scientific Publishing, Singapore.

Chiang AC (1984) "Fundamental Methods of Mathematical Economics", McGraw – Hill Companies, Singapore.

Chohan AH, Che-Ani AI, Tahir MM, Abbdullah NA, Tawil MM and Kamaruzzaman SN (2011), "Housing and Analysis of Design Defects: A Post-Occupational Evaluation of Private Housing in Malaysia", Journal of the Physical Sciences, Vol 6 (2), Pp. 193 – 203, 18th January, 2011, Kuala Lumpur, Malaysia

Clifton JR (1993), "predicting the Service Life of Concrete", ACI Materials Journal, Vol.90, pp 611-617.

Cole RJ (2000), "Current and Emerging Issues in Green Building Design", University of Columbia, Vancouver, Canada

Commission on Engineering and Technical Systems (1990), "Committing to the Cost of Ownership: Maintenance and Repairs of Public Buildings", National Academy of Sciences, Chicago, United States of America.

Construction Contacts (2010) "First structures Building in the Pre-historic Era" cited at http: // www. construction.com/? =307 on 12th July, 2011.

"Construction Innovation" cited at http://www.construction-inovation info on 24th September, 2010.

Consultants Network (2006), "Green Building" Concept cited at www.greenconcepts.com on 15th April, 2011.

Dale J (2007), "Innovation in construction: Ideas are the currency of the future", CIOB Publication, United Kingdom.

Desai S (2008), "How can Residents stall the Dilapidation of Their Buildings" cited at http:/knowledgeadda4u.blogspot.com/ on 15th April, 2010.

Diyana M (2009), “Case Study of Taman Seri Indah, Pulau Pinang”, Bachelor of Civil Engineering Degree Thesis, Faculty of Civil Engineering and Earth Resources, University of Malaysia Pahang.

East Sussex County Council (2001), “Corporate Building Maintenance policy”, East Sussex, United Kingdom.

El-Haram MA and Horner MW (2002), “Factors Affecting Housing Maintenance Cost”, Journal in Quality Maintenance Engineering Vol.8 (2) pp 115-123

Enterprenuer Media (2012), “Encyclopedia definition of Budget” cited at http://www.entreprenuer.com/encyclopedia/term/82266 htm on 22nd August, 2011.

Fairclough J(2001), “Rethinking construction Innovation and Research”, Department of Trade Industry, London, United Kingdom.

Gibson EJ (1977), “Maintenance Research”, British Research Establishment, Vol 37, pp 8 London, United Kingdom.

Granger CWJ (1980), “Forecasting in Business and Economics”, Academic Press Inc, New York, United States of America.

Gujarati DN (2004), “Basic Econometrics”, McGraw-Hill Companies, New Delhi, India.

Gupta P (2007), “Business Innovation in the 20th Century” cited at http://www.ebook.com on 17th September, 2010.

Hall D (2009), “Building Defects: Inspections and Reports” cited at http://www.buildingdefects.comau on 29th May, 2012

Horner MW, El-Haram MA and Munns AKC (1997), “Building Maintenance

Strategy: A new Management Approach”, Journal of Quality in Maintenance Engineering Vol 3(4), PP 273-280.

Hudson WR, Haas R and Waheed (1997),”Infrastructure Management: Integrating Design, Construction, Maintenance and Rehabilitation”, MCGraw-Hill, New York, United States of America.

Idrus A, Khamidi F and Lateef A (2009), "Value Based Maintenance Management Model for University Buildings in Malaysia, Journal of Sustainable Development Vol. 2 (3) of November, 2009.

Ishak N, Chohan A and Ramly A (2007), "Implications of Design Deficiency on Building Maintenance at Post-occupational Stage", Journal of Building Appraisal, February, 2007, Kuala Lumpur, Malaysia.

Kamal KS, Wahab LA, Ahmed AG and Karim SB (2007 "A paper on Building Conservation" Presented to International Conference on Built Environment in Developing Countries held between 3rd and 4th December, 2007 at University Science, Malaysia.

Kingoriah GK (2004),"Fundamentals of Applied Statistics", Jomo Kenyatta Foundation, Nairobi, Kenya

Kirira N and Bird (2009), "Government Institutions, Public Expenditure and the Role of Development Partners: Meeting Kenya's Environmental Challenges", Overseas Development Institute, Nairobi, Kenya.

Kothari CR (2010), "Research Methodology: Methods and Techniques", New Age International Publishers, Jaipur Rajasthan, India.

Lam KC (2000), "Planning and Execution of Business – Centred Maintenance for Perfect Buildings" cited at http: // www .c ibse .org /pdfs / centredmanagement.pdf on 15th August, 2011.

Langevine R, Allouche M and Abourizk S (2006), "A paper on Decision Support Tool for the Maintenance Management of Buildings" presented to Joint International Conference of Computing and Decision Making in Civil and Building Engineering held on 14th June, 2006 in Montreal, Canada.

Laszlo A and Krippner A (1998), "Systems Theory", cited at http:systems theory.htm on 25th July, 2011.

Lee HHY and Scott D (2009), "Overview of maintenance Strategy: Acceptable Maintenance Standard and Resources from a Building Maintenance Operation

Perspective”, Journal of Building Appraisal, Vol 4, pp 269 – 278.

Lekan A (2009), “Sustainability Strategies in Engineering Infrastructure Maintenance in Developing Countries, Building Technology Dept, School of Environmental Sciences, Covenant University, Ogun State, Nigeria.

Lekan A and Ayo B (2005), “An approach to Application of Total Quality Management in Building Maintenance Operation”, University of Lagos Akoka Yaba, Lagos, Nigeria.

Lateef A (2010), “Case for Alternative Approach to Building Maintenance”, Journal of Building Appraisal, February, 2010, Kuala Lumpur, Malaysia.

Lo SM, Lam KC and Yuen KK (2000), “View of Building Surveyors and Maintenance Services Engineers on Priority Setting of Fire Safety Attributes for Building Maintenance”, Facilities Vol 18 (13/14), pp 513-523

Lounis Z and Vanier DJ (2000), “A Multi-objective and Stochastic System for Building Maintenance Management”, Journal of Computer Aided Civil and Infrastructure Engineering, Vol.15 (5), pp 320-329.

Magolo AE (1994), “Maintenance Information Management: The Role of Management Systems in Built Asset Management”, Un-published Master of Arts Thesis, Department of Construction Management, University of Nairobi, Kenya.

Martin JLN (1987), “Monitoring the Movement of Maintenance Costs in Building Economics Management”, E & FN Spon, London, United Kingdom.

Masters LW and Brandt E (1987), “Prediction of Service Life of Building

Materials and Components”, CIB W80/RILEM 71 – PSL, Final Report

Marver TW (1971), “Building Services Design”, Aden of Mowbray Ltd, Oxford, United Kingdom

Mugenda O and Mugenda A (2003), “Research Methods: Qualitative and Quantitative Approaches”, Laba Graphics Services Ltd, Nairobi, Kenya

Murray (2008), "Indigenous Building Materials and Technologies", Triangle Council of Governments, McGraw Hill,New York, United States of America.

National Building Agency (1985), "Building Defects: Diagnosis and Remedy", Construction Press, United Kingdom

Oberg CP (2002), "Managing Maintenance as a Business" cited at http://www.Maintenanceresources.com/Reference Library/ezine/epac.html on 15th August, 2011

Okwemba RA (1981), "Building Maintenance Manuals and their Application to Building Maintenance Management", Unpublished Dissertation for Masters of Science in Building Maintenance Management, University of Reading, United Kingdom.

Ozguner O (1986) "Philosophy of Tall Buildings: Tall Buildings in the Urban Context," Dieter Acknnecht and Sadi Asset, UPM Press, PP11

Ollila A and Malmipuro M (1999), "Maintenance has a Role in Quality", The TQM Magazine Vol. II (1), pp 17-21

Olubodum F (2001), "A Multivariate Approach to the prediction of Maintenance Needs in Public Housing", Structural Survey, Vol 19, No. 2

Peterson B (1997), "Defining Asset Maintenance Management, Strategic Asset Management INC, Unionville, United States of America.

Pitt TJ (1997) "Data Requirements for Prioritization of Predictive Building Maintenance", Facilities Vol 15 (3/4), pp 97-104.

Pries F and Dore A (2005), "A Century of Innovation in the Dutch Construction Industry", Construction Management and Economics, Vol. 23, pp 561-564.

Purvis RL, Graber DR, Clear KC and Markov MJ (1992), "A literature Review of Time Deterioration Prediction Techniques", SHRP-C/UFR-92-613, National Research Council, Washington DC, United States of America.

Queensland Government (2010) "Maintenance Management Framework", Department of Public Works, Brisbane.

Ramly A (2006), “Links between Design and Maintenance”, Building Engineers, Vol 81, No. 5, May 2006.

Rao A (1996), “Personnel and Human Resources Management: Cases and Games”, Konark Publishers PUT Ltd, Delhi, India.

Republic of Kenya (2007), “Budget Outlook paper 2007/08-2009/10, Ministry of Finance, Nairobi, Kenya.

Republic of Kenya (1970), “Building Organization and Operational Manual”, Ministry of Public Works, Nairobi, Kenya.

Republic of Kenya (1998) “Civil Service Reform Medium Term Strategy – 1998 – 2001,” Government Printer, Nairobi, Kenya

Republic of Kenya (2011), “Draft National Building Maintenance Policy, Ministry of Housing, Nairobi, Kenya.

Republic of Kenya (2006),”Draft Housing Bill, 2006”, Government Printer, Nairobi, Kenya.

Republic of Kenya (2005) “Public Procurement and Disposal Act”, Government Printer, Nairobi, Kenya

Republic of Kenya (1996), “Report on Commission of Enquiry into Circumstances Leading to the Collapse of Sunbeam Supermarket”, Government Printer, Nairobi, Kenya

Riapan M (1986), “Problems Associated with Flat Roof as a Major Concern in the Maintenance of Government Buildings: A Case Study of Public Buildings in Nakuru and Eldoret”, Unplished Master of Arts Thesis, Department of Construction Management, University of Nairobi, Kenya

Roy SK, Thye LB and Northwood DO (1996), “The Evaluation of Paint Performance for Exterior Applications in Singapore’s Tropical Environment”, Building and Environment, Vol.31 (5), pp 477-486.

Royal Institute of Chartered Surveyors (2003), “A Report for Facilities Management”, September, 2003, London, United Kingdom.

Rukwaro R W (1990), “The Influence of Architectural Design Parameters in the Maintenance Cost of Building Services of Office Buildings in the City of Nairobi”, Unpublished Masters of Arts Thesis, Department of construction Management, University of Nairobi, Kenya.

Sayward JM (1984), “Salt Action on Concrete: Special Report No. 84-25”, "US Army Corps of Engineers’, Cold Regions Research & Laboratories, United States of America.

Seeley IH (1987) “Building Maintenance”, Palgrave Publication, New York, United States of America.

Shen Q (1997), “A Comparative Study of Priority Setting Methods for Planned Maintenance of Public Buildings”, Facilities, Vol.1 (12/13), pp 331-339.

Shohet IM and Paciuk M (2004), “Service Life Predictions of Exterior Cladding Components Under Standard Conditions”, Construction Management and Economics, Vol.22, pp 1081 – 1090.

Shohet IM, Puterman M and Gilboa E (2002), “Deterioration Patterns of Building Cladding Components for Maintenance Management”, Construction Management and Economics, Vol. 20(4), pp 305-314.

Slaughter FS (1998), “Model of Construction Innovation”, Journal of Construction Engineering and Management, May/June Issue, pp 226-231.

Solomon M (2005) “The Pick of Sustainable Crop”, Architectural Record, PP 160.

Smith PF (2001), “Architecture in a Climate of Change: A Guide to Sustainable Design,” MPG Books ltd, Bodmin, United Kingdom.

South Hams District Council (2006), “Building Maintenance Policy”, South Hams, United Kingdom.

Syagga PM (2009), "Research and Innovation in Built Environment Towards Vision 2030", Horizon Data Vol. 3(1), pp 1.

Tatum (1998), "Sustainable Technologies and Innovation", Futures, Vol.34(9-10), pp 823-840.

Teo EA and Harikrishna N (2006), "A Quantitative Model for Efficient Maintenance of Plastered and Painted Facades", Department of Building, National University of Singapore, Singapore.

Then DSS (1996), "A Conceptual Framework for Describing Built Asset Standards," Facilities, Vol 14 (7/8), pp 12-15.

Tricker RT (1982), "Effective Information Management", Beamont Executive Press, London, United Kingdom.

Tse PW (2002), "Maintenance Practices in Hongkong and the Use of the Intelligent Schedules", Journal of Quality in Maintenance Engineering, Vol 8 (4), PP 369 – 380.

Uzarki DR and Burley LA (1997), "Assessing Building Condition by the Use of Condition Indexes", American Society of Civil Engineers, New York, United States of America.

Walker A (2007), "Project Management in Construction", Blackwell Science, Oxford, United Kingdom.

White EN (1979), "Maintenance Planning, Control and Documentation", Growers Press Ltd, London, United Kingdom.

Wilkinson SJ and Reed RG (2006), "Office Buildings and the Environment" Presented to the 12th Annual Pacific Rim Real Estate Conference held between 22-25 January, 2006 at the University of Auckland, New Zealand.

Winch G (1998), "Zephyrs of Creative Destruction: Understanding the Management of Innovation in Construction", Building Research and Information, Vol. 26(4), pp 268-279

Wordsworth P and Riley (1996), “From Construction to Maintenance: Using the Bills of Quantity to Formulate a Maintenance Profile and Manual”, Royal Institution of Chartered Surveyors, Liverpool, United Kingdom.

APPENDICES

APPENDIX 1

BREAKDOWN OF FINANCIAL ALLOCATIONS FOR MAINTENANCE PROGRAMMES

APPENDIX 1: BREAKDOWN OF FINANCIAL ALLOCATIONS FOR MAINTANANCE PROGRAMMES

2010/2011 PRINTED ESTIMATES

- Ministry of State for Provincial Administration and Internal Security Kshs 543,236,000.00
- State House Kshs 539,520,000.00
- Office of the Vice President &Ministry of Home Affairs Kshs 284,587,500.00
- Ministry of state for Planning, National Development and Vision 2030 Kshs 18,400,000.00
- Office of the Deputy Prime Minister &Ministry of Finance Kshs 42,000,000.00
- Ministry of Regional Development Authorities Kshs Nil
- Ministry of Agriculture Kshs 8,121,560.00
- Ministry of Medical Services Kshs 90,067,170.00
- Office of the Prime Minister and Ministry of Local Government Kshs 761,935,570.00
- Ministry of Roads Kshs 80,700,000.00
- Ministry of Transport Kshs 305,892,000.00
- Ministry of Labour Kshs 22,540,000.00
- Ministry of Trade Kshs 16,200,000.00
- Ministry of National Cohesion and Constitutional Affairs Kshs 2,400,000.00
- Ministry of Gender, Children and Social Development Kshs 18,600,000.00
- Ministry of Livestock Development Kshs 38,237,200.00
- Ministry of Water and Irrigation Kshs 1,152,517,200.00
- Ministry of Environment and Mineral Resources Kshs 6,444,500.00
- Ministry of Co-Operative Development and Marketing Kshs 7,720,000.00
- Cabinet Office Kshs 27,000,000.00
- Ministry of East Africa Community Kshs 2,800,000.00
- State Law Office Kshs 7,400,000.00
- Judicial Department Kshs 136,000,000.00
- Ministry of Energy Kshs 3,700,000.000.00
- Ministry of Education Kshs 772,400,001.00
- Ministry of Information and Communication Kshs 5,200,348.00
- Kenya Anti-Corruption Kshs Nil
- Ministry of State for special Programmes Kshs 814,000.00
- Ministry of Lands Kshs 44,227,026.00
- Ministry of State for Immigration and Registration of Persons Kshs 92,000,000.00
- Ministry of State for National Heritage Kshs 8,920,000.00

• Ministry of Youth Affairs and sports	Kshs	161,624,494.00
• Ministry of Higher Education Science and Technology	Kshs	20,000,000.00
• Ministry of Housing	Kshs	120,000,000.00
• Ministry of Tourism	Kshs	6,800,000.00
• Office of the Prime Minister	Kshs	244,300,000.00
• Ministry of Public Health and Sanitation	Kshs	779,727,028.00
• Ministry of Forestry and Wildlife	Kshs	94,910,000.00
• Ministry of Fisheries Development	Kshs	44,575,000.00
• Ministry of Nairobi metropolitan	Kshs	46,000,000.00
• Ministry of Dev. of Northern Kenya and Other Arid Lands	Kshs	46,000,000.00
• Ministry of Public Works	Kshs	143,898,800.00
• Ministry of Industrialization	Kshs	40,800,000.00

TOTAL **Kshs 13,988,375,499.00**

APPENDIX 2

POPULATION SIZE

APPENDIX 2: POPULATION SIZE

A. PUBLIC OFFICE BUILDINGS, FOUR FLOORS AND ABOVE (CENTRAL BUSINESS DISTRICT)

1. Harambee House
2. Kenyatta International Conference Centre
3. Public Service Commission
4. Foreign Affairs
5. Sheria House
6. Prime Minister's Office
7. Protection House
8. Treasury
9. National Housing Corporation House
10. Reinsurance Plaza
11. Co-operative House
12. Vigilance House
13. Nyayo House
14. Teleposta Towers
15. Anniversary Towers
16. Jogoo House A
17. Nyati House
18. Times Towers
19. Utalii House
20. Bima House
21. Kencom House
22. City Square Post Office
23. City Hall Annex
24. Continental House
25. General Post Office
26. Maendeleo Ya Wanawake House
27. Housing Finance Company of Kenya
28. Railways Headquarters
29. Extelecoms House

30. Uchumi House
31. Jogoo House B
32. National Bank Building
33. Agricultural Finance Corporation
34. City Hall (old)
35. Electricity House

B. PUBLIC OFFICE BUILDINGS, FOUR FLOORS AND ABOVE (UPPER HILL AREA)

1. National Social Security Funds
2. Magereza House
3. Transcom House
4. Works House
5. Lands Office
6. Maji House
7. Milimani Commercial Law Courts
8. Milimani Law Courts
9. National Hospital Insurance Fund
10. Forodha House
11. Integrity House
12. Teacher Service Commission
13. Kilimo House
14. Afya House

C. PUBLIC OFFICE BUILDINGS, FOUR FLOORS AND ABOVE (INDUSTRIAL AREA)

1. Safety House
2. National Cereals and Produce Board
3. Madini House

SUMMARY

Central Business District Area	-	35 No
Upper Hill Area	-	14 No
Industrial Area	-	3 No
TOTAL	**-**	**52 No**

APPENDIX 3

SAMPLE POPULATION SIZE

APPENDIX 3: SAMPLE POPULATION SIZE

D. PUBLIC OFFICE BUILDINGS, FOUR FLOORS AND ABOVE (CENTRAL BUSINESS DISTRICT)

1. Harambee House
2. Kenyatta International Conference Centre
3. Public Service Commission
4. Foreign Affairs
5. Sheria House
6. Protection House
7. Treasury
8. National Housing Corporation House
9. Reinsurance Plaza
10. Co-operative House
11. Nyayo House
12. Teleposta Towers
13. Anniversary Towers
14. Jogoo House A
15. Utalii House
16. Bima House
17. Kencom House
18. City Hall Annex
19. General Post Office
20. Housing Finance Company of Kenya
21. Railways Headquarters
22. Uchumi House
23. Jogoo House B
24. National Bank Building
25. Electricity House

E. PUBLIC OFFICE BUILDINGS, FOUR FLOORS AND ABOVE (UPPER HILL AREA)

1. National Social Security Funds
2. Magereza House
3. Transcom House
4. Works House
5. Lands Office
6. Maji House
7. Milimani Commercial Law Courts
8. Milimani Law Courts
9. National Hospital Insurance Fund
10. Kilimo House
11. Afya House

F. PUBLIC OFFICE BUILDINGS, FOUR FLOORS AND ABOVE (INDUSTRIAL AREA)

1. Safety House
2. National Cereals and Produce Board
3. Madini House

SUMMARY

Central Business District Area	-	25 No out of 35 No
Upper Hill Area	-	11 No out of 14 No
Industrial Area	-	3 No out of 3 No
TOTAL	**-**	**39 No out of 52 No.**

APPENDIX 4A

QUESTIONNAIRE

(Targeting Caretakers of sampled Premises)

APPENDIX 4A: QUESTIONNAIRE

(Targeting Caretakers of sampled Premises)

Dear Respondent,

This questionnaire aims to collect information related to development of a model for effective maintenance of public office buildings in Nairobi. The information given is for academic purpose only and will be treated as very confidential. Please fill the question according to the instructions given.

SECTION A: DATA ON PREMISES

1. Premises Name:-
2. Location:-
3. Age of building (Years):-
4. Number of Floors:-
5. Total Floor Area:
6. External Finish:
7. Internal Finish:
    - Walls:
    - Floors:
8. Vertical Circulation: Stairs, Lifts, escalators, (tick as appropriate)

SECTION B: INFORMATION ON RESPONDENT

1. Designation

Inspector (Building/Elec/Mech ☐ Charge hand ☐

Building Surveyor/Archiect ☐ Architect ☐

Engineer ☐

Other, specify……………………….

2. Experience in the Field of Maintenance

Below 3 years ☐ 12-15 years ☐ 4-7 years ☐

8-11 years ☐ above 16 years ☐

SECTION C: SPECIFIC QUESTIONS

1) Task accomplishment

a) What major refurbishment/maintenance projects did you Programme for your premises last financial year?
Please tick as appropriate

Painting & Re-decoration ☐ Overhaul of ceiling ☐

Re-Flooring ☐ Replacement of lift ☐

Replacement of roofing felt ☐ Replacement of PABX ☐

Re-roofing ☐ Overhaul of Electrical Installations ☐

Re-partitioning works ☐ Overhaul of plumbing Drainage Installations ☐

Others specify ☐

b) What minor routine maintenance works did you undertake in the last Financial Year?

Replacement of Locks ☐	Replacement of taps ☐
Replacement of broken glass panes ☐	Replacement of wash hand basins ☐
Replacement of door Shutters ☐	Replacement of water closets ☐
Replacement of power sockets and switches ☐	Replacement of flushing cisterns ☐
Replacement of lighting fittings ☐	Replacement of bottle Traps ☐
Replacement of blocked drains ☐	Replacement ball valve ☐
Replacement of Broken glass panes ☐	Replacement of leaking roofing sheets or tiles ☐
Replacement of stained Ceiling boards ☐	Repairs to joinery fittings ☐
Replacement of water tanks ☐	Replacement of gutters ☐

Others specify…………………………………………………………

c) Did you accomplish maintenance works as programmed?

Yes ☐ No ☐

d) What percentage remained un-accomplished

i) Less than 50% ii) More than 50%

e) State main challenges for partial completion of programmed maintenance works in order of rank at a scale of (1 in 4)

a. In-adequate funding ☐

b. Delays in execution ☐

c. Delays in procurement ☐

d. Delays occasioned by in-adequate staffing ☐

2. Building Maintenance Policy/Manual:-

a. Given that there is no existing policy for maintenance of public buildings in Kenya, do you have an in-house maintenance policy and/or manual for your premises?

Yes ☐ No ☐

b) If yes, how effective

Excellent ☐ Good ☐ Average ☐ Below Average ☐

c) If no, is your organization in the process of developing a building maintenance policy and/or Manual ?

Yes ☐ No ☐

How important is building maintenance policy and/or Manual to your organization?

Very important ☐ Important ☐

Not at all ☐ Moderately Important ☐

3. Consumption of Utilities:-

a. What is the impact of consumption of water on operational costs?

Very high ☐ high ☐

Very Low ☐ Very Low ☐

b) What is the impact of consumption of electricity on operational costs?

Very High ☐ High ☐

Very Low ☐ Low ☐

c) In your own opinion, are there measures put in place to minimize consumption of water and electricity?

Yes ☐ No ☐

(c) If yes, state the measures put in place?

Reliance on more use of natural lighting & ventilation ☐

Adoption of energy saving electrical fittings ☐

Use of sensors in plumbing fittings ☐

Sensitization of users ☐

Use of water saving taps ☐

(d) (i) Do you have alternative sources of power other than electric Power?

Yes ☐ No ☐

(ii) If yes. List

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

(iii) Do you have alternative sources of water other than conventional piped water?

Yes ☐ No ☐

(ii) If yes. List

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

4. Inspections

a) Is maintenance inspections of your premises carried out regularly?

Yes ☐ No ☐

b) If yes, how frequent?

Monthly ☐ Quarterly ☐ Half ☐ Yearly ☐

Annually ☐ Every 3 years ☐ Every 5 years ☐

As a response to a defect or failure ☐ Not at all ☐

5. Staffing

a. Does your organization have a building maintenance unit?

Yes ☐ No ☐

b. What is the qualification of the head of building maintenance unit?

Architect ☐ Building Surveyor ☐ Engineer ☐

Inspector(Bld, Elect/Mech) ☐ Artisan ☐

Other specify…………………………………………………………

c. What is the staffing capacity of your maintenance unit?

d. Is the current staffing level of your maintenance unit adequate?

Yes ☐ No ☐

6. Mode of procurement of maintenance works:

a. How does your organization procure maintenance works?

By contracting ☐ using in-house staff ☐

Other specify…………………………………………………………

b. Is the arrangement cost effective?

Yes ☐ No ☐

c. If the arrangement is through use of in-house staff, has your organization availed sufficient tools and equipment to carry out the work?

Yes ☐ No ☐

APPENDIX 4B

QUESTIONNAIRE

(Targeting Maintenance Experts in the Technical Government Ministries and Departments)

APPENDIX 4B: QUESTIONNAIRE

(Targeting Maintenance Experts in the Technical Government Ministries and Departments)

Dear Respondent,

This questionnaire aims to collect information related to development of a model for effective maintenance of public office buildings in Nairobi. The information given is for academic purpose only and will be treated as very confidential. Please fill the question according to the instructions given.

Section A: Information on Respondent

3. Profession

Architect ☐ Engineer ☐

Building Surveyor ☐ Quantity Surveyor ☐

Others, specify...

4. Professional Experience

Below 3 years ☐ 12-15 years ☐

4-7 years ☐ above 16 years ☐

8-11 years ☐

5. Deployment Ministry

Ministry of Public Works ☐ Ministry of Housing ☐

Others, specify...

SECTION B: SPECIFIC QUESTIONS

1. Building Maintenance Policy/Manual:-

d. Given that there is no existing policy for maintenance of public buildings in Kenya, do you have an in-house maintenance policy and/or manual for maintaining public buildings?

Yes ☐ No ☐

d) If yes, how effective

Excellent ☐ Good ☐ Average ☐ Below Average ☐

e) If no, is the government in the process of developing a building maintenance policy and/or Manual ?

Yes ☐ No ☐

How important is building maintenance policy and/or Manual to building maintenance?

Very important ☐ Important ☐

Not at all ☐ Moderately Important ☐

2. Building materials specified at Construction Phase:

a) Does materials specified in the construction phase influence building maintenance cost?

Yes ☐ No ☐

b) If yes, explain

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

c) Rank in a scale of 1 in 7 cost effective and durable floor/wall finishes available in the Kenyan Market starting with the most cost effective and durable.

	Exterior wall	**Interior floor/wall**
i.	Keyed masonry ☐	PVC files ☐
ii.	Granite tiles ☐	Ceramic tiles ☐
iii.	Ceramic tiles ☐	Wood parquette ☐
iv.	Wall master ☐	Cement sand screen ☐
v.	Plastered painted ☐	Carpet ☐
vi.	Brick facing ☐	Granite tiles ☐
vii.	Fair faced ☐	Granito tiles ☐

3. Influence of Design on Cost of Maintenance

a) Does design affect cost of maintenance of public buildings in Kenya at post occupancy stage?

Yes ☐ No ☐

b) Please explain

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

c) To what extent has design affected cost of maintenance of public office buildings?

Very much ☐ Moderately ☐

Insignificant ☐ Not at all ☐

4. Rating of Causes of Defects and Structural Failure:-

a) What are the major causes of defects and structural failure in public office buildings in order of ranking on a scale of 1 in 8 starting with the most significant?

i. Normal tear and wear ☐

ii. Vandalism ☐

iii. Design deficiency ☐

iv. Negligence ☐

v. Natural Phenomena i.e. wind, lightening etc ☐

vi. Infestation by termites ☐

vii. Management problems ☐

viii. Poor supervision at construction ☐

b. Suggest strategies for minimizing the defects arising from the above causes:

1...
2...
3...
4...
5...

5. Inspections and Maintenance systems :-

a) Is maintenance inspections of public office buildings carried out regularly?

Yes ☐ No ☐

c) If yes, how frequent?

Monthly ☐ Quarterly ☐ Half Yearly ☐

Annually ☐ Every 3 years ☐ Every 5 years ☐

As a response to a defect or failure ☐ Not at all ☐

6. Maintenance Systems

a) Which system is practiced by the government in maintaining Public buildings?

Value based ☐ predictive ☐ Preventive ☐

Corrective ☐ None ☐

Other, specify ………………………………………………………

b) In your own opinion, which of the below listed maintenance systems is cost effective in the long run in order of significance to a a scale of 1 in 4

Value based ☐ Predictive ☐

Corrective ☐ Preventive ☐

d) What is the significance of regular maintenance of Public Office buildings to cost minimization?

Very significant ☐ significant ☐

Moderately significant ☐ Insignificant ☐

e) In your opinion, suggest the optimal period for undertaking planned periodic maintenance.

1 year ☐ 3 years ☐

5 years ☐ 10 years ☐

e) In your opinion, suggest reasonable period within which to conduct inspections for planned preventive maintenance.

7. Supervision:

Does supervision enhance value for money in the maintenance of public office buildings?

Yes ☐ No ☐

If yes, to what extent?

Very significantly ☐ significantly ☐

Moderately significantly ☐ insignificantly ☐

8. Research in Appropriate Materials and Technology for Building Maintenance

a. Does your Ministry have a unit dealing with research initiatives in appropriate materials and technology for building maintenance?

Yes ☐ No ☐

b. What is your rating for the significance of research in minimizing building maintenance costs?

Very Significant ☐ Significant ☐

Moderately Significant ☐ Insignificant ☐

6. Building Maintenance Cost Minimization Factors

In a scale of 1 in 10 rank factors that influence building maintenance cost minimization in public buildings starting with the most significant.

a. Renewable sources of utilities ☐

b. Regular preventive maintenance ☐

c. Positive attitude of users ☐

d. Appropriate maintenance policy and manual ☐

e. Timely adequate budgetary allocation ☐

f. Appropriateness of materials and technology of construction ☐

g. Appropriateness of design and effective supervision ☐

h. Effective supervision of maintenance works ☐

i. Regular research and innovation of maintenance systems ☐

j. Effective management structure of maintenance unit ☐

APPENDIX 4C

QUESTIONNAIRE

(Targeting budget officers of the sampled Government Ministries and Departments)

APPENDIX 4C: QUESTIONNAIRE

(Targeting budget officers of the sampled Government Ministries and Departments)

Dear Respondent,

This questionnaire aims to collect information related to development of model for effective influencing maintenance of public office buildings in Nairobi. The information given is for academic purpose only and will be treated as very confidential. Please fill the question according to the instructions given.

SECTION A: DATA ON PREMISES

1. Premises Name:-
2. Location:-

6. Designation

Chief Finance Officer ☐ Senior Finance Officer ☐

Finance Officer I ☐ Finance Officer II ☐

Others ………………………………

7. Working Experience in the Ministry/Department

Below 3 years ☐ 12-15 years ☐

4-7 years ☐ above 16 years ☐

8-11 years ☐

1. Budgetary Requisition

e. Indicate the estimated cost of the annual maintenance programmes in the current and the last two financial years. 2009/2010

Item	**2009/2010(Kshs)**	**2010/2011(Ksh)**	**2011/2012(Kshs)**
i. Minor Maintenance	……………….	……………….	…………………….
ii. Major Maintenance	……………….	……………….	…………………….
iii. Refurbishment	……………….	……………….	…………………….
iv. Total	………………	………………	…………………….

2. Budgetary Allocation

a) What is the annual budgetary allocation for maintaining your premises in the current and the last two financial years ?

Item	**2009/2010(Kshs)**	**2010/2011(Ksh)**	**2011/2012(Kshs)**
i. Minor	………………	……………	…………………….
Maintenance	………………	…………….	…………………….
ii. Major	………………	…………….	…………………….
Maintenance	…………….	…………….	…………………….
iii. Refurbishment			
iv. Total			

b) What is the annual budgetary allocation for payment of utilities in the current and last two financial years?

i) 2009/2010 (Kshs)……… 2010/2011 (Kshs) 2011/2012

Water – Kshs……………………………………………………………

ii) Electricity - Kshs……………………………………………………………

c) Did you manage to clear your water bills by the closure of last financial year?

Yes ☐ No ☐

d) If no, what was your outstanding balance? Kshs……………..

e. Did you manage to clear electricity bill by the closure of last financial year.

Yes ☐ No ☐

If yes, what was your outstanding balance?……………………………………

f. Is the budgetary allocation for maintenance of your premises adequate?

Yes ☐ No ☐

Please explain

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

g. To what extend would adequacy of maintenance budget minimize costs in the long run?

High Impact ☐ Moderate ☐

Low impact ☐ Not at all ☐

Please explain

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………

APPENDIX 5

INTERVIEW SCHEDULE

APPENDIX 5: INTERVIEW SCHEDULE

Item No.	Designation of Interviewee	Interview Focus	Interview Date & Time	Interview Duration
1.	Assistant Director - Estates	Maintenance systems, structure and challenges	5th September, 2011 at 9.00am	1 hr
2.	Principal Supt. Engineer (BS)	Maintenance of Building Services and Cost	6th September, 2011 at 3.00pm	1 hr
3.	Principal Supt. Engineer (Civil/Structural)	Effect of Structural Design and Quality Control on Maintenance of Civil Works and Cost	7th September, 2011 at 4.00pm	1 hr
4.	Senior Principal Supt. Architect	Influence of Architectural Design and Supervision on Maintenance Cost	8th September, 2011 at 10.00am	1 hr
5.	Senior Principal Supt. Quantity Surveyor	Factors Influencing Cost of Building Maintenance	9th September, 2011 at 11.30am	1 hr

APPENDIX 6

RESEARCH INSPECTION CHECKLIST

APPENDIX 6: RESEARCH INSPECTION CHECKLIST

NAME OF PREMISES………………………………………………

DEPARTMENTS AND MINISTRIES HOUSED:-

1……………………………………

2…………………………………….

3……………………………………

4……………………………………

5……………………………………

NO.	BUILDING ELEMENT	CONDITION	REMARKS
1	**Floors** Solid Timber Suspended floor Finishes: - Ceramic - Carpet - Porcelain - Granito - Granite - PVC - C/S Screed - Terrazzo - Grano - Parquet - T & G		
2.	**a) External Walls** Reinforced Concrete Masonry Brick Finishes: - Plaster paint - Wall master - Marble - Fairface - Tyrolene - Ceramic - Alucobond - Bush Hummered		

	- Keyed Masonry **b) Internal Walls** - Solid Partitions - Block board - Chip board - MDF Boards - Glass Folding Partitions Finishes - Plaster paint - Ceramic Tiles - Pain - Wall padding - T & G		
3	**Ceilings** RC Concrete Gypsum Celotex T & G Hardboard Accoustic tiles Chip Board Finishes - Paint - Tartaruga - Tyrolene		
4	**Doors** Steel Timber paneled T-doors Match boarded Solid flush Hollow flush Glass Aluminium Finishes: - Normal Paint - Spray painted - Varnish Iron Mongery: - Mortise locks - Night latch - Door Closers - Door stoppers		

	- Kicking plate - Floor spring - Hinges Glazing: - Louvers - Ordinary pane - Wired glass - Laminated glass - Glass blocks - Solar glass		
5.	**Windows** - Aluminium casement - Steel casement - Timber casement Finishes: - Normal paint - Spray paint - Varnish Iron Mongery - Window Stays - Window fasteners - Hinges Glazing: - Louvers - Ordinary panes - Wired glass - Laminated - Solar glass - Glass blocks		
6.	**Roofing** Flat roof Pitched roof Finishes: - Ordinary GCI - Pre-painted GCI - Sheet tiling - Concrete tiles - Clay tiles - Timber shingles - App water proofer - Asphaltic Felt Structural support - Steel truss - Timber truss - Reinforced concrete		

7.	**Structural Frame** RC Strip foundation RC column pad foundation RC Column pile foundation RC raft foundation RC beams Timber beams Structural steel		
8.	**Staircases** Timber Steel Reinforced concrete Finishes: - Timber - Chequered Steel plate - S/Screed - Ceramic tiles - Granito tiles - Granite Hand Rail: - PVC - Timber - Steel - Stainless steel - Precast concrete - Aluminium - Wrot iron Balusters: - Timber - Steel - Stainless steel - Pre-cast concrete - Aluminium - Wrot iron Anti-slip - Aluminium Strip - Carborandum - Grooves in tiles		
9	**Plumbing & Drainage Installation** Water distribution pipes Taps Gate valves		

	Wash hand basins Water closets Flushing cisterns Ball valves Bottle traps Floor traps Waste pipes Waste stuck Gulley traps Manholes Water meter inspection chambers Ground water tanks Roof water tanks Service ducts		
10	**Electrical/ Installations** Power distribution boards Consumer units Socket outlets Cooker sockets Lighting switches Lamp holder fittings Fluorescent fittings Bulkhead fittings Surface wiring Conduit wiring CCTV Structured cabling Access control Service ducts		
11	**Electrical Mechanical Fittings** Cookers Fans Air Conditioners Generators Water pumps Lifts Escalators Elevators PABX		
12	**Fire Prevention and Fighting Equipment** Fire hydrant Fire break glass Fire alarm system Smoke detectors Hose reels		

	Fire assembly point Portable fire extinguishers Fire Sprinkler system		
13	**Access Road and Parking** Road paving Storm water drains Road Kerbs Gulley Ports		
14	**Roof Water Drainage** Concrete gutters Metal gutters Metal down pipes Plastic gutters Plastic down pipes		
15	**Sun breakers** Concrete Aluminium Glass		
16	**Grounds, Sites & Fencing** Grass Trees Pavements Walkways Boundary Wall Razor Wire Electric Fence		

GENERAL REMARKS:

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………

NB

The assessment of condition of various elements of the building will be based on the following causes derived from literature review.

- Leakage
- Rot/rust

- Vandalism
- Natural causes
- Normal wear and tear
- Structural/design failure
- Infestation by termites
- Negligence by users.

APPENDIX 7

RESEARCH BUDGET

APPENDIX 7: RESEARCH BUDGET

The budget for the entire exercise include:-

Stationery (Papers and computer Accessories)	-	Kshs. 50,000.00
Reproduction and binding of documents	-	Kshs. 20,000.00
Transport and Lunches	-	Kshs. 30,000.00
Equipment (Laptop & Digital camera)	-	Kshs. 300,000.00
Sub Total	-	Kshs. 400,000.00
Add 5% Contingency	-	Kshs. 20,000.00
Grand total	-	Kshs. 420,000.00

APPENDIX 8

PROGRAMME OF RESEARCH ACTIVITIES

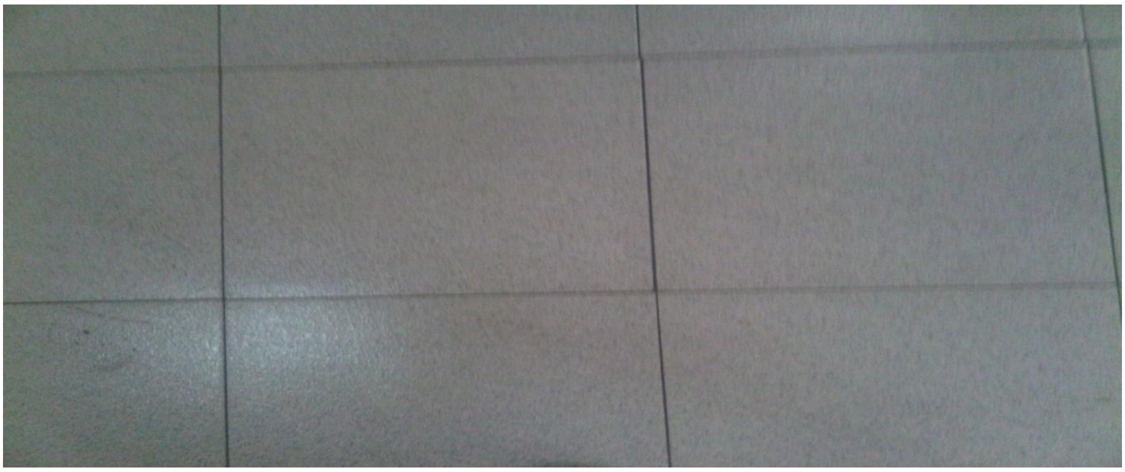
APPENDIX 8: PROGRAMME OF RESEARCH ACTIVITIES

			May,2011				June2011				July,2011				Aug2011				Sept.2011				Oct.2011				Nov,2011				Dec,2011			
ActNo	Act.	Dur.	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4
1	Finalizing on subject of study	1																																
2	Collection of relevant documents	1																																
3	Literature review	6																																
4	Preparation of research proposal	3																																
5	Review of research proposal	1																																
6	Preliminary survey	1																																
7	Selection of cases for study	1																																
8	Data Collection	4																																
9	Evaluation and analysis of data	4																																
10	Report writing	8																																
11	Review of report	2																																
12	Defending Report	2																																
13	Amending Report	2																																

APPENDIX 9

ADDITIONAL PHOTOGRAPHS

APPENDIX 9: ADDITIONAL PHOTOGRAPHS



Photograph A1: Floor Finish to Safety House

Good quality ceramic tiles at Safety House that are well maintained. Ceramic tiles are generally cost effective as long as they are not subjected to heavy traffic. Ceramic tiles used in heavy traffic areas for example lobbies and corridors discolour and wear out very fast.

Photograph A2: Stair Finish to Safety House

Good terrazzo stair finish at Safety House. Terrazzo is a hard durable floor finish that can withstand high impact and traffic. Despite this, there is a shifting trend to modern floor finishes which include ceramic, granite, porcelain and granite tiles. Its use is currently limited due to demands for aesthetics and the cumbersome laying methods.

Photograph A3: Use of Ceramic Tiles to Washrooms to Kenyatta International Conference Centre Building

Ceramic tiles are water proof and therefore suitable for use in wet areas. They are durable and only requires cleaning as opposed to painted surfaces which require regular painting.

Photograph A4: Kitchenette Window of Public Service Commission Building with Missing Louvre Glass Blades.

The missing glass lourve blade may have fallen off due to mishandling by users.

Photograph A5: Window with Fallen Glass Panes at Jogoo House A
This is mostly attributed to negligent handling

Photograph A6: Missing Glass Pane to the Access Door to Machine Room of Works House
This may be as a result of hard bangs by users.

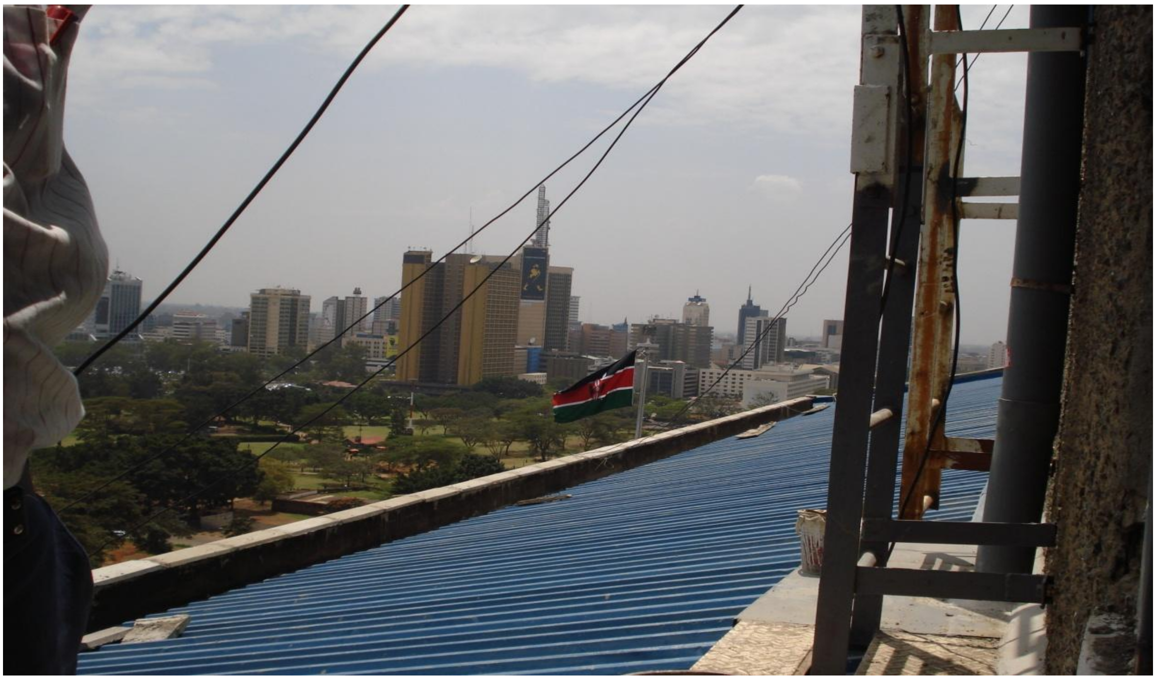
Photograph A7: Door Fan Light with Cracked Glass Pane at Works House.
This is attributed to negligent handling

Photograph A8: Window with Broken Glass Panes at National Cereals and Produce Board Building.

This is attributed to negligent handling

Photograph A9: Re-roofing to Transcom House

The re-roofing was executed as a solution to the failed existing flat roof.



Photograph A10: Re-roofing to Afya House

The re-roofing was executed as a solution to the failed existing flat roof

Photograph A11: Re-roofing to Maji House
The re-roofing was executed as a result of the failed existing flat roof.

Photograph A12: Re-roofing to Works House

Leakage marks appears below sections not yet re-roofed. Contractor on site trying to carry out repairs.

Photograph A13: Steel Caged Fire Fighting Hose Reel and Air Conditioner at National Cereals and Produce Board Building.

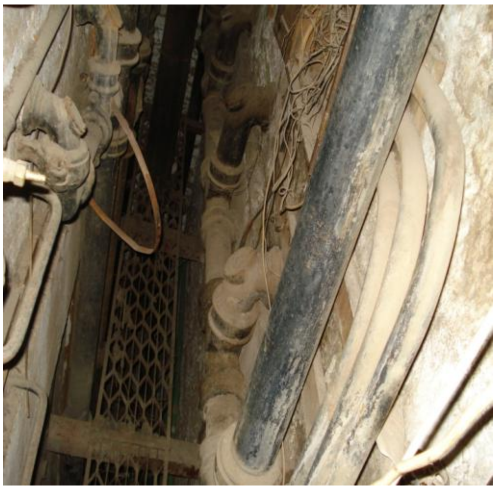
The fire fighting hose reel and air conditioner encased in a metal grill to discourage vandalism. The metal grille may however impede fire fighting during outbreaks. Installation of appropriate security surveillance systems would discourage vandalism.

Photograph A14: Power Consumer Unit and Fighting Equipment in Magereza House.

Power consumer unit and fighting equipment not grilled but located in common space. This facilitates accessibility during fire outbreaks and electrical faults. To discourage vandalism CCTV surveillance systems needs to be installed.

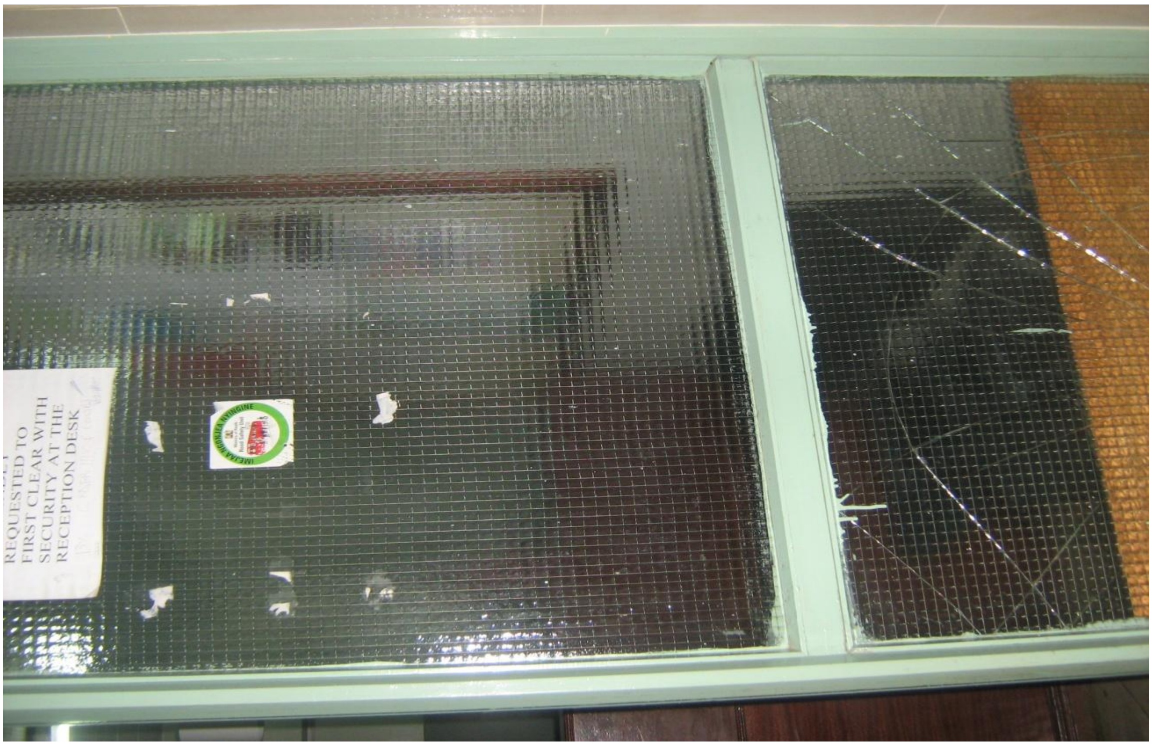
Photograph A15: Broken Down Flush Water Cistern and Water Closet at National Social Security Fund Building

The damage to the water cistern and water closet may be attributed to mishandling by users. Non- replacement is mainly due to budgetary constraints.



Photograph A16: Cracked Wash Hand Basin, Leaking Pipes in a Service Duct and Surface Wiring at Jogoo House A.

The cracked wash hand basin may be attributed to mishandling while the leakage from pipes may be as a result of aging. This building is approximately 60 years of age whereas no major overhaul on building services has been undertaken.



Photograph A17: Window with Cracked Glass Pane at Transcom House.
The glass pane breakage may be as a result of the users being negligent.

APPENDIX 10

ADDITIONAL TABULATION OF DATA

APPENDIX 10: ADDITIONAL TABULATION OF DATA

Table A1: Response on whether Materials specified at construction phase influence cost of Maintenance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	1	1.4	1.4	1.4
	Yes	73	98.6	98.6	100.0
	Total	74	100.0	100.0	

Table A2: Response Whether Design Influences Cost of Maintenance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	3	4.1	4.1	4.1
	Yes	70	94.6	95.9	100.0
	Total	73	98.6	100.0	
Missing	System	1	1.4		
Total		74	100.0		

Table A3: Response on the Extent to which Design affects Cost of Building Maintenance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Insignificant	1	1.4	1.4	1.4
	Moderately	29	39.2	39.2	40.5
	Very Much	44	59.5	59.5	100.0
	Total	74	100.0	100.0	

Table A4 Rating of Measures Put in to Reduce Consumption of Utilities

Natural Lighting and Ventilation					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	10	29.4	34.5	34.5
	Yes	19	55.9	65.5	100.0
	Total	29	85.3	100.0	
Missing	System	5	14.7		
Total		34	100.0		

Energy Saving Electrical Fittings					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	5	14.7	17.2	17.2
	Yes	24	70.6	82.8	100.0
	Total	29	85.3	100.0	
Missing	System	5	14.7		
Total		34	100.0		

Sensor Type Plumbing Fittings					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	17	50.0	58.6	58.6
	Yes	12	35.3	41.4	100.0
	Total	29	85.3	100.0	
Missing	System	5	14.7		
Total		34	100.0		

Sensitization of users					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	13	38.2	44.8	44.8
	Yes	16	47.1	55.2	100.0
	Total	29	85.3	100.0	
Missing	System	5	14.7		
Total		34	100.0		

Water Saving Taps					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	6	17.6	20.0	20.0
	Yes	24	70.6	80.0	100.0
	Total	30	88.2	100.0	
Missing	System	4	11.8		
Total		34	100.0		

Table A5 – Importance of Research in Minimizing Building Maintenance Cost

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	12	16.2	16.4	16.4
	Yes	61	82.4	83.6	100.0
	Total	73	98.6	100.0	
Missing	System	1	1.4		
Total		74	100.0		

Table A6: Significance of Research in Minimizing Building Maintenance Cost

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Insignificant	2	2.7	2.7	2.7
	Moderately significant	7	9.5	9.6	12.3
	Significant	19	25.7	26.0	38.4
	Very significant	45	60.8	61.6	100.0
	Total	73	98.6	100.0	
Missing	System	1	1.4		
Total		74	100.0		

Table A7: Cost Effectiveness of Different Approaches to Maintenance

		Frequency	Percent	Valid Percent	Cumulative Percent
Value Based Maintenance					
Valid	Not cost effective	39	52.7	61.9	61.9
	Cost effective	24	32.4	38.1	100.0
	Total	63	85.1	100.0	
Missing	System	11	14.9		
Total		74	100.0		
Predictive Maintenance					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not cost effective	30	40.5	46.2	46.2
	Cost effective	35	47.3	53.8	100.0
	Total	65	87.8	100.0	
Missing	System	9	12.2		
Total		74	100.0		
Corrective Maintenance					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not cost effective	49	66.2	79.0	79.0
	Cost effective	13	17.6	21.0	100.0
	Total	62	83.8	100.0	
Missing	System	12	16.2		
Total		74	100.0		
Preventive Maintenance					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not cost effective	21	28.4	30.4	30.4
	Cost effective	48	64.9	69.6	100.0
	Total	69	93.2	100.0	
Missing	System	5	6.8		
Total		74	100.0		

Table A8:Maintenance Systems Practiced by the Government

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Value based	4	5.4	5.6	5.6
	Predictive	2	2.7	2.8	8.5
	Preventive	6	8.1	8.5	16.9
	Corrective	57	77.0	80.3	97.2
	None	1	1.4	1.4	98.6
	Others	1	1.4	1.4	100.0
	Total	71	95.9	100.0	
Missing	System	3	4.1		
Total		74	100.0		

Table A9: Response on In-adequate Funding as a Challenge

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Challenge	11	32.4	34.4	34.4
	Not Challenge	21	61.8	65.6	100.0
	Total	32	94.1	100.0	
Missing	System	2	5.9		
Total		34	100.0		

Table A10: Response on Delays in Execution as a Challenge

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Challenge	27	79.4	84.4	84.4
	Not Challenge	5	14.7	15.6	100.0
	Total	32	94.1	100.0	
Missing	System	2	5.9		
Total		34	100.0		

Table A11: Response on Delays in Procurement Process as a Challenge

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Challenge	11	32.4	34.4	34.4
	Not Challenge	21	61.8	65.6	100.0
	Total	32	94.1	100.0	
Missing	System	2	5.9		
Total		34	100.0		

Table A12: Response on Under-staffing as a Challenge

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Challenge	24	70.6	75.0	75.0
	Not Challenge	8	23.5	25.0	100.0
	Total	32	94.1	100.0	
Missing	System	2	5.9		
Total		34	100.0		

Table A13: Rating of Causes of Common Building Defects.

	Normal tear & wear	Vandalism	Design deficiency	Negligence	Natural Phenomena	Termite infestation	Mgt. problems	Poor supervision
Mean	0.49	0.59	0.57	0.63	0.40	0.38	0.53	0.63

Table A14: Ranking of Major Maintenance Works

Maintenance Activity	No. of Respondents	Frequency	Percentage	Mean
Major Painting & Re-decoration	34	24	70.6	0.71
Major Re-flooring	34	12	35.3	0.35
Major Replacement of Roofing of Water Proofing Membrane	34	5	14.7	0.15
Major Re-roofing	34	11	32.4	0.32
Major Re-partitioning Works	34	17	50.0	0.50
Major Overhaul of Ceiling	34	6	17.6	0.18
Major Replacement of Lift	34	11	32.4	0.32
Major Replacement of PABX	34	9	26.5	0.26
Major Overhaul of Electrical Installations	34	13	38.2	0.38
Major Overhaul of Plumbing/Drainage Installations	34	11	32.4	0.32

Table A 15:Ranking of Minor Maintenance Works

Maintenance Activity	No of Respondences	Frequency	Percentage	Mean
Minor Replacement of locks	34	28	82.35	0.82
Minor Replacement of broken glass panes	34	27	79.41	0.79
Minor Replacement of door shutters	34	11	32.35	0.32
Minor Replacement of power sockets & switches	34	26	76.47	0.76
Minor Replacement of lighting fittings	34	25	73.53	0.74
Minor Clearance of blocked drains	34	14	41.18	0.41
Minor Replacement of stained ceiling boards	34	13	38.24	0.38
Minor Repairs to tanks	34	9	26.47	0.26
Minor Replacement of taps	34	20	58.82	0.59
Minor Replacement of wash hand basins	34	17	50.00	0.50
Minor Replacement of water closets	34	15	44.12	0.44
Minor Replacement of flushing cisterns	34	24	70.59	0.71
Minor Replacement of bottle traps	34	24	70.59	0.71
Minor Replacement of ball valves	34	24	70.59	0.71
Minor Replacement of leaking roofing sheets/tile	34	15	44.12	0.44
Minor Repairs to joinery fittings	34	12	35.29	0.35
Minor Replacement of gutters	34	9	26.47	0.26

Table A16: Rating of Factors Influencing Minimization of Building Maintenance Cost

	Renewable Utilities	Regular Preventive Maintenance	Positive Attitude of Users	Appropriate Maintenance Man.	Timely & Adequate Budgetary allocation.	Appropriateness of Materials	App of Des. & Supv.	Eff. Superv.	Reg. Res.	Eff Mtg Struc. of MU
Mean	3.53	5.68	4.95	6.23	5.43	6.69	6.69	5.65	4.38	4.99

Table A 17: Ranking of the Performance of Various Interior Finishes

	PVC files	Ceramic tiles	Wood parquette	Cement sand screen	Carpet	Granite tiles	Granito Tiles
Mean	2.51	2.84	2.44	2.62	2.10	2.59	2.78

APENDIX 11

RAW DATA FOR BUDGET TOGETHER WITH AGES AND FLOOR AREAS

	Age of the premise (Yrs)	Floor Area (Meters squared)	Total budgetary requisition for 2009/10	Total budgetary requisition for 2010/2011	Total budgetary requisition for 2011/12	Total budgetary allocation for 2009/10	Total budgetary allocation for 2010/11	Total budgetary allocation for 2011/12
	9	700	85,000	48,840	25,600	85,000	80,000	77,200
	9	792	1,500,000	80,000	77,200	1,640,000	1,096,030	691,546
	11	900	1,550,000	1,640,000	1,640,000	1,873,630	1,240,000	750,000
	14	917	1,640,000	1,760,000	1,760,000	1,910,000	1,640,000	1,442,560
	14	933	1,863,954	1,926,717	1,894,389	3,000,000	1,760,495	1,640,000
	14	1,168	2,300,000	2,028,160	2,400,000	3,155,075	1,987,129	2,082,000
	16	1,185	3,550,000	2,240,000	2,500,000	4,900,000	2,084,000	2,200,000
	25	1,280	3,600,000	2,322,000	2,642,000	5,000,000	2,100,000	2,632,770
	28	1,288	4,989,500	2,400,000	2,800,000	5,500,000	2,322,000	3,132,000
	28	1,400	5,000,000	2,600,000	3,132,000	6,000,000	2,383,505	3,300,000
	30	1,500	5,800,000	3,500,000	4,000,000	6,750,000	2,600,000	4,000,000
	30	1,530	6,750,000	3,801,000	4,400,000	9,340,000	2,900,000	5,000,000
	31	1,560	11,000,000	3,820,000	4,837,500	9,645,709	4,000,000	5,600,000
	31	1,883	13,300,433	6,100,000	5,700,000	10,000,000	5,500,000	6,412,680
	31	1,950	13,303,000	6,400,000	8,385,519	13,300,433	6,400,000	8,200,000
	31	2,100	15,464,376	7,278,000	8,540,400	14,172,356	8,360,000	8,385,519
	31	2,250	17,373,876	8,360,000	15,200,000	14,782,734	8,502,354	8,540,400
	31	2,496	25,000,000	10,441,230	15,642,659	16,151,749	10,195,000	8,675,621
	32	2,688	25,490,057	10,800,000	16,659,904	18,000,000	10,441,230	10,000,000
	32	2,776	27,600,000	20,000,000	19,236,045	26,609,951	14,244,000	11,035,224
	33	2,800	33,300,000	26,689,755	25,000,000	29,074,400	14,500,000	15,642,659
	33	3,485	40,000,000	32,000,000	29,000,000	30,000,000	15,540,000	16,367,252
	33	3,500	40,000,000	32,800,000	38,130,714	30,733,168	19,540,000	16,659,904
	33	3,600	40,326,787	34,000,000	39,000,000	35,000,000	20,000,000	19,500,000
	35	3,611	50,000,000	35,000,000	40,324,909	39,750,000	22,317,000	25,000,000
	35	3,800	55,000,000	35,500,000	53,600,000	43,000,000	24,746,546	29,000,000
	36	3,900	59,088,200	36,875,851	55,000,000	45,000,000	25,000,000	30,000,000
	37	3,920	59,500,000	36,999,787	57,243,000	47,948,000	27,000,000	33,000,000
	38	4,000	64,000,000	40,000,000	60,000,000	56,088,200	29,389,216	34,915,500
	38	4,200	75,557,658	45,774,126	67,479,132	72,048,576	30,550,174	38,500,000
	42	4,554	80,000,000	47,000,000	69,831,000	75,557,658	37,000,000	45,107,239
	43	4,992	82,000,000	51,043,000	70,000,000	106,000,000	45,774,126	46,280,000
	44	5,220	105,900,256	65,000,000	85,000,000	151,000,000	58,000,000	51,290,000

	44	5,284	198,200,000	68,000,000	90,000,000	755,000,000	63,189,488	66,241,360
	45	5,500	788,000,000	70,000,000	101,000,000	.	65,490,227	67,479,132
	46	7,303	.	76,000,000	112,000,000	.	70,000,000	70,000,000
	54	8,480	.	79,627,000	145,000,000	.	79,627,000	107,000,000
	54	9,000	.	86,000,000	361,000,000	.	667,000,000	656,000,000
	55	15,600	.	800,000,000	895,000,000	.	.	.
Valid	39	39	35	39	39	34	38	38
Missing	0	0	4	0	0	5	1	1
Mean	32.21	3,437.05	55,943,802.77	46,047,576.05	64,479,134.92	49,630,289.03	36,949,987.37	38,481,198.21
Sum	1,256	134,045	1,958,033,097	1,795,855,466	2,515,081,971	1,688,016,639	1,404,499,520	1,461,780,566

APENDIX 11: RAW DATA FOR BUDGET TOGETHER WITH AGES AND FLOOR AREAS