KYAMBOGO UNIVERSITY

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APPLICATION OF VALUE ANALYSIS CONCEPT ON CONSTRUCTION COST OF LOW VOLUME ROADS IN UGANDA

BY

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NOVEMBER, 2019

DECLARATION

I, Okello Emmanuel, declare that this dissertation is my original work and it has never been submitted to any other University or institution of higher learning for a similar or any other degree award.

Signature: ....

Date: ....

APPROVAL

The following research by Okello Emmanuel which was carried out under the Title: **"Application of Value Analysis Concept on Construction Cost of Low Volume Roads in Uganda"** has been accomplished under our supervision and is ready for submission with our approval for the award of a Degree of Master of Science in Construction Technology and Management of Kyambogo University.

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DEDICATION

This dissertation is dedicated to my parents, wife and children. I also dedicate it to my colleagues of Master of Science in Construction Technology and Management of Kyambogo University cohort 2016/2017.

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To the Most High God who ordained this path for me before I even knew about it and made it possible for me to undertake this journey. Thank you Lord for the Strength, Wisdom, Grace and every provision I needed to make this dream a reality.

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LIST OF ACRONYMS

CARs:	Community Access Roads
DSD:	Double Surface Dressing
FY:	Financial Year
FYs:	Financial Years
GEC:	General Electric Company
LCS:	Low Cost Seals
LGC:	Local Government Commission
LVR:	Low Volume Roads
MELTC:	Mt. Elgon Labour based Training Centre
MoTPW:	Ministry of Transport and Public Works
MoWT:	Ministry of Works and Transport
PA:	Premix Asphalt
RFP:	Road Formation Phase
RTI:	Rural Transport Infrastructure
SDG:	Sustainable Development Goal
SSD:	Single Surface Dressing
UNRA:	Uganda National Roads Authority
US:	United States
VA:	Value Analysis
VE:	Value Engineering

ABSTRACT

The success of implementation of highway infrastructure projects is usually measured against three parameters; quality, time and cost. However, some of these projects do not achieve expected project goals in terms of quality. Secondly, project delivery is not within a reasonable amount of time, and finally, costs are not in line with their budget limits. This study applied Value Analysis (VA) methodology in the construction of Low Volume Roads (LVRs) in Uganda, to mitigate the aspects of time and cost but still ensuring that the functionality and quality aspects are not jeopardized, through the generation of innovative alternatives.

The methodology included document review and cost analysis of LVR projects previously implemented in ten districts in Northern and Eastern Uganda. In this study VA technique involved the employment of a composite or mixed method of work, incorporating both mechanization and manual labour during the Road Formation Phase (RFP), as opposed to the existing labour based methods. The VA technique was applied to two construction projects, that is: the construction of 800 meters of LVR in Financial Year (FY) 2017/18 in Kole District which project was undertaken by the researcher and during the construction of a 1,200 meter LVR in Bukedea District in the same year.

Comparison of the cost when the VA is used, with the current cost through hypothesis testing was done, and the alternative hypothesis that the cost reduces on application of the mixed method VA technique during the Road Formation Phase (RFP) was upheld at 95% confidence level. It was established that average cost per metre of LVR when using the conventional labour methods was UGX. 250,000, while an average cost per metre of UGX. 228,157 was achieved when the mixed method approach was used, thereby realizing an 8.7% reduction in the average cost per metre of the construction of LVRs.

The researcher thus concluded that the cost of LVR construction significantly reduces when VA is applied during the RFP. The researcher recommended the use of the mixed method VA technique for the ongoing and future LVR construction projects under the Low Cost Seal (LCS) Program and proposed that further research should be done to apply VA on the sealing phase of LVR construction.

Key Words:

Value Analysis, Cost per Metre, Mixed Method, Road Formation Phase, Low Volume Roads, Low Cost Seal.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Worldwide, construction projects are getting bigger in size day by day and it is becoming necessary to complete these projects in planned cost, quality and time. With regard to cost, quality and time, it is important to find measures to enhance the value of the products obtained from these construction projects as this industry increases in size. One of the possible ways of enhancing value in the construction industry is through conducting Value Analysis (VA), Value Analysis is thus defined as a creative method which aims at precisely and effectively pointing out unnecessary costs which do not contribute to quality, provide usefulness, prolong the product's lifespan or improve the external appearance of a product and other characteristics, desired by the customer (Leber, 2004), Lawrence D. Miles, an electrical engineer by training, is known as the father of Value Analysis (VA) concept; he developed the technique while working with General Electric Company (GEC) in the United States (US) in the late 1940s. Lawrence D. Miles developed a system of cost reduction which he called Value Analysis and he expressed value as a ratio between the cost of the function and the worth of the function.

According to LGC (2009), a VA study was conducted for Dr. Fine Bridge Replacement Project in US 101 near Crescent City, California in July 2009. The cost estimate used for the original design for this project was $51.114 million. However, with the application of VA concept, the bridge length was reduced at the ends and replaced with fills; also isolation bearing in the superstructure was introduced resulting in the reduction of the size of piers in the original design as a result there was a net saving of approximately $2.6 million and performance was improved by 4%. These two factors, when combined using the value equation (Value = Performance / Cost), resulted in a value improvement of 10%.

Low Volume Roads (LVRs) are roads with traffic volumes of not more than 400 vehicles per day (Songjukta, 2019), they have enormous impacts on economies, communication and social interaction. Examples of LVRs are; farm-to-market roads (feeder roads), roads in developing countries linking administrative units and roads to parklands (Douglas, 2017).

This research was carried out on Low Volume Roads construction in Uganda particularly Eastern and Northern Uganda because these are areas where construction of LVRs were piloted under Rural Transport Infrastructures (RTI), by Ministry of Works and Transport (MoWT) starting in FY 2013/2014. This research applied VA concept by adjusting the construction method from being labour intensive during road formation phase to using both labour and mechanization.

In Uganda, mass infrastructural investment has been geared towards high volume roads, but attention should also be drawn to the LVRs which serve the rural areas that harbor the largest population in the country. There are, however, efforts by the government of Uganda to seal the LVRs and so far the project has been piloted in 23 districts in Uganda but the progress in terms of coverage is slow (only 38.6km by June 2015 had been covered under LCS) due to high cost of construction (Muhakanizi, 2016). The relationship between poverty incidence and roads development indicates that improving roads access is an effective way of reducing rural poverty (Warr, 2005).

This study has focused on selected LVRs because poor rural roads infrastructure is one of the main hindrances to the socio-economic and political development of any community (Calderon, 2010), and it is among the major reasons why the economy of many developing countries is picking up at a relatively very slow pace.

Poor funding, high traffic volumes, harsh weather conditions, poor workmanship, poor road construction materials and technology are some of the attributes of poor road infrastructure in third world countries yet road transport is by far the most dominant mode of inland transport (Hirtz, 2002).

In Uganda, the total road length is 129,469km and of the total, National road length is 22,009km (17%), District roads total length is 33,662km (26%), Urban roads total length is 9,063km (7%) and Community Access roads is 64,735km (50%). Out of the total road length in Uganda 5,224km (4%) was paved or tarmacked by the end of FY 2014/2015 and 3,981km of the National roads were paved out of 22,009km (21.7%) (MoWT, 2016).

The district roads, which currently in Uganda are LVRs are mostly un-surfaced with only 38.6km (0.11%) tarmac/sealed under low cost seal programme championed and spear headed by Mt. Elgon Labour Based Training Centre (MELTC). Therefore, there is need to increase this percentage hence the need for VA.

1.2 Statement of the Problem

In 2013, Government of Uganda through Mt. Elgon Labour Based Training Centre (MELTC) introduced sealing of district roads under low cost seal (LCS) program to improve on performance and durability. However, the cost of construction of a LVR under low cost seal in Uganda currently is estimated to be between UGX. 250 and 500 million per kilometer according to Osama Kayima in an interview by (Mafabi, 2018). Among other factors, because of this high cost, only 38.6 km out of 33,662 km of LVRs were sealed by end of 2015 and most of the sections which are not sealed, are in poor surface condition with potholes, gullies as well as poor drainage. As a result, a lot of travel time is lost and the transportation of people, goods and services is grossly negatively affected, thereby crippling economic growth.

There is therefore need to apply VA concept to reduce the construction cost of LVRs, where cost reduction if achieved would result into a saving that could aid in sealing more lengths of LVRs and improve surface conditions of roads. This would consequently result in reduced travel time and transport cost of goods and services, reducing cost of production if other factors like fuel cost remains constant hence aid economic growth in the region.

1.3 Objectives of the Study

1.3.1 Main Objective

The main objective of the study was to explore the application of Value Analysis (VA) concept on the construction cost of low Volume Roads (LVRs) in Uganda.

1.3.2 Specific Objectives

The specific objectives of the study were:

i. To establish the current construction cost of Low Volume Roads in Uganda,
ii. To determine cost of construction of Low Volume Roads through application of Value Analysis concept,
iii. To conduct a comparative construction cost analysis of Low Volume Roads upon application of VA and without VA technique by testing hypothesis.

1.4 Research Questions

The researcher sought to answer the questions below in order to test the impact of VA on the cost of LVRs construction in Uganda. These questions were formulated based on the specific objectives of the study.

1) What is the current unit construction cost of LVRs in Uganda?
2) What is the unit cost of construction of LVRs when the proposed VA concept is applied?
3) What can be done to reduce the construction cost of LVRs in Uganda?

1.5 Research Justification

Uganda is a predominantly agricultural nation with the agricultural sector contributing up to 26% of the GDP of the Nation (Uganda Investment Authority, 2017). However, for the Agricultural sector to flourish the infrastructural or road sector is rather an important element, as the people practicing agriculture need to access their markets using the existing road network. As such, the development of the road infrastructure is a key area of investment. To ensure that the investment in the road sector is sustainable, the more efficient and cost saving techniques should be explored in the road infrastructure construction. This is the basis for the need of Value Analysis in the design and construction of Uganda's road network.

Sealing the road surfaces of low volume roads in Uganda has been going on in some twenty-three (23) districts in Lango, Acholi and Teso sub regions but at a slow coverage as only 38.6km out of 33,662km was sealed over a span of four years due to the high cost involved and this study sought to find alternative construction method that could deliver the product at the least cost, making savings that cumulatively could be used to extend the coverage.

Roads are thought to be the catalyst in the process of economic development (Rostow 1962) and are a particular important factor to the growth of rural areas (De Vera Garcia, 1984) and thus the construction of LVRs that serve the rural areas is an important response to its development need and the construction costs of these roads is also of uttermost interest.

1.6 Significance of the Study

The benefits of this study of applying the concept of VA on the cost of construction of low volume roads in Uganda will include the following:

To the government, the reduction in the cost of construction of the low volume roads resulted in savings that could be used to extend the road network coverage with the same budget.

To the community, travel time will be reduced, dust nuisance will be minimized and reduce the burden of dust related illness like asthma and other lung diseases when more roads are sealed.

To the environment, gravel material loss from the road surface due to erosion will be minimized, saving gravel from fast depletion hence a sustainable consumption of the earth natural resource, a response to Sustainable Development Goal (SDG) number 12.

Academically, the study will provide a basis for further research about Value Analysis in road construction.

To the Policy makers, the study could be a basis in guiding Policy Framework regarding road sealing and construction cost reduction strategy.

1.7 Scope of the Study

1.7.1 Geographical Scope

The study was conducted in ten (10) selected districts where LCS projects have successfully been completed in eastern and northern Uganda from 2013 to 2017 and the results inferred on 23 Districts in Lango, Acholi and Teso sub regions of Uganda. The researcher then used stratified sampling technique for the two sub regions of Northern and Eastern Uganda and thereafter reached out to the districts that successfully sealed more length of LVRs.

1.7.2 Content Scope

The researcher reviewed the costs of at least 3 – 5km of LVRs constructed in each of the ten districts under the LCS program.

The study focused on the existing LVRs constructed in the piloted districts in Uganda under RTI funding. The researcher reviewed documents of the projects implemented to track their cost.

For comparative purpose, the researcher designed, prepared BOQ and constructed 0.8km of LVR section in Kole district, one of the study areas while applying VA concept to determine the cost that guided towards drawing inference over the two scenarios where the VA was never applied at all stages and in the event that VA was applied during Road Forming Phase (RFP).

The researcher during the construction phase of 0.8km trial section, applied the mix-method (blended labour with equipment), other than the labor intensive technique alone in the Road Formation Phase (RFP) which is currently being practiced for the LCS construction of the LVRs, with the aim of cutting down on the labour cost and reduce on the construction period as strategies to reduce cost and enhance value.

Another project in Bukedea district measuring 1.2km also blended labour with equipment during road formation phase was also sampled for this study.

1.7.3 Time Scope

The researcher took two years to undertake this study from September 2017 to September 2019 from dissertation development up to submission of dissertation.

1.8 Conceptual Framework

This study's independent variables were as shown in Figure 1.1. The researcher manipulated the labour size and capacity and efficiency of equipment the rest of the independent variables were not manipulated. The envisaged outcome was a reduced cost in construction of the LVRs, reduced completion time and increased coverage of LCS on LRV roads.

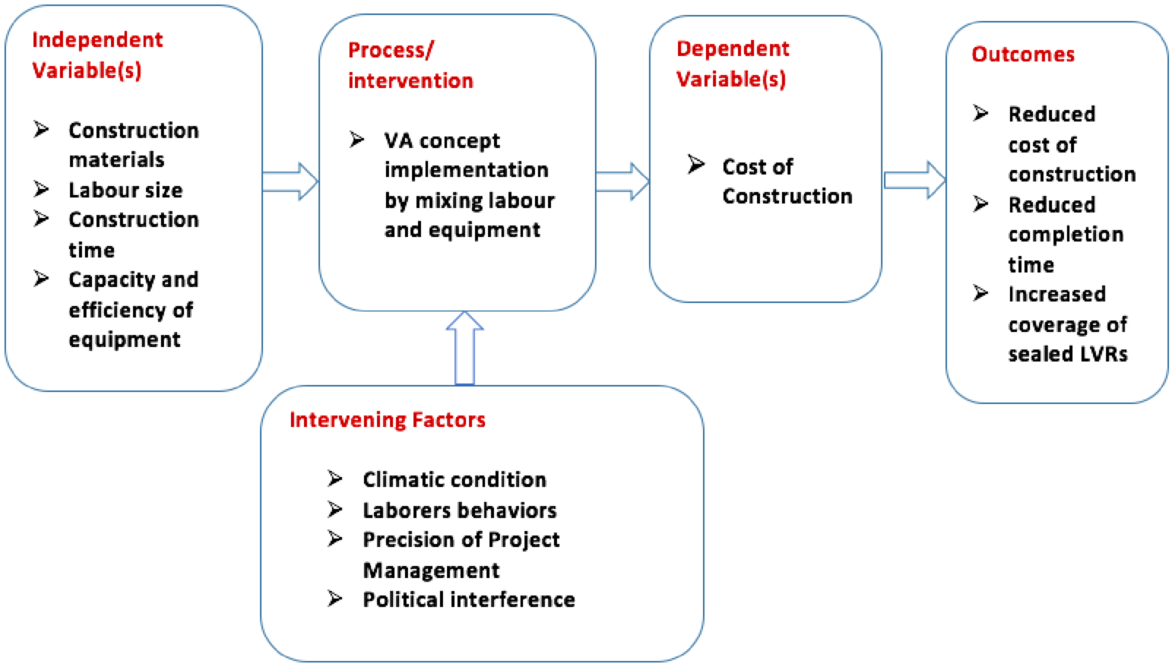


Figure 1.1: Conceptual Framework

1.9. Chapter Summary

This chapter discussed the background of this research dissertation and particularly how the concept of VA started; it discussed statement of the problem, objectives of this study, research questions, research justification, significance of the study, scope of the study and conceptual framework. The next chapter discusses literature review, which basically gives some insights on Low cost seal constructions in Uganda and also highlights the arguments of some scholars in relation to Value Analysis.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

In the previous chapter, a background to the study was given and the problem to be addressed defined. The objectives of the research were clearly stated and justification was given for carrying out the research. In this chapter, literature was reviewed, especially on cost of construction of roads and low volume roads in particular using low cost seal in Uganda and elsewhere and detailed the theory behind the concept of Value Analysis and Value Engineering on construction projects especially roads construction projects.

2.2 Classification of Roads in Uganda

Roads in Uganda are classified majorly as National Roads and District Roads. Both the National roads and the District roads can be classified basing on their function.

JICA (2012) identified that in Uganda, there were two road manuals/design guidelines which are the Road Design Manual and the District Road Manual, and both were published by the Ministry of Works and Transport. The Road Design Manual was prepared for national road planning and design while the District Road Manual was for district roads managed by the Ministry of Local Government. In both manuals there were different explanations for functional road classification systems as shown in the Tables 2.1 and 2.2.

Table 2.1: Functional Road Classification System for National Roads in Uganda

	Class	Definition
A	International Trunk Roads	Roads that link International Important Centres. Connection between the national road system and those of neighbouring countries. Major function is to provide mobility
B	National Trunk Roads	Roads that link provincial capitals, main centres of population and nationally important centres. Major function is to provide mobility
C	Primary Roads	Roads linking provincially important centres to each other or to a higher class road (urban/rural centres). Linkage from districts, local centres of population and development areas to higher class roads. Major function is to provide both mobility and access
D	Secondary Roads	Roads linking locally important centres to each other, to more important centres, or to higher class roads (rural/market centres) and linkage between locally important traffic generators and their rural hinterland. Major function is to provide both mobility and access.
E	Minor Roads	Any road link to minor centre (market/local centre) and all other motorable roads. Major function is to provide access to land adjacent to the secondary road system.

Source: MoWT (2010)

Table 2.2: Functional Road Classification System & Route Numbering

Class	Definition
District Class I Roads	District Class I roads serve national interests in that they satisfy criteria established for secondary and/or tertiary road systems of MoWT's Trunk Road Network. District Class I roads will be candidates for eventual upgrading to the Trunk Road network after which they become the responsibility of UNRA for maintenance and further development. District I roads, to qualify for upgrading to MoWT jurisdiction, need to be engineered and constructed to Trunk Road standards
District Class II Roads	District Class II roads provide the basic internal transport needs of the district. District Class II roads connect to UNRA secondary or tertiary road systems, interconnect the district capital and county administrative centres, and provide direct access for district population centres to district health, educational, marketing and administrative facilities. Such roads generally have a gravel surface and carry, on average, twenty or more motorized vehicles per day
District Class III Roads	District Class III roads (including cul-de-sacs) are typically low motorized traffic volume roads extending into the districts' lightly populated peripheral regions. District Class III roads may, at times, serve as connectors to and/or between district class II roads, but generally do not provide direct routing to major public activity centres. Such roads generally have an earth/gravel surface and carry, on average, less than twenty motorized vehicles per day
District Access Roads	In Uganda, the community access road (CARs) network comprises an extensive system of low motorized traffic volume, usually dry weather only, earth roads serving primarily pedestrians, bicycles and animal drawn carts. Neither inventory/condition surveys detailing the actual extent and condition of this network, nor any clear definition of design class or appropriate design standard exist at present. During implementation by district local government staff of their district road inventory and condition surveys (ADRICS), local authorities at sub-county level are provided the opportunity to identify those CARs considered most important for the survival and continued development of their communities. This process will, over time, enable identification of the most important CARs and result in the development works. For complete details of the ADRICS procedure, refer to District Road Manuals Manual B.

Source: (MoWT, 2010)

The district roads are the major area of concentration in this study. These roads are Low Volume Roads LVRs and are mostly un-surfaced with only 38.6km (0.11%) tarmac/sealed under low cost seal programme championed and spear headed by Mt. Elgon Labour Based Training Centre (MELTC). Because these roads connect different Districts to main trade routes within the country, there is need to increase the length of District paved roads by investing in their construction funding or adopt a cheaper and more efficient alternative.

The current low coverage of paved roads in Uganda can be attributed to the high costs incurred in the construction of highways generally. Highway/road construction ventures usually involve large amounts of money as capital investment. The report by MoWT (2017) revealed that the cost per km for upgrading from gravel to Double Surface Dressing (DSD) standard was USD 1,800,000-2,000,000 in the FY 2016/17. This, therefore, makes it necessary to ensure that the cost is reduced and that higher value for money is obtained during the construction of highways through the application of VA technique.

2.3 Construction Process of Roads

According to Suryakanta (2017), the construction of water bound macadam road involves the following 6 basic steps as given below: Preparation of sub-grade; Preparation of sub-base; Preparation of base; Preparation of wearing course; Preparation of shoulders and Opening of road to traffic.

2.3.1 Preparation of Sub-Grade

Consists of the naturally occurring material on which the road is built, or the imported fill material used to create an embankment on which the road pavement is constructed. Subgrades are also considered layers in the pavement design, with their thickness assumed to be infinite and their material characteristics assumed to be unchanged or unmodified. Prepared subgrade is typically the top 300mm of subgrade (Haseeb, 2017).

According to Suryakanta (2017), sub-grade is provided by digging up the sub-soil and the level of the sub-grade is decided by subtracting the total thickness of the pavement from the finished level of the road pavement. The sub-grade should be thoroughly compacted using steel drum rollers before the construction of the subsequent layers of the road pavement.

2.3.2 Construction of Sub-Base

A subbase is layer of granular material provided above subgrade generally natural gravel. It is usually not provided on subgrade of good quality. It is also called granular subbase (Haseeb, 2017).

According to Suryakanta (2017), on a well compacted sub-grade, 10 to 20 cm size boulders or broken stones are spread in layers of 120 to 150 mm thickness and total width of the sub-base to be kept 600 mm wider than pavement width, projecting 300 mm on each side. The sub-base is then compacted by a roller to provide an even surface.

A nominal minimum CBR of 30 per cent is required at 95 per cent modified AASHTO MDD (test method T-180). Where construction traffic loading or climate is severe during construction, the Engineer is advised to specify more stringent requirements. Broadly, the poorer the conditions, the lower should be the limits on PI and linear shrinkage, and the more the need for a well graded better-quality material. Conversely for less severe conditions, particularly in drier areas some of these requirements may be relaxed (MoWT, 2010).

2.3.3 Construction of Base

According to Suryakanta (2017), specified materials of the base course is spread on the prepared sub-base or directly on the sub-grade and proper graded, thickness and cross sections maintained as per design in the supplied drawings.

Some of common materials used for base construction in road construction are naturally occurring granular materials such as lateritic, calcareous and quartzite gravels, river gravels and other transported gravels or granular materials resulting from the weathering of rocks and graded crushed stones (MoWT, 2010).

2.3.4 Construction of Wearing Course

According to Suryakanta (2017), the wearing course may be laid in one or two layers according to the total designed thickness and the thickness of each layer should not exceed 100 mm. Prior to the construction of the wearing course all the defective portions of the newly laid base course are checked and rectified. The binding material is then applied in two to three thick layers at a slow and uniform rate. Each layer of binding material is rolled after adding sufficient water. The slurry is swept in with brooms to fill the void properly. The moving wheel of the roller should be cleaned with water. The operations of spreading of binder, sprinkling of water, sweeping with brooms and rolling should be continued till the voids get filled and slurry forms a wave before moving the wheel of the roller.

2.3.5 Construction of Shoulders and Opening to Traffic

While curing the pavement surface, the shoulders should be prepared by filling earth to the specified cross slope and compacted properly by rolling or by tamping. Width and thickness of the shoulder should be as per specification (Suryakanta, 2017).

After properly drying, the road pavement may now be opened to traffic, ensuring that the traffic is distributed uniformly over the full width of the pavement.

2.4 Construction of Low Volume Roads (LVRs)

Low Volume Roads (LVRs) are roads with traffic volumes of not more than 400 vehicles per day (Songjukta, 2019); they have enormous impacts on economies, communication, and social interaction. Examples of LVRs are; farm-to-market roads, roads in developing countries linking administrative units and roads to parklands (Douglas, 2017).

However, most of the LVRs in Uganda are un-surfaced and in most cases are maintained using naturally occurring gravels which if over used, they get depleted and with time there is bound to be no materials for road constructions for sub bases and bases therefore this study emphasizes on sealing the LVR surfaces to limit overuse of gravel materials hence a sustainable consumption of the earth natural resources in line with sustainable development goal number 12.

2.5 Construction of Low Volume Roads with Low Cost Sealing Technology

The construction processes required for a LVR with a wearing course or road seal does not, in principle, differ markedly from that adopted for other types of road. However, LVRs are much more sensitive to the social, economic and technical context in which they are built. Variations can be significant with regard to the choice of construction method, type of resources available and type of construction materials being used. This requires the adoption of an appropriate construction strategy which, on some projects, may require the contractor to create productive employment through the use of labour-based methods of construction (ERA, 2016).

ERA (2016) identified the typical range of activities that a contractor would need to consider in undertaking the construction of a LVR. These include the adoption of an appropriate construction strategy as well as appropriate techniques for undertaking earthworks and pavement construction operations using locally available materials. The importance of compaction is highlighted, as well as problems that may be encountered in dealing with poor soils, such as expansive, collapsible and dispersive soils. Finally, the precautions that should be followed in undertaking shoulder construction and surfacing of LVRs are addressed.

The design of sealed LVRs as presented by the MoTPW (2013), works contain many layers with different functions. The main components of LVRs pavement are shown in Figure 2.1 whilst the purpose of these various components is summarized in Table 2.3

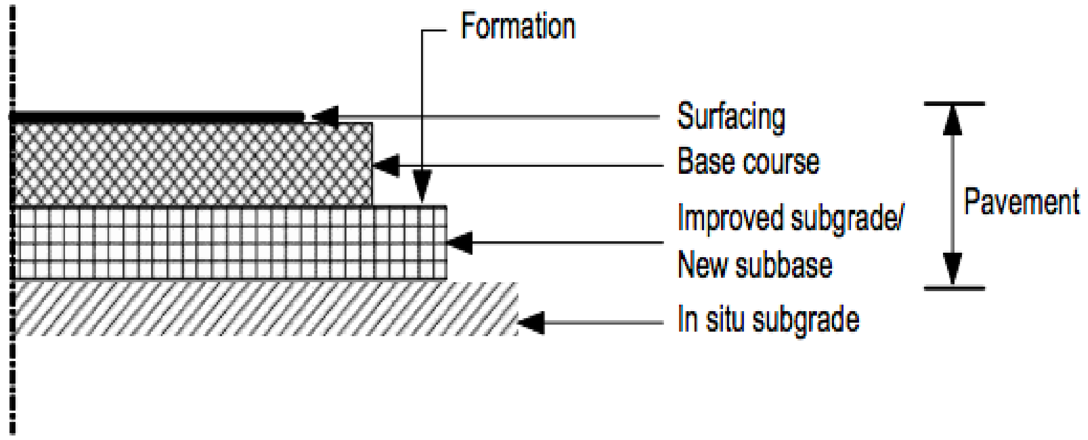


Figure 2.1: Main components of a sealed LVR pavement

Source: MoTPW (2013)

Table 2.3: Components of the LVRs which are sealed and their purposes

Pavement component	Purpose
Surfacing	Provides a smooth running surface Provides a safe, economical and durable all-weather surface Minimizes vehicle operating and maintenance costs Reduces moisture infiltration into the pavement Provides suitable properties for the local environment, e.g. dust suppression, skid resistance and surface texture
Base (base course)	Provides the bulk of the structural capacity in terms of load spreading ability by means of shear strength and cohesion Minimizes changes in strength with time by having relatively low moisture susceptibility Minimizes the ingress of moisture into the pavement by having adequate shrinkage and fatigue properties
Subbase/improved subgrade (reformed & compacted original gravel wearing course	Provides a stable platform for the construction of the base and surfacing Assists in providing adequate pavement thickness so that the strains in the in situ subgrade are kept within acceptable limits
In situ subgrade	Refers to the naturally occurring material on which the pavement and improved subgrade are constructed

Figure 2.2 shows the cross sectional design of a sealed LVR while Figure 2.3 shows the drainage component of a sealed LVR.

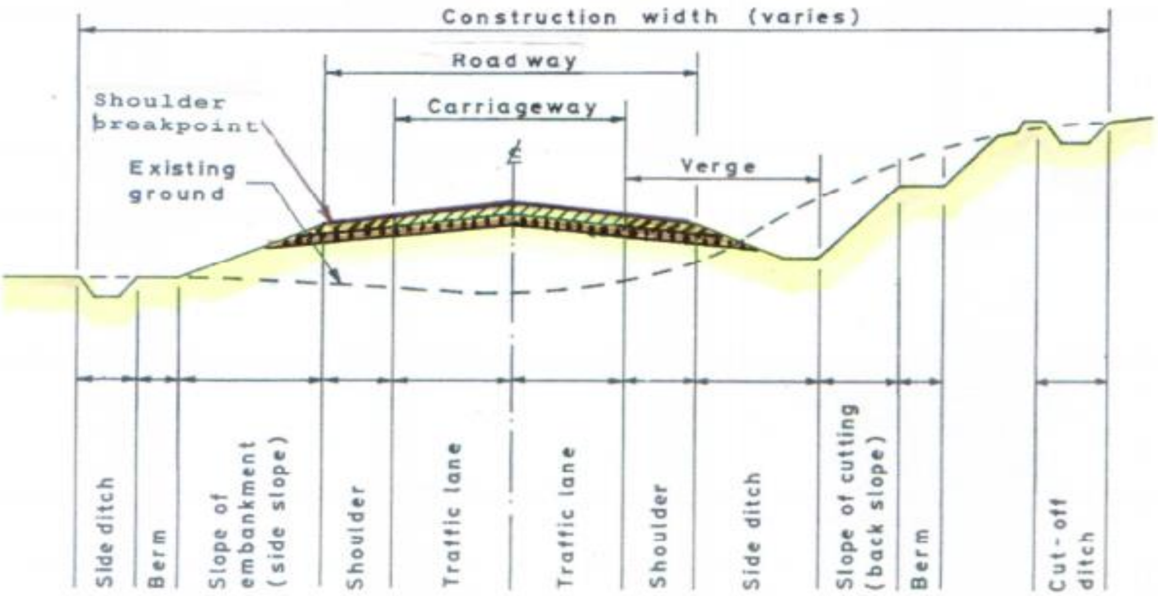


Figure 2.2: Cross Sectional Design of a sealed LVR

Source: MoTPW (2013)

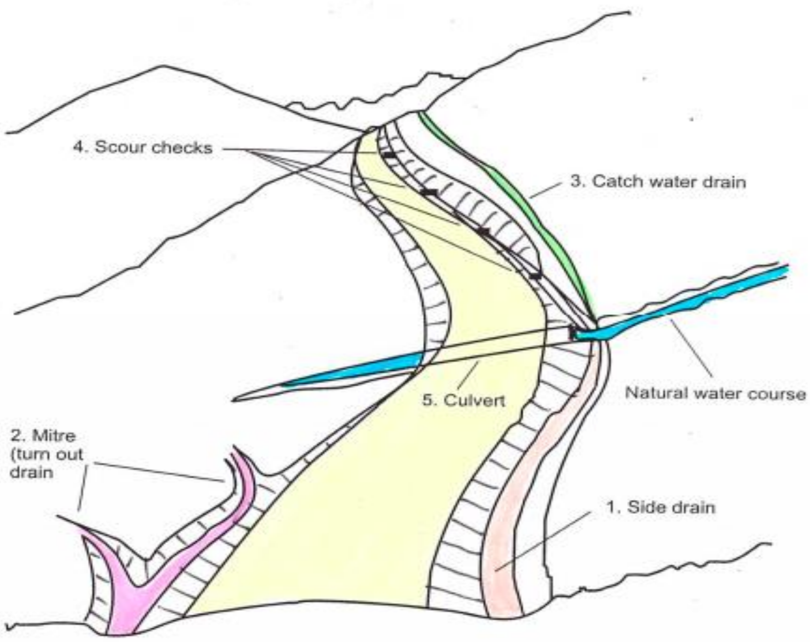


Figure 2.3: Drainage Components of a sealed LVR

Source: MoTPW (2013)

In Uganda there have been some technologies tried and implemented to seal the surfaces of LVRs under low cost seal but this research seeks to get alternative to have the cost of these technologies reduced while maintaining the performance. The different low cost sealing technologies are discussed below.

2.6 Low Cost Seal (LCS)

There are a number of low cost seal technologies tried and implemented in different parts of the world and they are intended to provide a cost-effective and sustainable alternative to natural gravel surfaces, with more manageable maintenance requirements and lower transport costs.

There are six low cost sealing technologies tried in Uganda and implemented by MELTC (Muhakanizi, 2016), and they are explained below:

2.6.1 Sand Seal

These consists of a prime coat, a film of binder (cutback bitumen or emulsion) followed by a graded natural sand or fine sand-sized machine or hand-broken aggregate (max. size typically 6 – 7 mm) which must then be compacted. They are especially useful if good aggregate is hard to find and also suitable for labour-based construction, especially where emulsions are used, and requires simple construction plant. Single sand seals are not very durable but performance can be improved with the application of a second seal (Muhakanizi, 2016).

2.6.2 Slurry Seal

Slurry seal consists of a mixture of fine aggregates, Portland cement, emulsion binder and additional water to produce a thick creamy consistency which is spread to a thickness of 5-15 mm, they are not normally used on new roads; more typically used for re-texturing surface dressings prior to resealing or for constructing Cape seals, this seal is very suitable for labour-based construction using relatively simple construction plant (concrete mixer) to mix the slurry.

Thin slurry (5 mm) is not very durable (life 3-4 years) but performance can be improved with the application of a thicker (15 mm) slurry (life span of 6-7 years).

2.6.3 Surface Dressing

This consists of a binder (emulsion or penetration grade) sprayed onto the previously primed surface and then covered with a layer of crushed aggregate chippings (single surface dressing – SSD) or with a second another application of binder and aggregate (double surface dressing – DSD), DSD is usually used to seal an unpaved surface; SSD used as a maintenance treatment for existing bituminous sealed roads or in combination with a sand seal to improve its durability. SSD plus sand seal is fairly durable (life 6-7 years) but performance can be improved with the application of a second seal (life span of 8-10 years).

2.6.4 Otta Seal

This seal consists of a low viscosity binder (e.g. cutback bitumen, MC 3000 or 150/200 penetration grade bitumen) followed by a layer of graded aggregate (crushed or screened) with a maximum size of up to 19 mm, due to the fines in the aggregate, there should be extensive rolling to ensure that the binder is flushed to the surface.

The seal may be constructed in a single layer or, for improved durability, with a sand seal over a single layer or in a double layer, it is very suitable for labour-based construction but requires relatively complex construction plant (bitumen distributor + binder heating facilities), the seal provides a very durable type of surfacing (life span of 5-6 years for single seal, 8-10 years for single seal + sand seal and 12-15 years for double seal).

2.6.5 Penetration Macadam

This is constructed by first applying a layer of rolled coarse (e.g. 40/60 mm aggregate) followed by the application of emulsion or penetration grade binder, next, the surface voids in the coarse aggregate layer are filled with finer aggregate (e.g. 10/20 mm aggregate) to lock in the coarse aggregate followed by an additional application of emulsion binder which is then covered with fine aggregate (e.g. 5/10 mm) and rolled. The seal is very suitable for labour-based construction as aggregate and emulsion can be laid by hand and produces a stable interlocking, robust layer after compaction (life of 8-10 years) but the cost is relatively high due to the high rate of application of bitumen.

2.6.6 Cold Mix Asphalt

This consists of an admixture of graded gravel (similar to an Otta seal) and a stable, slow-breaking emulsion which is mixed by hand or in a concrete mixer. After mixing the material, it is spread on a primed road base and rolled, the seal is very suitable for labour-based construction; requires very simple construction plant and produces a dense surfacing, comparable to an Otta seal (life span of 8-10 years)

This research therefore identified alternative of implementing one of the technologies above and specifically Single Surface Dressing (SSD) with sand capping due to its lifespan of 8-10 years as per the study above and for this research Value Analysis was applied. The study is necessary to further reduce the cost.

According to Muhakanizi (2016), SSD is the predominant method employed in Uganda, sealing LVRs totaling up to 90% of all the sealed roads. Other sealing methods used were Double Surface Dressing (DSD) and Premix Asphalt (PA) accounting for 5% each of the remaining 10% sealed roads. Figure 2.4 shows the percentage application of the different LCS technologies on the LVRs.

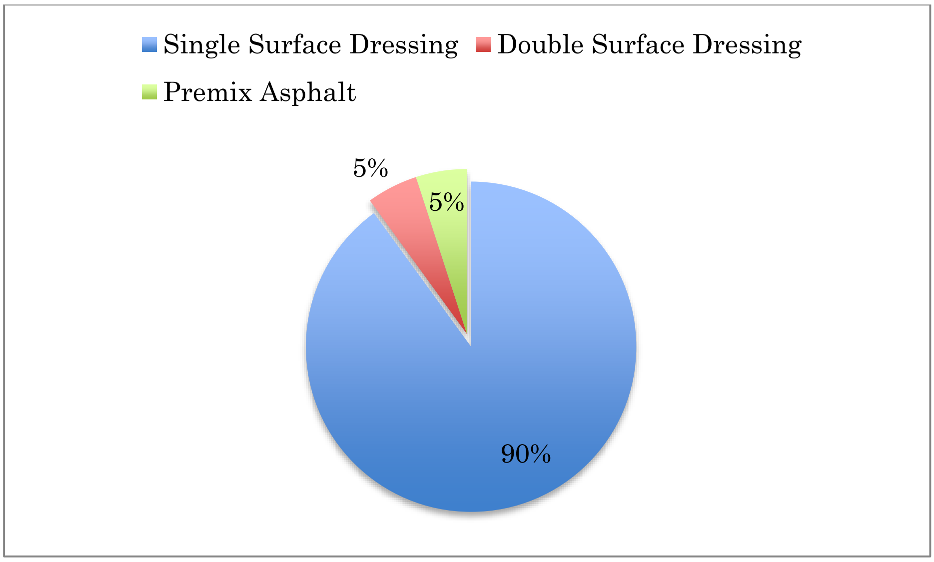


Figure 2.4: Percentage usage of LCS technologies on LVR. Source: Muhakanizi (2016).

2.7 Value Engineering and Value Analysis Concept

Value Engineering and Value Analyses has been interchangeably used by different scholars but may have noticeable differences and interrelationships that are spelled out from some of the different scholars in this literature review.

Value Analysis, Value Engineering and Value Management are the concepts of a single administrative approach aimed at finding practical solutions and reduce the unnecessary cost. Value Analysis is a study applied on projects completed or products and methods which are currently being used, to look for improvement of their performance and get rid of the extra costs. Value Engineering is designed to improve the quality and reduce the cost of construction projects and applied during project idea or after completion of public perception while Value Management is a comprehensive concept of how to manage programmes and how to setup value studies and follow up, so that value engineering workshop or Value Analysis is part of this process (Ilayaraja & Zafar, 2015)

2.7.1 Value Engineering

According to Schneiderova (2016), Value Engineering is not a design/peer review or a cost-cutting exercise but rather is a creative, organized effort, which analyzes the requirements of a project for the purpose of achieving the essential functions at the lowest life cycle cost (LCC). Through a group investigation, using experienced, multi-disciplinary teams, value and economy is improved through the study of alternative design concepts, materials, and methods without compromising the functional and value objectives of the client.

VE can be applied at any point in a project, even in construction. However, typically the earlier it is applied the higher the return on the time and effort invested as seen in Figure. 2.5.

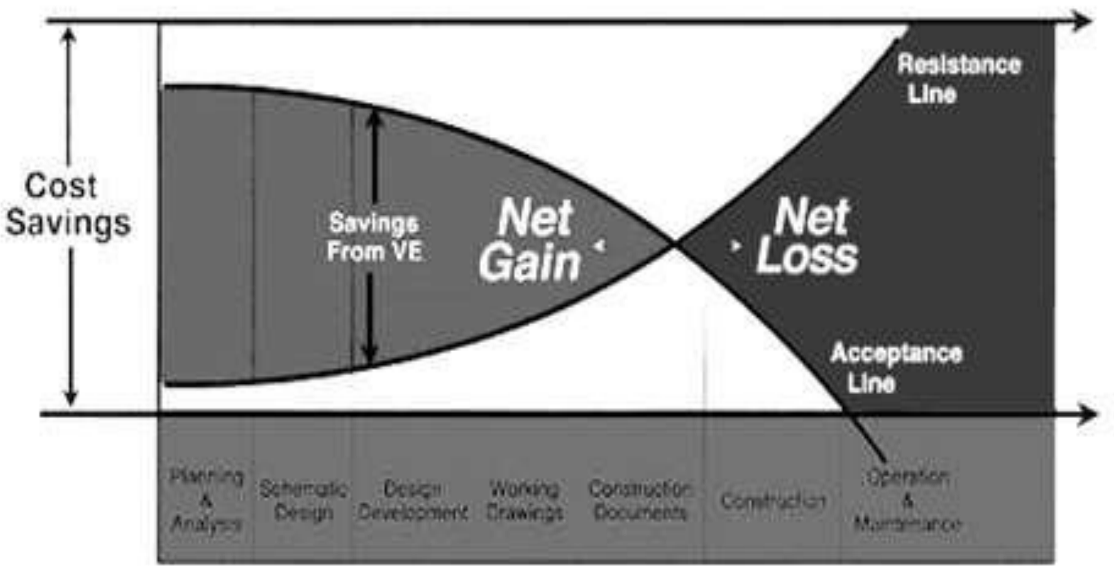


Figure 2.5: Potential savings from Value Engineering application.

Source: Dell'lsolla, (1998).

Schneiderova (2016) suggested the three main stages of a project when VE can be applied.

2.7.1.1 Planning

At the planning stage of development, there are additional benefits to be derived from a Value Engineering workshop. An independent team can review the program, perform a functional analysis of the project, obtain the owners and users definition of value, define the key criteria and objectives for the project, verify the proposed program, review master plan utility options, offer alternative solutions, and verify the budget.

2.7.1.2 Design

Design is the stage that most VE participants usually become involved, the point at least when the design has made it to the schematic stage. The primary tool available to the VE team is the workshop. The workshop is an opportunity to bring the design team and client together to review the proposed design solutions, the cost estimate, and the intended implementation schedule and approach, with a view to implementing the best design solution in order to achieve value for money. The definition of what is good value on any particular project will change from client to client and project to project.

The five-step "VE Job Plan" is followed, as prescribed by SAVE International (2007):

- Information Phase (understanding the background, analysis of the key functional issues, the cost and impacts associated with function)
- Creative Phase (ways to provide the necessary function at a lesser LCC - improved value for client)
- Analysis Phase (criteria definition for evaluation, ideas analysis, weighted evaluation)
- Development Phase (ideas are expanded into workable solutions – design change, evaluation of advantages and disadvantages, cost comparison, LCC calculation, comparison to original design).
- Presentation Phase (recommendations, key cost impacts).

2.7.1.3 Construction

Value engineering is still possible during construction phase. Contractors can be provided with monetary incentives to propose solutions that offer enhanced value to the owner, and share the financial benefits realized.

Clearly the owner must consider contractor-generated proposals very carefully, from both a life-cycle perspective, and a liability perspective (Schneiderová, 2014). The team must be brought in to the decision-making process to agree to the proposed change in order not having any negative impact on the overall design and project function.

The VA concept of the mixed method of construction of LVRs falls within this phase and it is important that the project owner, financer and the construction contractor agree on the change in the construction methods from the current labour intensive to the suggested mixed method.

2.7.2 Value Analysis

2.7.2.1 Definitions of Value Analysis

According to Fasal (1972), Value Analysis is the methodical investigation of all the components of the existing product with the goal of discovering and eliminating costs without interfering with the effectiveness of the product. In Value Analysis, the systematic analysis of a product is performed in terms of an already existing prototype of the product; all information concerning the actual costs and all the specifications determining required performances are obtained from past experience with the prototype itself.

According to Zimmerman and Hart (1988), Value Analysis is a proven management technique using systematized approach to seek out the best functional balance between cost, reliability and performance of a product or project.

Miles understood that products are purchased for what they can do either through the work they perform or the pleasing aesthetic qualities they provide. Using this as his foundational information, he focused on understanding the function of the component being manufactured. He questioned whether the design could be improved or if a different material or concept could achieve the function. These specialized teams typically address project-related issues such as increased sales revenue, improved product performance, and reduced resource usage (Miles, 1972; SAVE International, 2007). In this research, the question is whether using a mixed method of labour in the RFP would give a better lower cost during the construction of LVRs with similar quality and performance.

The objective of VA is to achieve equivalent performance for lower cost without “reducing in the slightest degree of quality, safety, life, reliability, dependability and attractiveness that the customer wants” (Miles,1972). The aim of VA is also to achieve an assigned target product cost by; (i) identifying improved product designs that reduce the product’s cost without sacrificing functionality and/or (ii) eliminating unnecessary functions that increase the product’s costs and for which customers are not prepared to pay extra for (Miles, 1972). The former is more relevant in the case of road construction. Performance is given top priority.

In a similar pursuit to enhance value, Kou (2001) studied the vertical cooperate framework in Taiwan’s electronic industry. The research investigated the switching mode power supply industry to find out how to use value engineering to enhance the product function, reduce the product size and keep the thermal management ability within a reasonable range.

Venkateswaran and Son (2005) argued that VA is an organized way of thinking or looking at an item or a process through a functional approach. Value Analysis is an effective tool for cost reduction and the results accomplished are far greater. It improves the effectiveness of work that has been conventionally performed as it questions and probes into the very purpose, design and method of manufacture etc. of the product with a view to pinpointing unnecessary costs.

Formentini and Pietro (2011) argued that besides improving the value of a product, VA provides other benefits like reduce risk, improve quality and understand customer requirements of a knowledge transfer in multi-project settings. VA turned out to be a very important means for improving the quality and reducing the costs of products/services in companies which use it. At the same time these companies can systematically orient their knowledge and the creative flow and thus create efficient competitive advantages (Cerqueiro, 2011).

Apart from the huge amount of funds required, construction sector has varieties of construction projects involving large number of stakeholders, materials, construction and management techniques. Considering the fast increase in size of construction industry today, it would be possible through VA studies to identify and overcome the various loop holes with creative alternatives which resulted into higher productivity, cost reduction, better performance, better quality, simpler design (Civil, structural, mechanical, etc.) and optimum project duration without affecting the function of any project or service (Dhayalkar, 2016).

2.7.2.2 Value Analysis Methodology

The Value Analysis methodology is based on a multi-stage job plan, sometimes also called as "Value Analysis job plan" (Walk, 2012). Some sources list five phases, while others range up to eight. Table 2.4 *s*hows the sequence of phases of different job plan given by some leading experts or practitioner and societies exercising Value Analysis job plan.

Table 2.4: Sequence of Phases of the Different Job Plans in Exercising Value Analysis Job Plan.

Trufty (1983) (7 Phases)	**Venkataraman (1992) (10 Phases)**	**Mudge (1971) (7Phases)**
1. Information Phase 2.Speculation Phase 3.Analysis Phase 4.Development Phase 5.Implemenation Phase 6.Follow- Up Phase	1. Project Selection Phase 2. Information Phase 3.Function Phase 4.Creative Phase 5. Analytical Phase 6.Evaluation Phase 7.Recommendation Phase 8.Implementation Phase 9. Review Phase 10. Extension Phase	1.General Phase 2.Information Phase 3.Function Phase 4.Creation Phase 5.Evaluation Phase 6.Investigation Phase 7.Recommendation Phase
Dell'Isola (1974) (4 Phases)	**Zimmerman (1988) (5 Phases)**	**Miles (1972) (5 Phases)**
1.Information Phase 2.Speculation Phase 3.Analytical Phase 4.Proposal Phase	1.Information Phase 2.Creative Phase 3.Judgement Phase 4.Development Phase 5.Recommendation Phase	1.Information Phase 2.Functional Analysis Phase 3.Creation Phase 4.Judgement Phase 5.Development Phase
US Environment Protection Agencies (6 Phases)	**Society of American Value Engineers (5 Phases)**	**Society of Indian Value Management (6 Phases)**
1.Information Phase 2.Creative Phase 3.Analytical Phase 4.Investigation Phase 5.Recommendation Phase 6.Implmatation Phase	1.Information Phase 2.Creative Phase 3.Evaluation Phase 4.Development Phase 5.Presentation Phase	1.Information Phase 2.Function Phase 3.Creative Phase 4.Evaluation Phase 5.Investigation Phase 6.Recommendation Phase

Information Phase

During the information phase, the team gathers as much information as possible in order to discuss the design, background, constraints and projected costs of the project. The team is made familiar with the present state of the project. All team members participate in a functional analysis of the project as a whole, and then of its component parts, to determine the true needs of the project. Areas of high cost or low worth are identified (Anon., n.d.).

Functional Analysis Phase

During the functional analysis phase, the project will be analysed in order to clarify the required functions. It tries to identify what functions are important and which performance characteristics are required for these functions (Anon., n.d.)

Creativity Phase

This step requires a certain amount of creative thinking by the team. A technique that is useful for this type of analysis is brainstorming. This stage is concerned with developing alternative, more cost effective ways of achieving the basic function. All rules of brainstorming are allowed, and criticism needs to be avoided as it could cease the flow of ideas. The team should list down all ideas, not regarding whether they sound apparently ridiculous. Two powerful techniques to promote creativity are by: Establishing positive thinking and Developing creative ideas. The desired thing at this point is a large number of ideas, no matter whether they look ridiculous. A number of check-lists and idea-stimulators could be used for the purpose (SAVE International, 2007).

i. Analytical phase

Analytical phase of the Value Analysis job plan has following two basic objectives which are to select for further analysis, the most promising of the idea generated during the creativity phase and to submit these ideas to preliminary screening and to identifying the meaningful and feasible ideas (Zimmerman, 1988).

During the analystical phase, the ideas must be refined to meet the necessary environmental operating conditions of the particular situation. Ideas obviously, which do not meet these requirements are dropped. Ideas having potential, but beyond the capability of present technology are put aside for possible discussion with the concerned parties (Walk, 2012).

ii. Evaluation Phase

In this phase of the workshop, the VA team judges the ideas developed during the creative phase. The VA team ranks the ideas. Ideas found to be irrelevant or not worthy of additional study are disregarded; those ideas that represent the greatest potential for cost savings and improvements are selected for development. A weighted evaluation is applied in some cases to account for project impacts other than costs (both capital and lifecycle). Ideally, the VA team would like to evaluate all attractive ideas but time constraints often limit the number of ideas that can be developed during the workshop. As a result, the team focuses on the higher ranked ideas. This phase is designed so that the most significant ideas are isolated and prioritized (Sharma & Belokar, 2012).

iii. Recommendation Phase

In the development phase, final recommendations are developed from the alternatives selected during the analysis phase. Detailed technical and economic testing is conducted and the probability of successful implementation is assessed. The presentation phase is actually presenting the best alternative (or alternatives) to those who have the authority to implement the proposed solutions that are acceptable. During the implementation and follow-up phase, management must assure that approved recommendations are converted into actions. Until this is done, savings to offset the cost of the study will not be realized (SAVE International, 2007). Figure 2.6 illustrates the Job Plan process flow. Each of the Job Plan phases must be performed in sequence because each phase provides information and understanding necessary for the successful execution of the next phase.

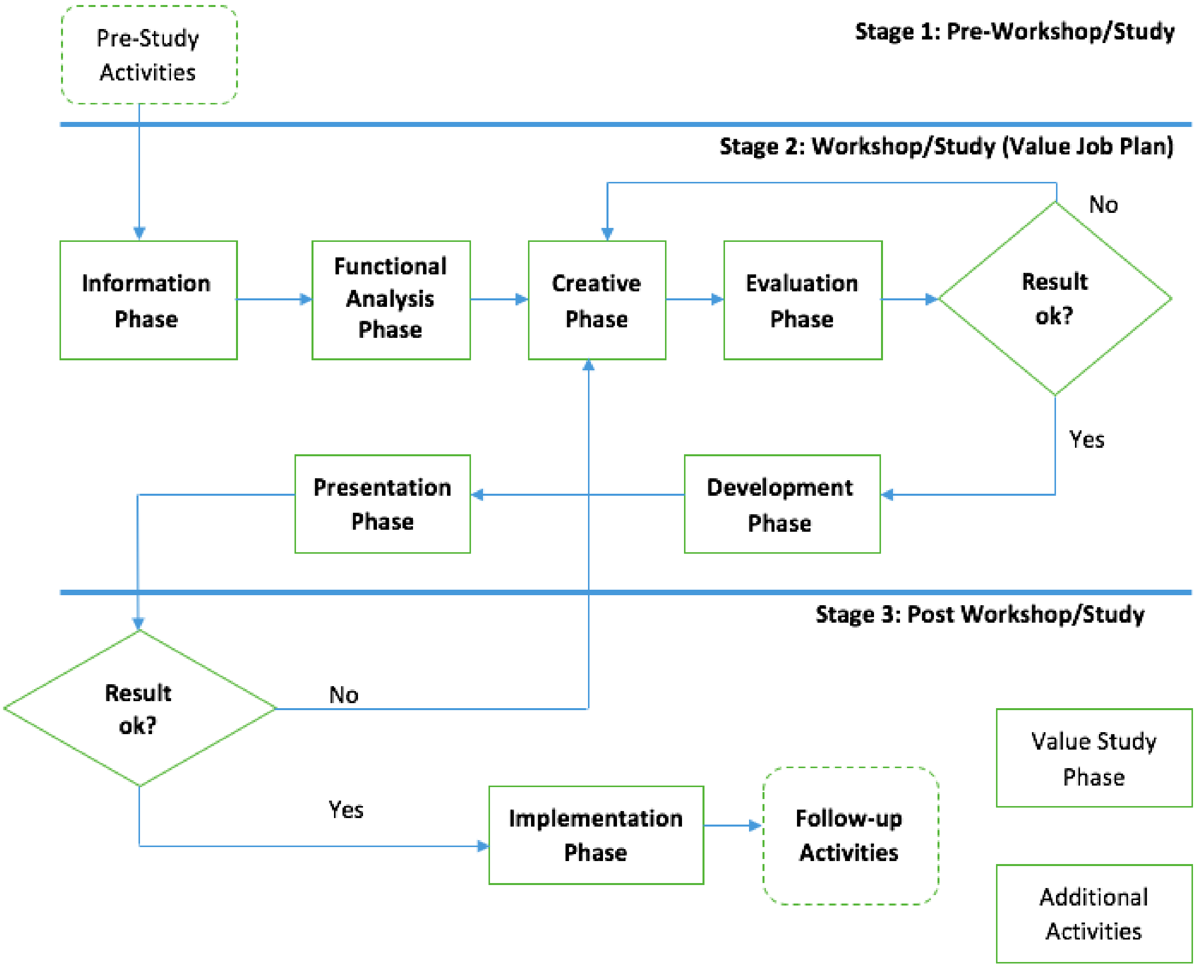


Figure 2.6: Value Study Process Flow Diagram.

Source: (SAVE International, 2007)

2.8 Causes of High Cost of Roads Construction Projects

Researches on construction projects in some developing countries indicate that by the time a project is completed, the actual cost exceeds the original contract price by about 30 %, (Pettang, 2016).

The main controllable causes of the projects cost overruns include but are not limited to the following: Inadequate project formulation: Poor field investigation, inadequate project information, bad cost estimates, lack of experience, inadequate project formulation and feasibility analysis, poor project appraisal leading to incorrect investment decisions; Poor planning for implementation: Inadequate time plan, inadequate resource plan, inadequate equipment supply plan, interlinking not anticipated, poor organization poor cost planning; Lack of proper contract planning and management: Improper pre-contract actions, poor post award contract management; Lack of project management during execution: Insufficient and ineffective working, delays, changes in scope of work and location, law and order; and the Construction method selected or adopted (Chitkara, 2011).

2.9 Chapter Summary

In this chapter, literature was reviewed to provide a better understanding of Value Analysis, LVR construction using LCS and the costs involved and how the application of the former can reduce the cost and give better sustainability with regard to financing road construction projects, the next chapter details the methodology used in carrying out the research.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

In the previous chapter literature was revealed with regard to LVR construction with LCS and Value Analysis. The literature was according to themes generated from the specific objectives of the study. This chapter covers methodological steps, which included but not limited to research design, research approaches, research population, sampling, description of study area, sources of data and data analysis.

3.2 Research Design

A research design is the "arrangement of conditions for data collection and analysis in a manner that aims to combine relevance to the research purpose" (Kothari, 2004). It is useful for efficient execution of research through a maximum collection of information cost effectively. It also enables the researcher to comeup with valid conclusions on the research, (Miller and Brewer, 2003).

This research was quantitative and it was designed in such a manner that questionnaires were used to obtain the data on the construction cost of the LVRs under the low cost sealing program in Lango, Acholi and Teso sub regions in Uganda. The data on cost and magnitude in terms of length of LVR projects was obtained through document analysis from the payment certificates, Bills of Quantities and questionnaires filled in by the implementers of LVRs construction projects, and they were used to obtain the cost per meter of each construction project. The cost per meter obtained from the data analysis for the LVRs constructed using the labour intensive method was obtained in fulfilment of specific objective one.

The researcher then obtained data from field and laboratory experiments for the designed phase of the 0.8 km section which was used to validate results from document analysis. These experiments included but were not limited to traffic counts to establish the Traffic levels, soil gradation test, Atterberg limit tests, lime composition in gravel soil for soil strength enhancement for the road base.

The researcher supervised the construction of the 0.8km Road in Kole District using the mixed method during the RFP and obtained the construction cost per meter. The researcher also obtained all data on the cost per meter when the mixed method had been used to address specific objective two.

The cost per meter obtained from the data analysis for the LVRs constructed using the labour intensive methods was compared to the cost per meter when mix-method was employed during the RFP and the hypothesis that the average cost per meter was less when the VA technique was applied to address specific objective three.

3.3 Research Approach

The approach for this study was majorly quantitative. Quantitative approach emphasizes objective measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques. Quantitative research focuses on gathering numerical data and generalizing it across groups of people or to explain a particular phenomenon (Wadsworth and Muijs, 2010).

Cost tracking of the implemented projects was assessed by the quantitative approach using pre-designed questionnaire and this aided establishing the statistics like average cost per metre of LCS roads, which was in line with specific objective one.

The researcher designed and supervised construction of the 0.8 km section while introducing the mixed method which was the use of a Grader and reduced on labour as a strategy to reduce on construction cost and time during road formation phase, this is in line with specific objective two.

Testing of the hypothesis was done at a level of significance $\boldsymbol{\alpha}$ = 0.05.

There were some qualitative aspects in the research which were essentially used to make sense of qualitative data obtained regarding construction of LVRs in Uganda. Qualitative research seeks "meaning by looking at all aspects of the same phenomenon", (Miller and Brewer 2003).

3.4 Research Population and Sample Size

The study population is an entire group about which some information is required to be ascertained (Banerjee, & Choudhury, 2010). The study population for this research comprised of 23 districts in Eastern and Northern Uganda where the sealing of LVRs were piloted and being implemented under (RTI) funding and the researcher sampled 10 districts out of the 23 districts, based on the length of LVRs constructed successfully where districts that constructed more length were selected.

For this study, the researcher used stratified sampling strategy to select the 10 districts (Lango sub region included Kole, Apac and Oyam. Acholi sub region included the districts of Pader, Amuru, Lamwo and in Teso sub region the study included Ngora, Kaberamaido, Bukedea and Kumi) as the researcher selected districts that constructed at least 3 to 5 Km length of LVRs within the study period from FY 2013/2014 – 2016/2017.

3.5 Sampling Strategies

Sampling is described as "the process of obtaining information about an entire population by examining only a part of it". Sampling saves time, money and produces results relatively faster (Kothari, 2004).

The three major sampling techniques employed were: stratified random sampling, purposive sampling and simple random sampling.

3.5.1 Stratified Sampling

Stratified sampling method divides the original sample into nonintersecting homogeneous subsets (strata), including instances of all types. Then random or systematic selection methods are applied to each subset (Kothari, 2004:156). For this study the 23 districts were split into two strata: Eastern region and Northern region.

3.5.2 Purposive Sampling

According to Etikan (2013), the purposive sampling technique, also called judgment sampling, is the deliberate choice of a participant due to the qualities the participant possesses. It is a nonrandom technique.

For this project only the districts that had constructed and sealed LVRs with a uniform road sub base and base thickness, road width, used the same cost sealing option and had embankment length not more than 10% of the total construction length and the embankment height less than one meter were purposively selected. Ten (10) districts met these criteria and were selected for the study. These districts are shown on the map in Appendix II.

Purposive sampling was also applied when selecting the ten (10) respondents to the questionnaires used in this research because, they had specific knowledge that the researcher sought to answer the research questions.

3.5.3 Simple Random Sampling

Simple random sampling is a sampling scheme with the property that any of the possible subsets of n distinct elements from the population of N elements is equally likely to be the chosen sample. This definition implies that every element in the population has the same probability of being selected for the sample (Kalton, 1983).

Simple random sampling was used when carrying out field experiments to obtain data on the subgrade strength and Atterberg limits during the design of the 800m road in Kole District. The copy of the design is appended to this report (See Appendix III).

3.6 Sources of Data

3.6.1 Primary Data Sources

Primary data which are data collected for the first time and in its original character (Kothari 2004:95). The primary data were collected from 10 districts of the 23 districts in Lango, Acholi and Teso sub regions, where the technology of construction of the LVRs was piloted. For purpose of design for the 0.8 km section in Kole, data collected from the road section included traffic data and soil samples tested from Mbale regional laboratory where the results were used in the design.

3.6.2 Secondary Data Source

Secondary data are data collected for purposes of a prior study, or data already collected by someone else and has gone through the statistical process (Miller and Brewer, 2003; Kothari, 2004). Information from secondary data can be treated as part of primary information sources (Denscombe, 2014). The secondary data was carefully examined per objective to check its appropriateness to the study before using it as advised by (Lewis, 2003). The targeted respondent for each district was the District Engineer and documents like work plans, drawings, specifications, Bill of Quantities, final payment accounts and completion certificates for the low cost seal projects within the study period were reviewed. Some of this data were provided by the District Engineers by filling in the semi structured questionnaires.

3.7 Data Collection Tools

The researcher used a questionnaire for collection of data on cost of LCS on LVRs in Uganda. A questionnaire is a document designed with the purpose of seeking specific information from the respondents (Sansoni, 2011). The researcher purposively selected ten (10) district engineers and administered a questionnaire, copy of which is appended to this report (see Appendix IV). Data that was needed to generate a design of the 0.8Km LCS road in Kole District upon which the mix method VA technique was applied was collected through experiments. Measurement tools like tape measures and testing kits like Dynamic Cone Penetration instruments to collect data needed for the design.

3.8 Data Analysis

The data anylisis refers to the manupilation of data to make meaning by use of the specific instruments of analysis, including mathematical techniques and different types of computer software (Gay & Airasain, 2003).

The data collected during this research was entered into a Microsoft Excel spreadsheets where statistical information related to cost was generated like average cost per meter for each of the selected district for the study period. The overall average cost per metre where the labour intensive techniques and where the mixed method techniques were employed, for all the sampled districts were also generated.

Hypothesis testing was performed to check the significance of the findings on the cost per metre upon application of the mixed method VA technique at a 95% confidence interval. The t-test. The procedure for testing the hypothesis was as shown below:

i. Stating the null hypothesis and the alternative hypothesis.

Null hypothesis, H_0 ;$\mu_2 = \mu_1$, Alternative hypothesis, H_1;$\mu_2 < \mu_1$.

μ_1 is the average cost per metre when labour intensive methods were employed during the RFP and μ_2 is the average cost per metre when VA was used during the RFP

ii. One – tail test is performed at a level of significance α= 0.05 and confidence level of 95%

iii. The t-test is applied, the critical value$t_{\alpha=0.05}$for N-1 degree of freedom is obtained

iv. Calculated test statistic value is calculated using the formula$\frac{\mu_2 - \mu_1}{s.d/\sqrt{n-1}}$

v. Make a decision to uphold or reject the null hypothesis by comparing the critical value and calculated test statistic.

3.9 Research Ethical Considerations

The ethical issues that this research will consider are described by Miller and Brewer (2003:95) as those that lead to "creating a mutually respectful, win- win relationship in which participants are pleased to respond candidly and valid results are obtained. The study considered all fundamental research ethics, where confidentiality was ensured to all participants as none of their names and personal information like age were disclosed throughout the research. Protection of research participants and any other stakeholders from any harm as a result of the information they provided was observed. Participants were informed about the objectives of the study, procedures, risk and benefits of the research and gave their consent to participate in the study and that no information from them was disclosed to other people.

In order to carry out the study ethically and legally, the researcher obtained a research clearance letter from Kyambogo University. The research clearance letter was presented to the District officials who issued a permission letter to allow the researcher collect data from the Low Volume Roads within the districts.

3.10 Chapter Summary

The previous chapter reviewed literature This chapter presented the methodology employed during the research by which data was obtained and analyzed in order to achieve the main objective of this research. In the next chapter, the findings are given and discussed stating the limitations of the study.

CHAPTER FOUR: PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

4.1 Introduction

The study focused on the application of Value Analysis concept on construction cost of low volume roads in Uganda. The objectives of the study were to establish the current construction cost of LVRs in Uganda, to determine cost of construction of LVRs through application of VA concept, and to conduct a comparative construction cost analysis of LVRs upon application of VA and without the VA technique.

The field findings were arrived at through analyzing and interpreting data that were collected using questionnaires from ten rural districts in three sub regions that is Lango sub region included Kole, Apac and Oyam. Acholi sub region included the districts of Pader, Amuru, Lamwo and in Teso sub region the study included Ngora, Kaberamaido, Bukedea and Kumi.

Ten (10) questionnaires were issued to the District Engineers of the ten selected districts and there was 100% response. Ten (10) percent of the respondents were female and 90% were male as shown in figure 4.1

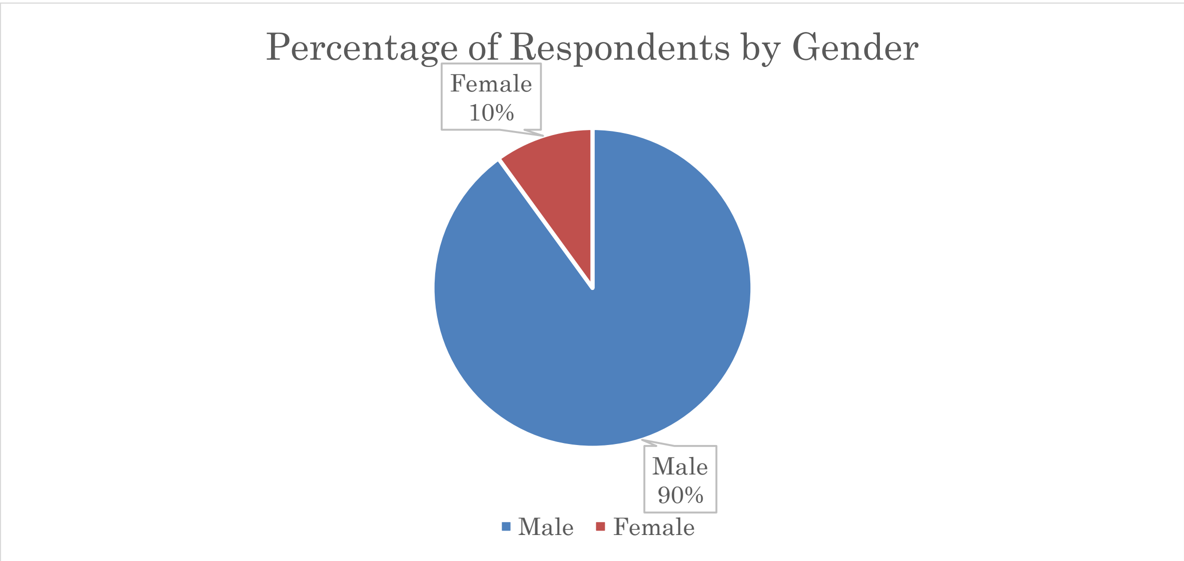


Figure 4.1: Percentage of respondents by Gender

The data obtained from the respondents revealed that a total of 43,660 meters or 43.66Km of LVRs were constructed and sealed over a period of four FYs for a total amount of UGX. 10,784,061,438. A cost per meter was computed using the total cost and the total length of all the LCS data obtained from the ten districts and it revealed that generally the average cost per metre of the LVRs was UGX 247,001. A more detailed computation of the average cost per metre is presented in the subsequent parts of this chapter.

Figure 4.2 is a graph showing the length in meters of the LVRs sealed each year in the ten districts studied. The first FY in the study period 2013/14 registered the longest length of LRVs construction in the four FYs. The question whether or not the finances invested each year were commensurate to the amount of works was depicted in a similar bar graph in Figure 4.3 which showed the same shape as the graph in Figure 4.2. This implied that in the FY 2015/2016 where the least meters of LVRs were constructed (8,800m), the total amount spent that year was the least (UGX. 2,147,492,859) in comparison to the rest of the years. The year with the most meters of LVRs constructed also had the highest cost recorded.

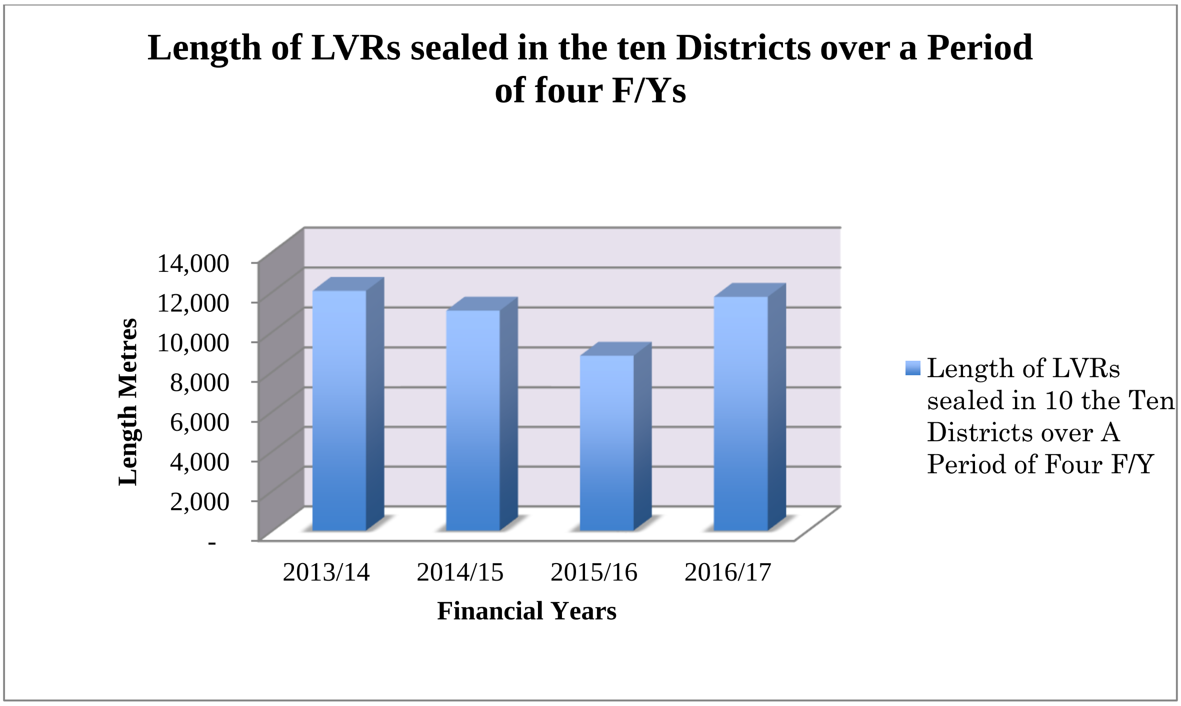


Figure 4.2: Lengths in meters of the LVRs constructed and sealed each year in the ten districts studied

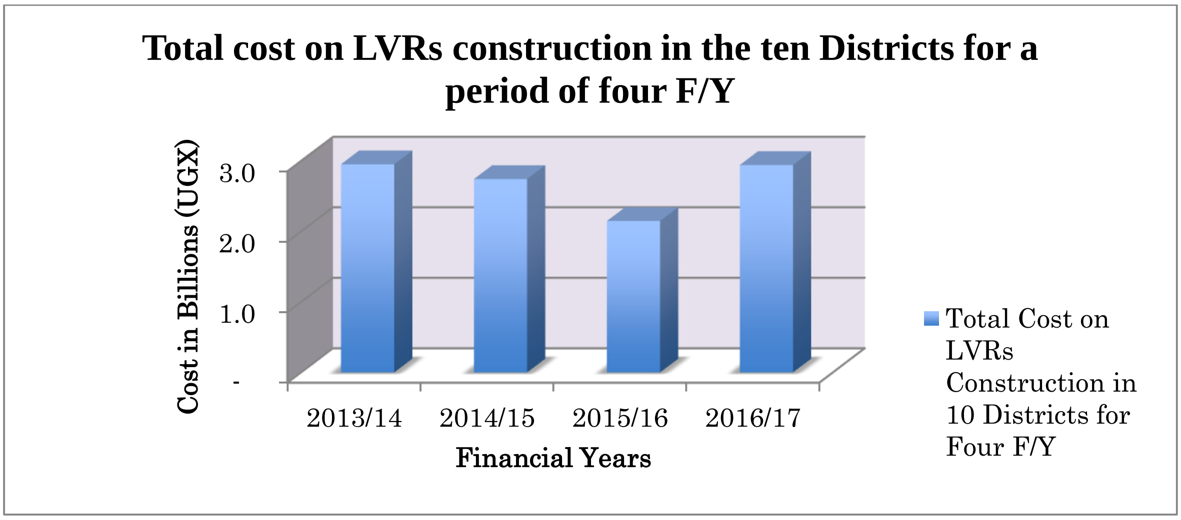


Figure 4.3: Total Cost on LVRs construction for a period of four FYs in the ten Districts studied

4.2 Construction cost per meter for LVRs in the 10 Districts studied

Table 4.1 presents the amount of money spent on construction of the LVRs in the 10 studied districts over a period of four FYs and the corresponding length of the road pavement actually constructed. Considering that the length of roads constructed in the 10 Districts studied was different, the Cost per meter was considered and used to compare the cost.

Table 4.2 shows the Cost Per meter of the LVRs in the 10 studied Districts over a period of four FYs.

Table 4.1: Cost of LRVs in 10 Districts over Four FYs and the Corresponding Length of Road Pavement Actually Constructed

		COST (UGX), VAT EXCLUSIVE				**SEALED LENGTH (METERS)**			
S/N	DISTRICT NAME	2013/14	2014/15	2015/16	2016/17	2013/14	2014/15	2015/16	2016/17
1	Kole	401,963,478	318,017,369	177,360,424	203,744,552	1,600	1,250	700	800
2	Oyam	240,656,333	250,656,333	250,756,333	260,656,333	1,000	1,000	1,000	1,000
3	Apac	461,143,268	-	497,250,721	408,345,261	2000	-	2,200	1,500
4	Pader	361,000,000	289,800,000	-	199,100,000	1,500	1,200	-	700
5	Lamwo	248,380,000	360,500,000	250,000,000	385,960,000	1,000	1,500	1,000	1,800
6	Amuru	294,860,455	290,560,000	-	256,708,320	1,200	1,200	-	1,000
7	Bukedea	235,500,000	255,000,000	271,000,000	156,000,000	1,000	1,000	1,000	600
8	Ngora	125,000,000	179,000,000	200,000,000	315,000,000	500	810	800	1,150
9	Kumi	183,390,067	401,850,245	129,125,381	497,716,565	650	1,500	500	2,200
10	Kaberamaido	400,000,000	397,360,000	372,000,000	258,700,000	1,600	1,600	1,600	1,000
	Total for 10 districts	**2,951,893,601**	**2,742,743,947**	**2,147,492,859**	**2,941,931,031**	**12,050**	**11,060**	**8,800**	**11,750**

Table 4.2: Cost per metre of the LVRs in the 10 studied Districts for a Period of Four FYs

	COST PER METRE (UGX)				
DISTRICT NAME	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**AVERAGE COST OF EACH DISTRICT FOR THE 4 YEARS (UGX)**
Kole	251,227	254,414	253,372	254,681	**253,423**
Oyam	240,656	250,656	250,756	260,656	**250,681**
Apac	230,572	-	226,023	272,230	**242,942**
Pader	240,667	241,500	-	284,429	**255,532**
Lamwo	248,380	240,333	250,000	214,422	**238,284**
Amuru	245,717	242,133	-	256,708	**248,186**
Bukedea	235,500	255,000	271,000	260,000	**255,375**
Ngora	250,000	220,988	250,000	273,913	**248,725**
Kumi	282,139	267,900	258,251	226,235	**258,631**
Kaberamaido	250,000	248,350	232,500	258,700	**247,388**
AVERAGE FOR 10 DISTRICTS EACH YEAR (UGX)	**247,486**	**246,808**	**248,988**	**256,197**	

The cost per metre values in Table 4.2 above were summarized in a frequency table and thereafter, a histogram and a frequency polygon were drawn. Table 4.3 is the frequency table for the cost per metre in the ten districts over the four FYs. Also Figure 4.4 is the histogram and the frequency polygon obtained from the cost per metre of the 10 districts that were actually studied for a period of Four FYs.

Table 4.3: Frequency Table for the Cost per Metre in the 10 Districts Studied over a period of the four FYs

Class (Cost per Metre)	Frequency
210000-219999	2
220000-229999	3
230000-239999	3
240000-249999	7
250000-259999	13
260000-269999	3
270000-279999	4
280000-289999	2
290000-299999	0

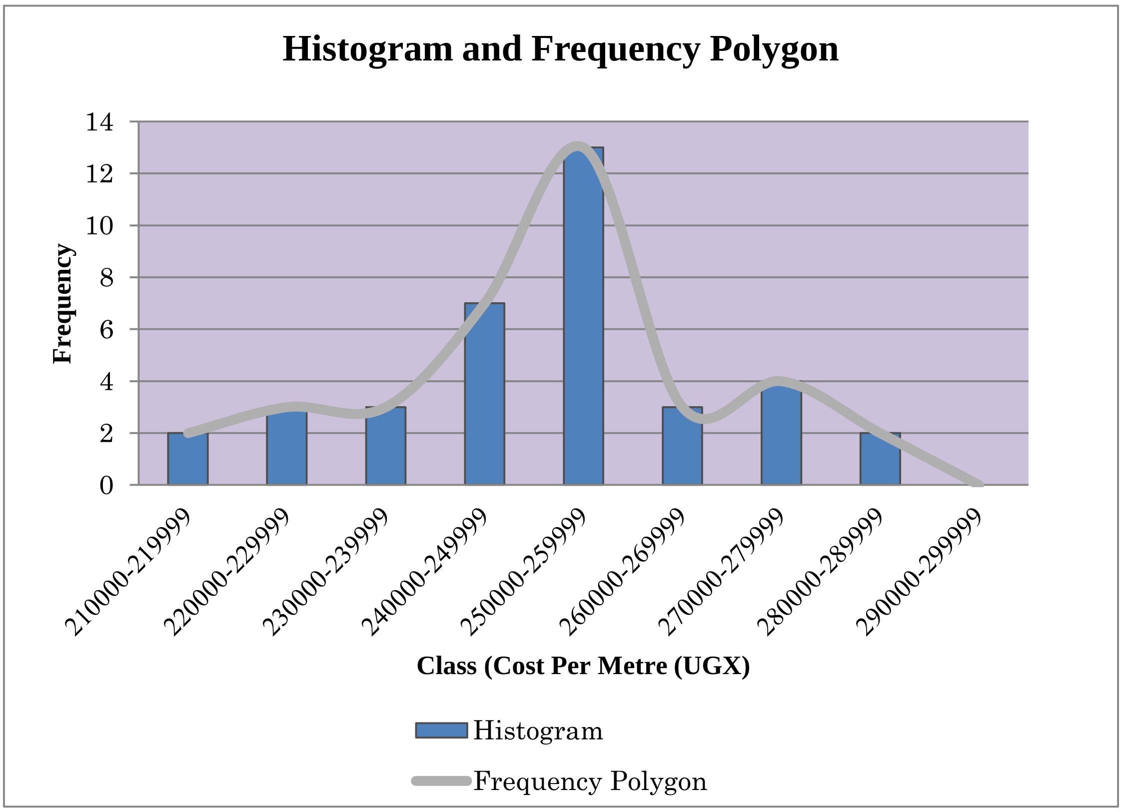


Figure 4.4: Histogram and the Frequency polygon obtained from the Cost per Metre values of the 10 Districts that were actually studied for a period of four FYs.

The histogram and frequency polygon depicted that the construction cost per metre for the construction of LVRs was normally distributed. Polygon was plotted, and the random variable, cost per metre follows a normal distribution with the expression X ~ N (250,000, 252,640,497), where X is the random variable and N denotes normal distribution.

The mean, median and modal cost of the cost per metre were equal, that is UGX. **250,000** which also suggested that the data was normally distributed.

4.3 Trend of the Cost Per Metre in each District over the four FYs period

4.3.1 Kole District

The Cost/Metre of the LVRs constructed for four FYs in Kole District was seen to increase in the second year reaching UGX. **254,414** and thereafter decrease, and again increase in the two subsequent FYs respectively. The average cost per metre was UGX. **253,423.** These fluctuations were attributed to the fluctuating cost of labour in Kole District.

Figure 4.5 is a graphical representation of the trend of the cost per metre for LVRs in Kole over a period of four FYs.

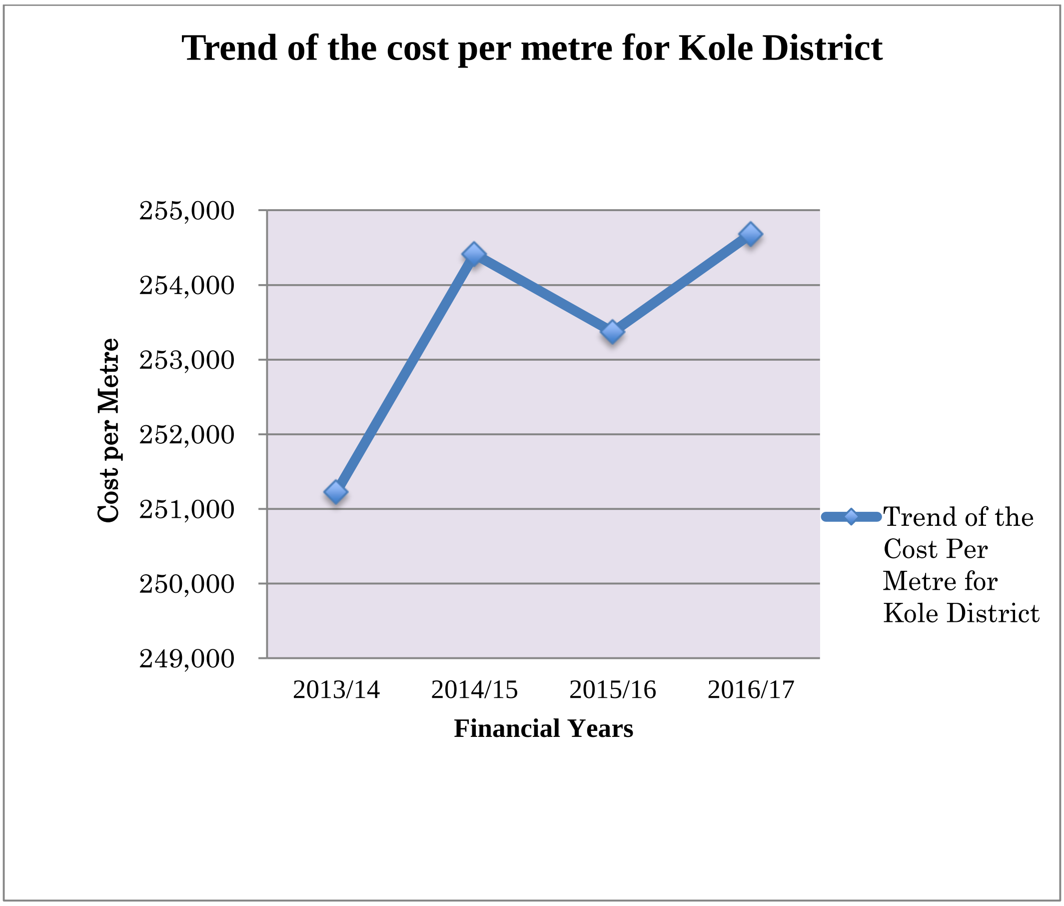


Figure 4.5: Trend of cost per metre for LVRs in Kole over a period of four FYs

4.3.2 Oyam District

In Oyam District, the Cost per Metre was seen to increase over the period of four FYs. The cost of 260,656 was recorded as the highest Cost per Metre in the FY 2016/17. The Figure 4.6 is a graphical representation of the Trend of the cost per metre for LVRs in Oyam District over a period of four FYs. The possible result for a slight increment in the cost per meter in FY 2014/15 to FY 2015/2016 was the rather stable price of labour in those years. However, the labour cost was seen to increase in the year after leading to a steep increment in the cost per metre.

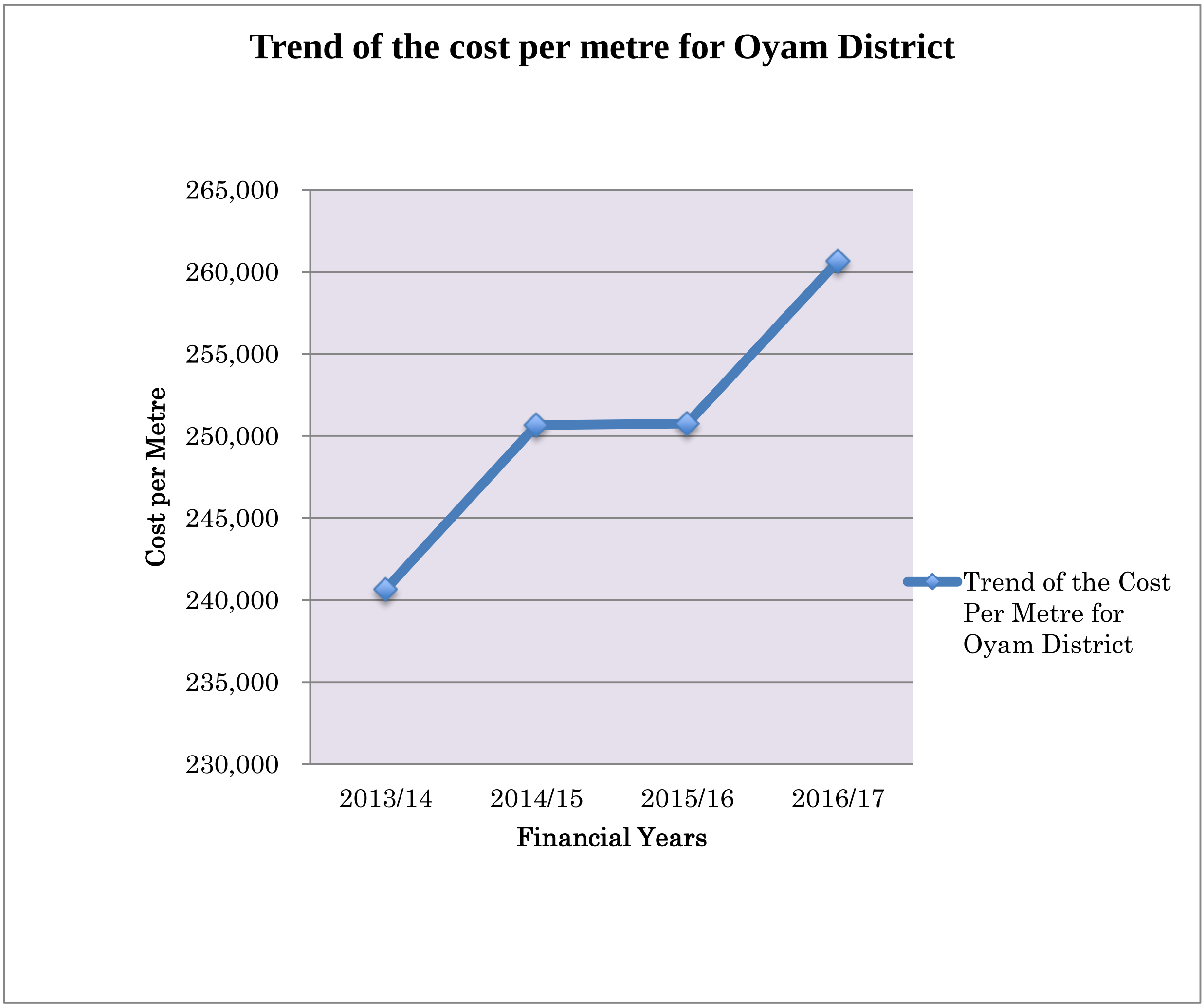


Figure 4.6: Trend of the Cost per Metre for LVRs in Oyam District over a period of four FYs

4.3.3 Apac District

The cost per metre for construction of LVRs in Apac district reduced from the first year to its lowest in the FY 2015/16. There were no works done in the 2014/15, and as such, no cost was recorded. The cost per metre was at its highest in the last FY 2016/2017. The Figure 4.7 is a graphical representation of the trend of the cost per metre for LVRs in Apac District over a period of four FYs.

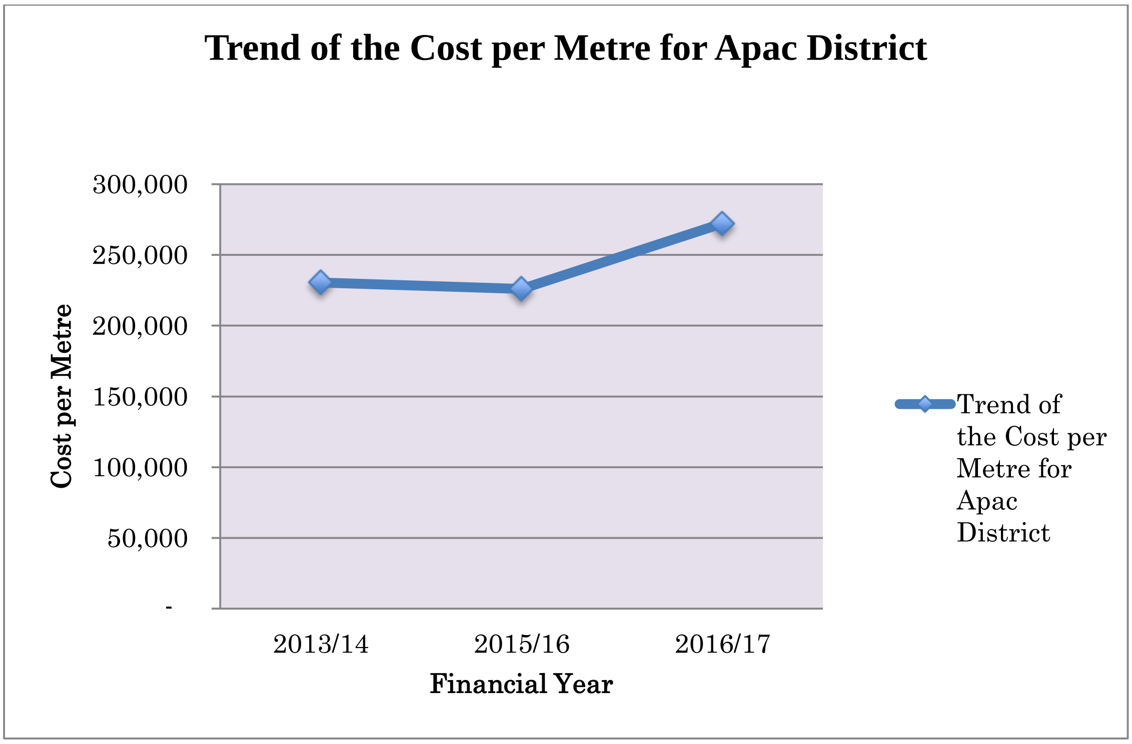


Figure 4.7: Trend of the Cost per Metre for LVRs in Apac District over a period of four FYs

4.3.4 Pader District

The construction cost per metre for LVRs in Pader district increased every FY except for the FY 2015/16 where no works were done, implying that zero cost were incurred that year and as such no cost per metre was computed. The average cost per metre in Pader District was UGX.

255,532. The Figure 4.8 is a graphical representation of the trend of the cost per metre for LVRs in Pader District over a period of four FYs.

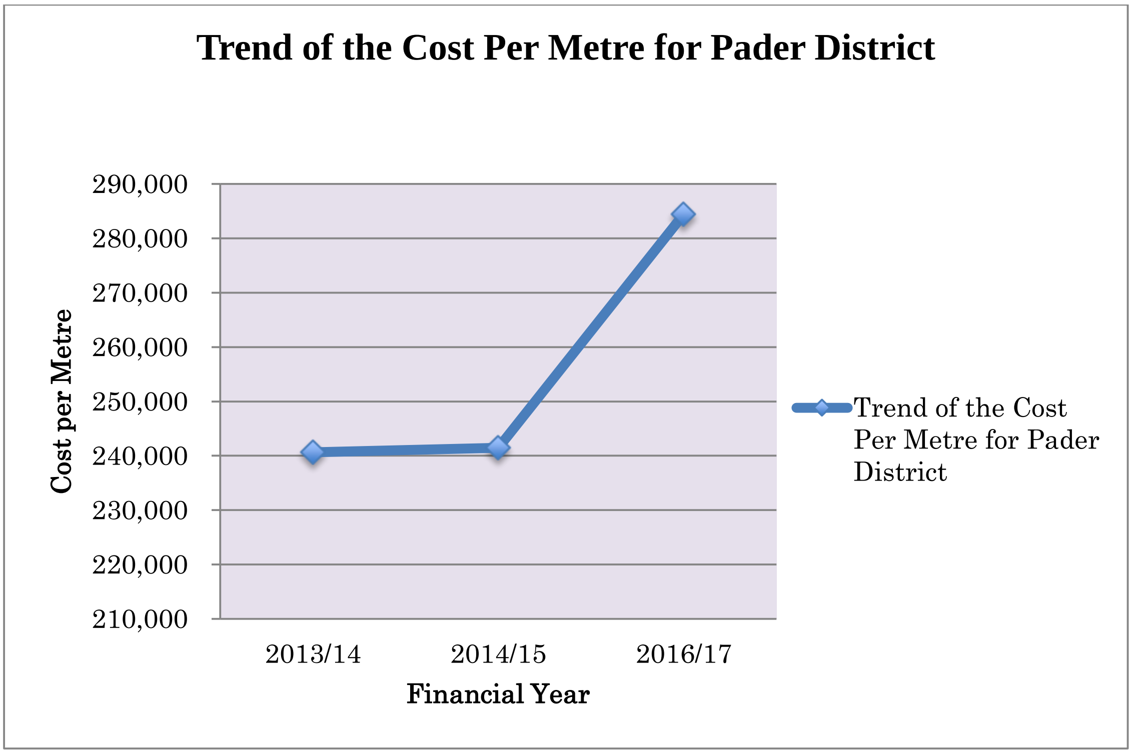


Figure 4.8: Trend of the Cost per Metre for LVRs in Pader District over a period of four FYs

4.3.5 Lamwo District

There was a noticeable general decrease in the construction cost per metre for LVRs in Lamwo District. In the third FY 2015/2016 however, there was a slight increase in the cost per meter from the one observed in 2014/2015, after which, the lowest cost per metre was recorded in the last FY 2016/2017 in Lamwo District. The average cost per metre calculated in Lamwo over the four FYs was 238,284. The reasons for the general decrease in the unit cost is likely to be the low bid sums as a result of competition for the works in Lamwo District as explained by the District Engineer. Figure 4.9 is a graphical representation of the trend of the cost per metre for LVRs in Lamwo District over a period of four FYs.

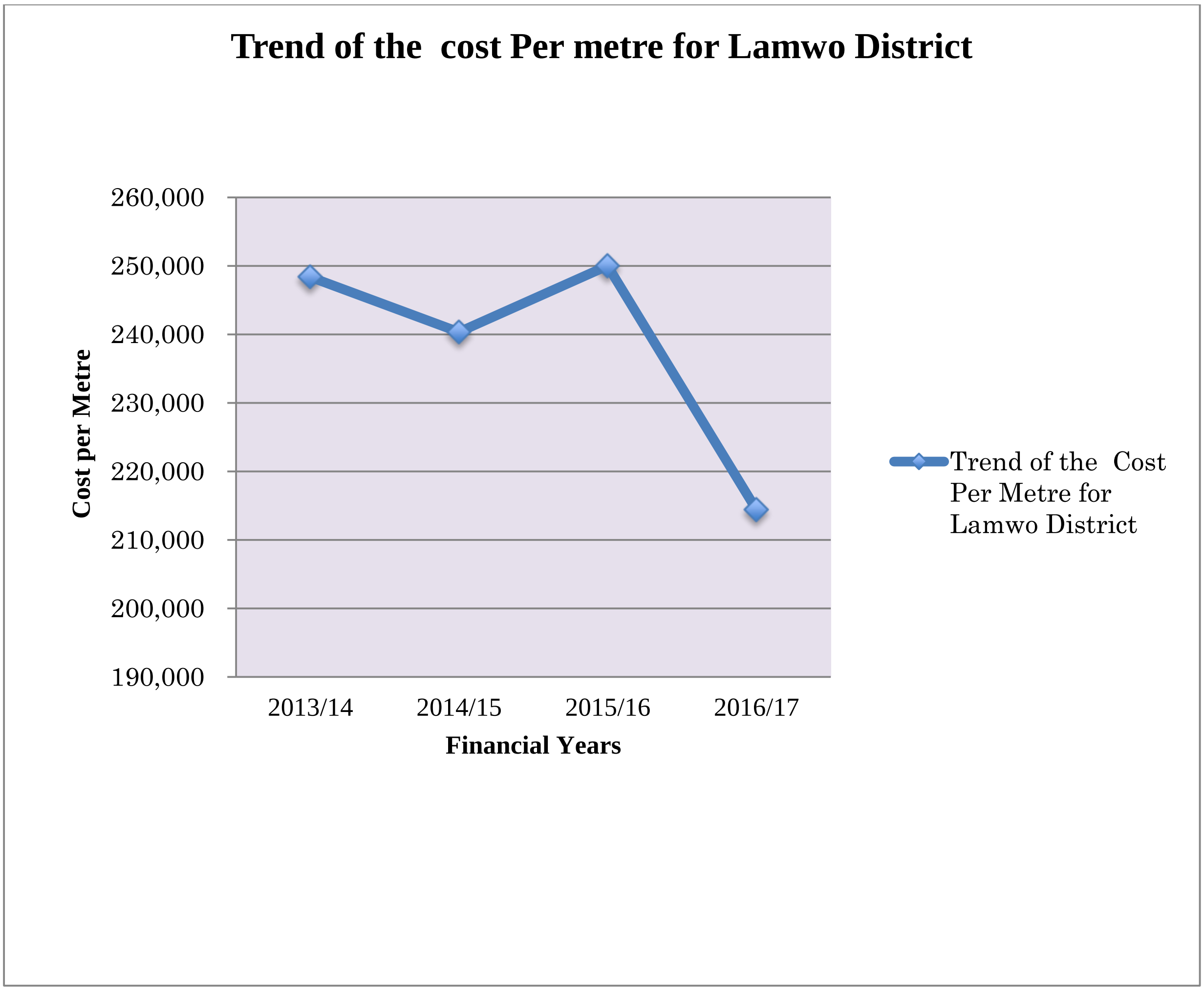


Figure 4.9: Trend of the Cost per Metre for LVRs in Lamwo District over a period of four FYs

4.3.6 Amuru District

In Amuru, the there was a small decrease in the construction cost per metre in the second year and in the FY 2015/16, no construction of LVRs was done. However, the highest cost per metre was recorded in the last FY 2016/2017. The average construction cost per metre in Amuru District was UGX. 248,186. Figure 4.10 is a graphical representation of the trend of the cost per metre for LVRs in Amuru District over a period of four FYs.

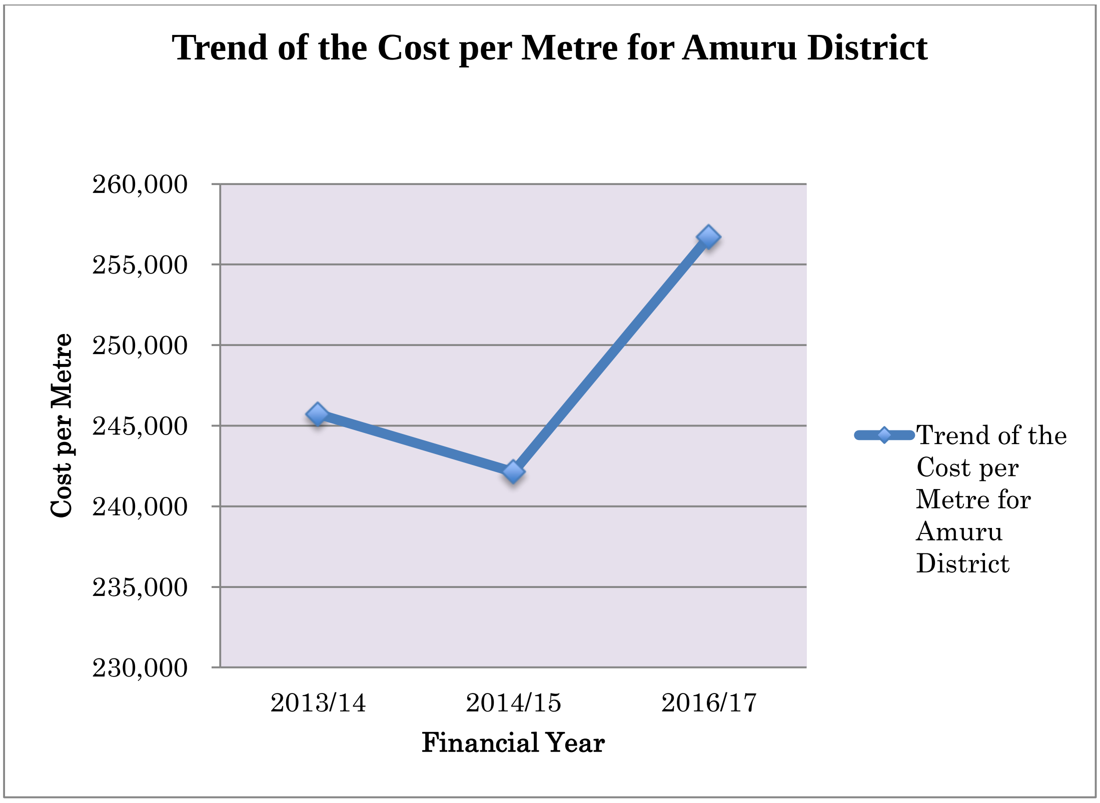


Figure 4.10: Trend of the cost per metre for LVRs in Amuru District over a period of four FYs

4.3.7 Bukedea District

The construction cost per meter did increase up to FY 2015/2016 reaching UGX. 271,000 and fell to UGX. 260,000 in the FY 2016/2017. The average construction cost for LVRs in Bukedea District was UGX 255,375. There was a fall in the cost per metre in the last year as the use of the mixed method VA technique was being embraced in Bukedea District. Figure 4.11 is a graphical representation of the trend of the cost per metre for LVRs in Bukedea District over a period of four FYs.

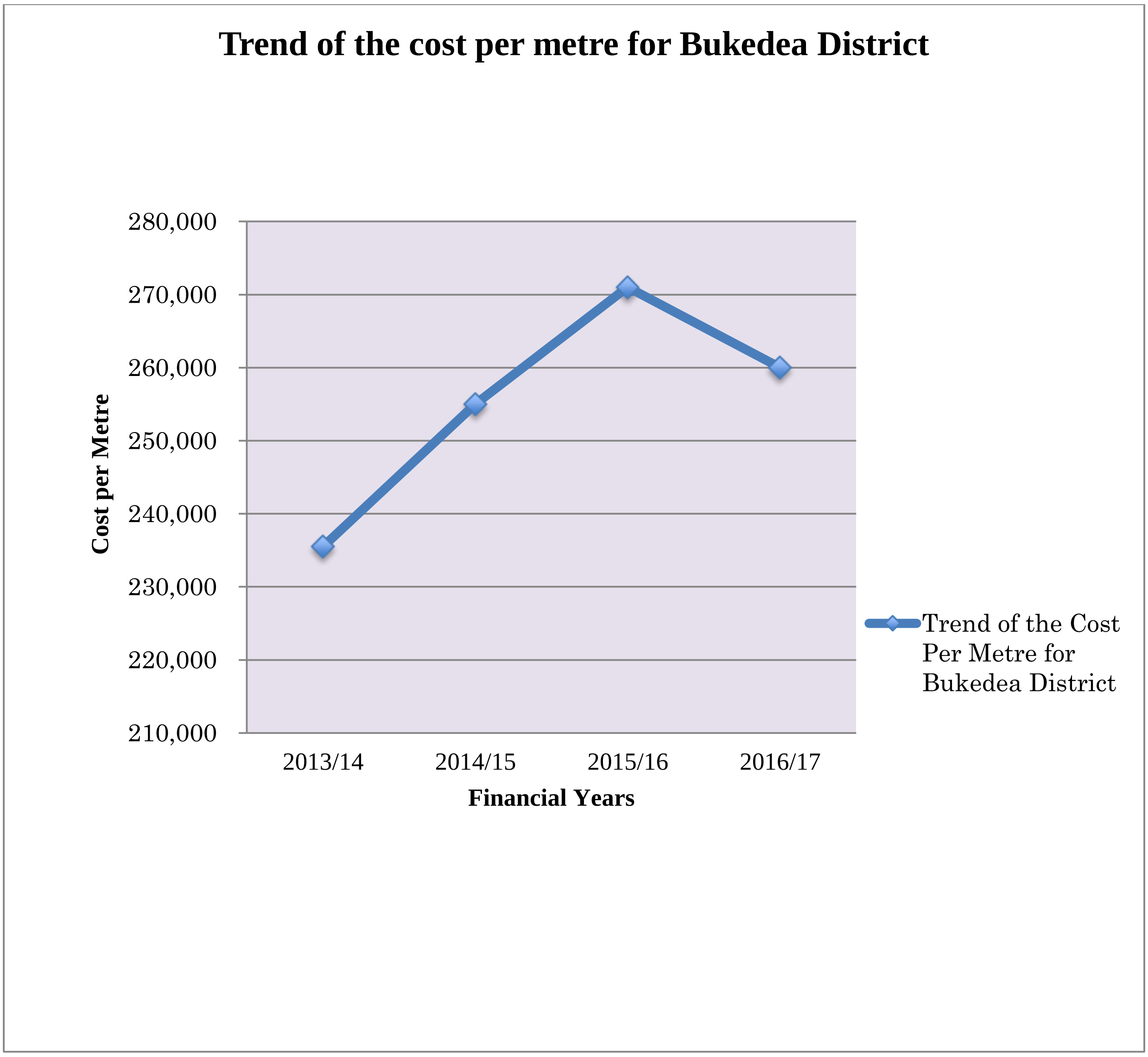


Figure 4.11: Trend of the Cost per Metre for LVRs in Bukedea District over a period of four FYs

4.3.8 Ngora District

The construction cost per metre was seen to drop to its lowest in the FY 2014/2015 and then increased gently until the FY 2016/2017 in Ngora District. The average construction cost was UGX248,725. The likely cause of the increase over the last three years as shown in Figure 4.12 may be the change in labour costs. The Figure 4.12 is a graphical representation of the trend of the cost per metre for LVRs in Ngora District over a period of four FYs.

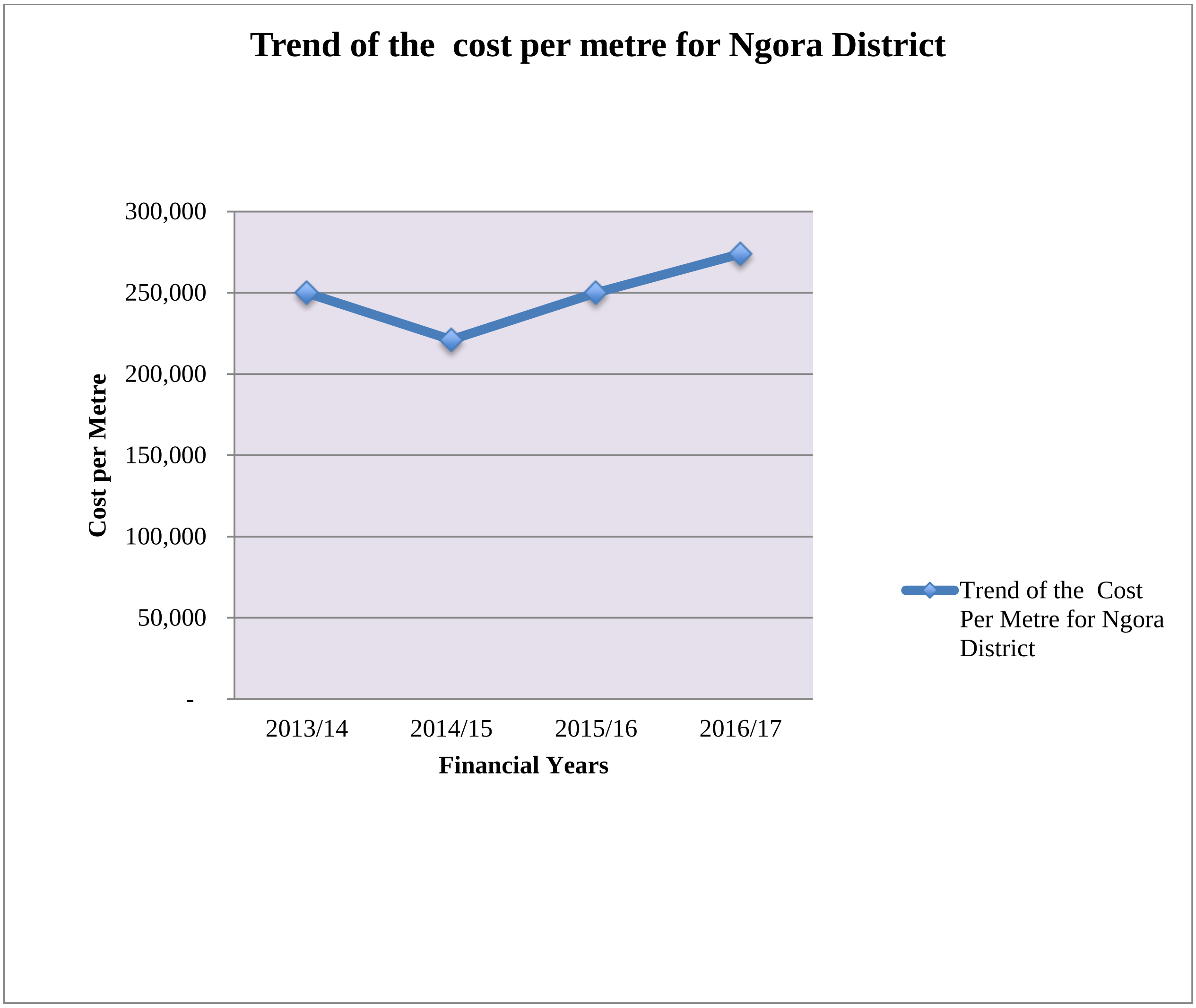


Figure 4.12: Trend of the Cost per Metre for LVRs in Ngora District over a period of four FYs

4.3.9 Kumi District

In Kumi District, a decrease was noticed in the construction cost per metre of the LVRs in the second FY 2014/15 and the decrease continued in the next years until the FY 2016/2017 in which the lowest cost per metre was recorded in the final year. The general trend depicted reduction in the cost during the four-year period. Figure 4.13 is a graphical representation of the trend of the cost per metre for LVRs in Kumi District over a period of four FYs.

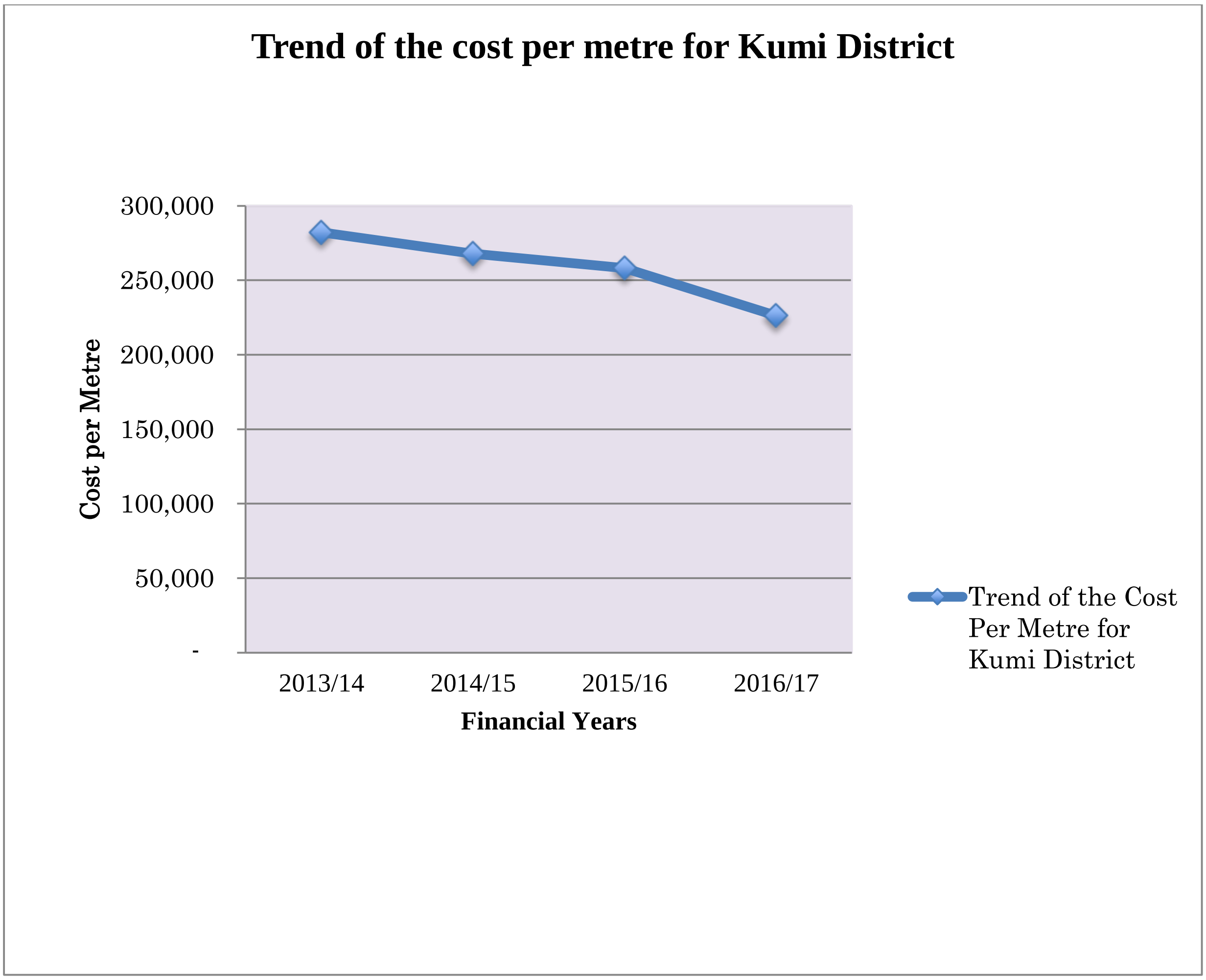


Figure 4.13: Trend of the Cost per Metre for LVRs in Kumi District over a period of four FYs

4.3.10 Kaberamaido District

In Kaberamaido District, the construction cost per metre of LVRs was seen to fall in the second and third FYs of the program implementation and there after increase was recorded. The average cost per metre for LVRs construction in Kaberamaido was 267,200. Figure 4.14 is a graphical representation of the trend of the cost per metre for LVRs in Kaberamaido District over a period of four FYs.

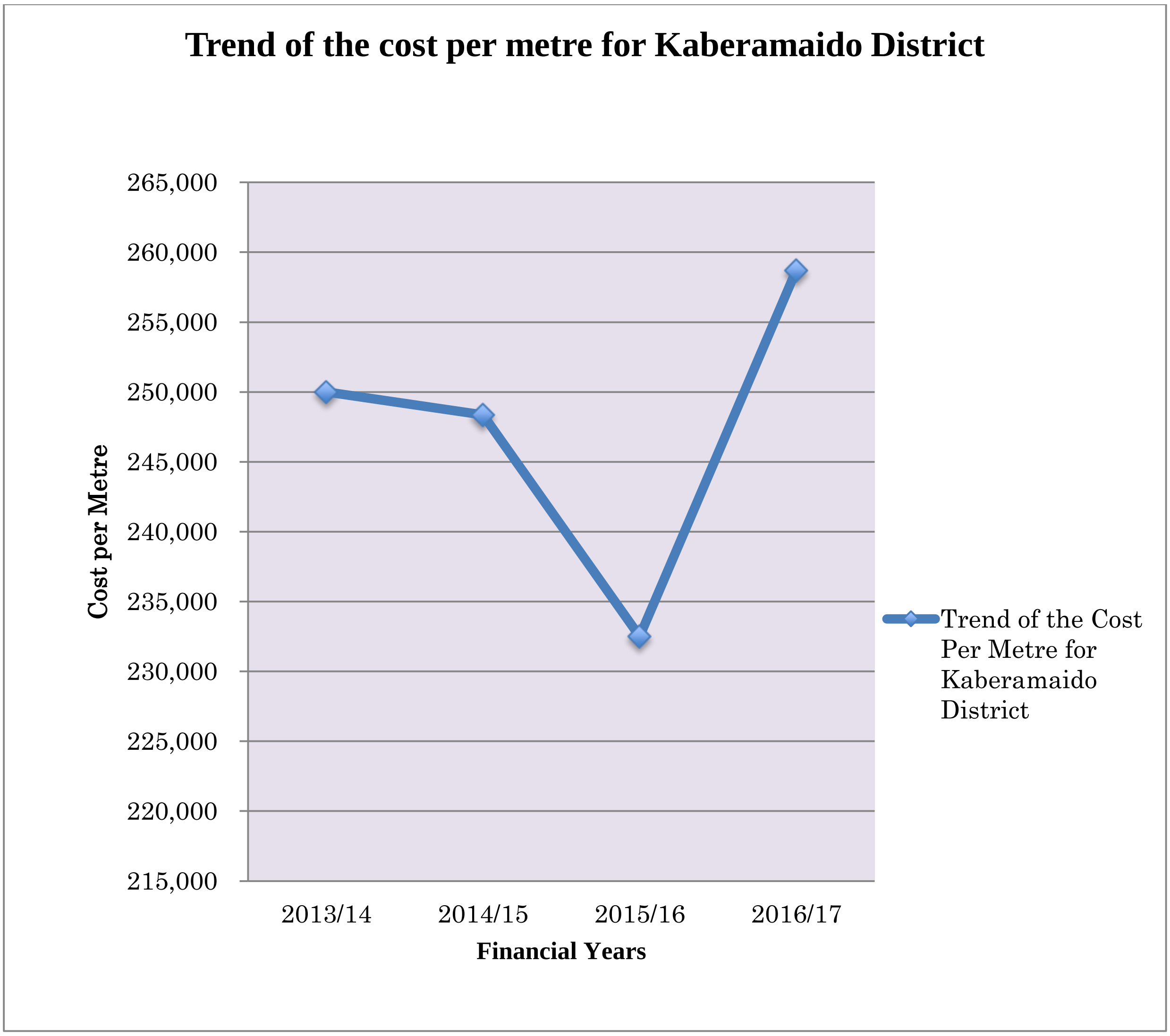


Figure 4.14: Trend of the Cost per Metre for LVRs in Kaberamaido District over a period of four FYs.

4.4. Trend of the Average Cost per Metre for all The 10 Districts combined over the four FYs

The average cost per metre was seen to decrease slightly in the second FY and then increase thereafter to reach its highest in the fourth FY 2016/2017. Figure 4.15 is a graphical representation of the trend of the average cost per metre for the four FYs. The average cost per metre for each of the four FYs in all the 10 Districts studied was obtained and the trend plotted.

The significant increase in the trend of the average cost per metre can be majorly attributed to significant increase in the cost of labour.

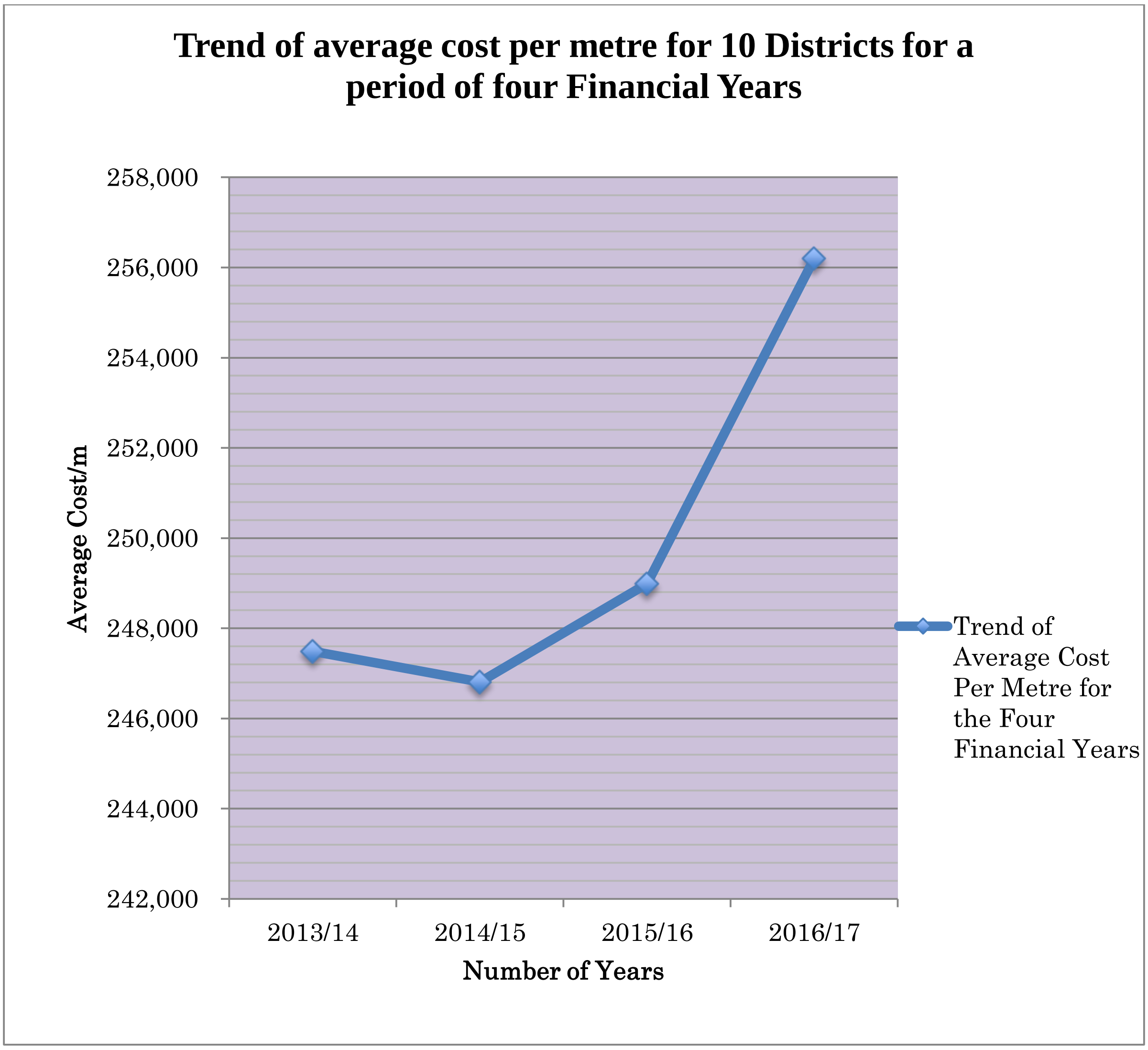


Figure 4.15: Trend of average cost per meter for the four FYs.

The average construction cost per metre from the graph in Figure 4.15 was seen to have a general increase and thus if the LVRs construction is to be sustainable, there is a need to intervene and ensure that the costs are reduced.

4.5. Average Cost of LVRs for All Ten (10) Districts

The average cost per district was variant with Kumi District registering the highest cost per metre of UGX. 258,631. Lamwo District had the lowest average cost per metre of UGX. 238,284 for the four FYs. Kaberamaido, Ngora, Amuru, Lamwo and Apac registered average cost per metre less than UGX. 250,000 as shown in Figure 4.16. The difference in the wage rate and cost of materials in the different districts was found to be the cause of the fluctuating variations in the average cost per metre of LVR construction across the ten Districts for the four FYs.

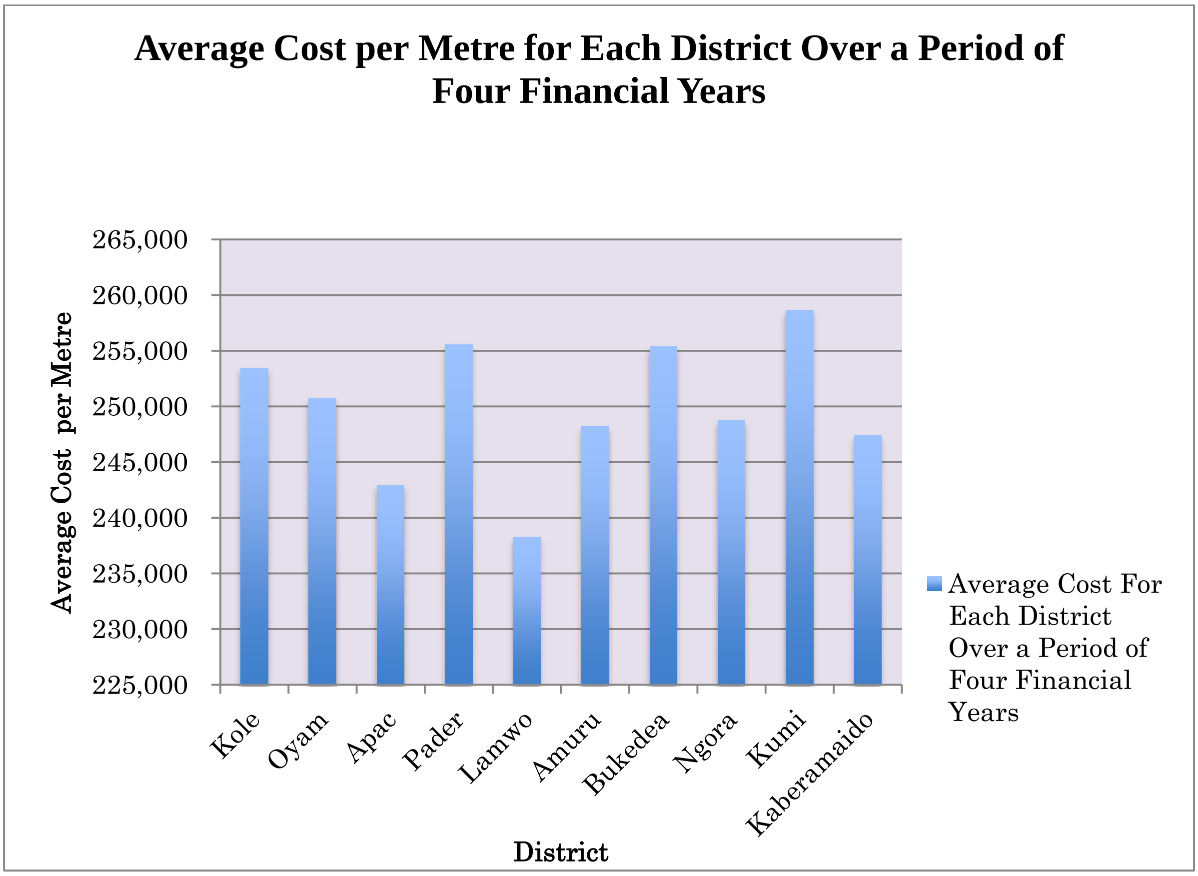
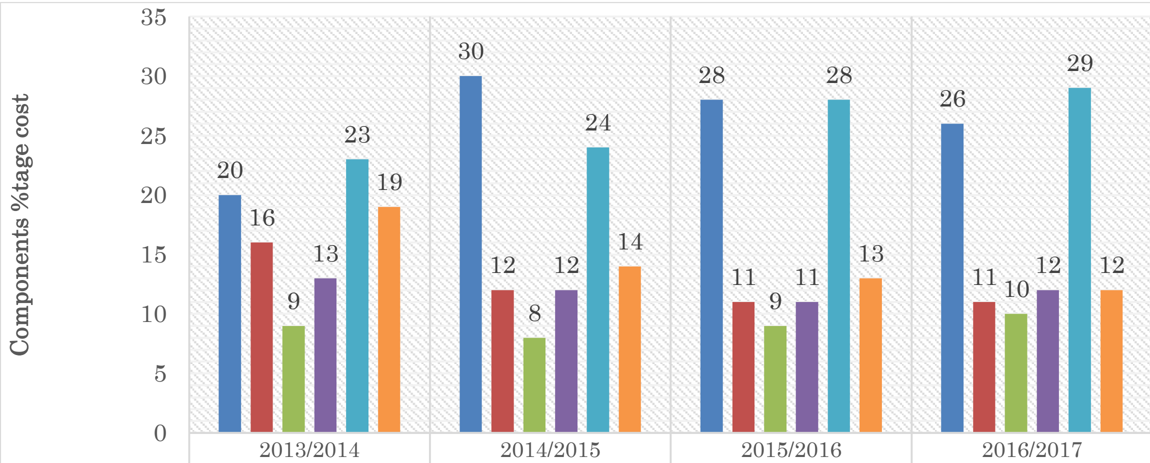


Figure 4.16: Average Cost per Metre for Each District Over a Period of Four Financial Years

4.6 Distribution of The Construction Cost Across the Construction Phases

There were different phases of construction undertaken including the Conception Phase, Feasibility Phase, Design Phase and Construction Phase. The construction phase for the LVRs consisted of Road Formation, MC 30 Primer Coating, K 160 Coating, application of chippings and drainage works. The findings revealed that a percentage of the cost was used on each stage of construction covering the materials and labour employed in the construction at the respective stages of the LVR construction. Figure 4.17 is a graphical representation of the various stages in the LVR construction and the percentage of the total cost spent during each phase in the construction of these roads over the four FYs.



	2013/2014	2014/2015	2015/2016	2016/2017
RF Cost	20	30	28	26
Lime Cost	16	12	11	11
Chippings cost	9	8	9	10
MC 30 Cost	13	12	11	12
K160 Cost	23	24	28	29
Drainage Cost	19	14	13	12

Figure 4.17: Various stages in the LVR construction and the percentage of the total cost spent during each stage in the construction over four FYs

The Road formation phase and K160 sealing are the two most expensive activities thereby the researchers approach of reducing cost in the road formation phase is desirous in an overall cost reduction.

Road formation was seen to cover (20-30) % of the total cost in the construction of the LVRs under the Low Cost Sealing program in Northern and Eastern Uganda. The researcher therefore worked with the rational that alteration of the method employed in RFP from labour based to mixed methods would affect the cost on this stage which would in turn reduce the unit cost of the LVR.

4.7 Cost/ Metre Obtained After Application of VA

4.7.1 The 0.8Km LVR in Kole District

To test out VA concept of using the mixed method in the RFP of the construction phase of LRV, 800m stretch of road in Kole District was designed and constructed in the FY 2017/18. Figure 4.18 shows the Geometric Design of the 0.8km road section designed by the researcher.

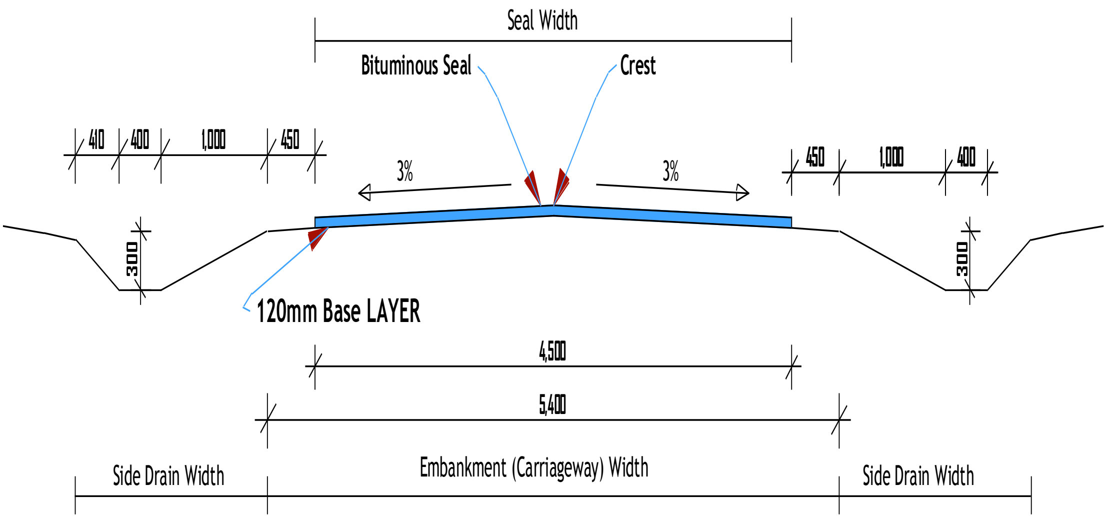


Figure 4.18: Geometric Design of the 0.8 Km road stretch designed by the researcher to test the mixed method VA technique

A design extract of 0.8Km LVR in Kole District is appended to this report (See Appendix III).

The overall cost per meter obtained after implementing this project in Kole District incorporating the mixed method was UGX. 227,215. This was lower than the computed average cost per metre of UGX. 250,000 when VA concept was not applied.

4.7.2 The 1.2Km LVR in Bukedea District

The researcher also proposed the use of the mixed method on the construction of a 1,200m LVR in Bukedea District. The method was also adopted in Bukedea District and applied resulting in a cost per metre of UGX. 229,099. This was the lowest cost that has been recorded in LVR construction under the LCS programme in Bukedea District.

Table 4.4 shows the cost of the two LVRs constructed in Kole and Bukedea District constructed using the mixed method VA technique during the RFP and their corresponding lengths and cost per metres.

Table 4. 4: Cost of LRVs in Two Districts in FY 2017/18 and the Corresponding Length of Road Pavement Actually Constructed

District	Cost of Project (UGX) 2017/18	Sealed Lengths(m) 2017/18	Cost Per Metre (UGX) 2017/18
Kole	181,772,000	800	227,215
Bukedea	274,918,800	1,200	229,099
Average cost per metre			228,157
Standard deviation			1,332

The average costs per metre of the projects in the two projects in FY 2017/18 that adopted the mixed method VA technique was UGX. 228,157, less than the average cost per metre of UGX. 250,000 computed in the 10 Districts when construction involved the use of the labour based techniques in the Road formation phase.

The results obtained showed a reduction of UGX. 21,843 in the average cost per metre of LVR construction upon application of the LVR technique but there was need to check the significance of the said reduction. To establish the significance of the application of the VA technique, hypothesis testing was done as seen under the next sub section.

4.8 Testing Hypothesis

To test the claim that the cost per metre of LVRs under low cost seal program in Lango-Acholi and Teso sub regions when employing the mixed method VA technique was lower than the average cost per meter UGX. 250,000 when the labour intensive methods were employed during the RFP.

Key Points to note

- The Average cost per metre μ_1 when Labour Intensive Methods were Used during the RFP = (UGX) 250,000
- The sample average cost per metre μ_2 when the mix method VA technique was used during the RFP =UGX. 228,157
- The sample Standard Deviation from the mean when the mix method VA technique was used during the RFP = UGX. 1,332
- The number of observations in the sample or sample size n, were 2.

Taking the overall population mean cost/ metre when the Mixed method VA technique is used during the RFP to be μ_2, a hypothesis test was done.

Procedure

vi. Null hypothesis, H_0 ;$\mu_2 = \mu_1 \; or \; \mu_2$ =250,000.

Alternative hypothesis, H_1;μ_2 <250,000.

vii. One – tail test is performed at a level of significance α= 0.05 and confidence level of 95%

viii. The t test is applied, the critical value $t_{\alpha=0.05}$ for 1 degree of freedom is obtained

$t_{\alpha=0.05}$ = -6.314

ix. Calculated t value $\frac{\mu_2 - \mu_1}{s.d/\sqrt{n-1}} = \frac{228157 - 250{,}000}{1332/\sqrt{2-1}}$ = - 16.40

x. Decision

Since t< $t_{\alpha=0.05}$, the Null Hypothesis was rejected and the Alternative Hypothesis is upheld.

Therefore there was sufficient evidence at 95% confidence level to show that the average cost per metre μ_2 when using the mixed method VA technique is less than the average cost per metre when the labour based techniques were employed during the RFP.

4.9 Discussion

In line with the first specific objective, of this research, the current average cost per metre was found to be UGX. 250,000 which is in agreement with (Mafabi, 2018). This cost can therefore be inferred on the population of the 23 Districts for the four years. However, there was a general increase in the average cost per metre in the 10 districts studied over the four FYs except in the FY 2014/15. The increasing cost requires the application of a VA technique if the investment in the construction of LVRs is to be sustainable. This increase in the cost per metre depicts an exponential curve that shows the likelihood of the cost increasing further more in the future.

In line with the second specific objective, it was found that on application of the mixed method VA technique for LVR construction using LCSs technology, the average cost per metre was UGX. 228,157. This value was also lower than the average cost per metre of UGX. 250,000 when VA was not applied for four FYs in the Ten Districts studied. There was an overall 8.7% reduction in the cost per metre in comparison with the average cost per metre when the labour intensive technique was employed during the RFP. This finding could imply that the Mixed method is a more cost saving alternative than the labour based methods during the RFP. There were some other advantages that came along with the use of the mixed method including the reduction in the project duration which also culminated in the reduction of overhead costs in comparison with when the labour intensive technique is employed.

The issues associated with management of many laborers are likely to be reduced with the use of the mixed method which sees a significant reduction in the number of laborers replacing them with machinery as opposed to the labour intensive method employed during the road formation phase of many LVRs. The cost that goes into supervision of many workers can be saved when the mixed method VA technique is employed.

For specific objective three, hypothesis was tested to and the alternative hypothesis that the cost per metre when VA is used is less than the cost per metre when labour intensive methods are used was upheld at 95% confidence interval.

4.10 Limitations of the Mixed Method VA Techniques

As with any engineering (or human) solution, the mixed method VA concept on LVRs too has limitations. The downside of the use of the mixed method VA technique during the road formation phase is the impact it has on the environment. Oil spills are often seen from machinery, and a considerable amount of air and noise pollution is usually noticed. This labour intensive techniques are not seen to emit as much poisonous substances in the atmosphere and environment as much as the mixed method.

The use of the mixed method in the RFP would render many people jobless as they will be replaced with machines. Therefore, the acceptability of this VA technique among the labour communities that are employed by the LVRs construction would be minimal.

The mixed VA technique only concentrates on the Road Formation Phase and does not adjust cost in other phases mostly during application of K160 which is the second most expensive phase in the construction of LRVs under the Low Cost Sealing Program in the piloted projects in Lango, Acholi and Teso sub regions in Uganda. Therefore, there is need for further research to source for alternative cheaper material that can replace K160 as a binder in sealing construction of LVR.

The study was conducted in Lango, Acholi and Teso sub regions of Uganda that have fairly flat terrain therefore, the findings cannot be replicated in hilly and mountainous areas like western Uganda. The findings and statistics can only be inferred to the 23 Districts where the Low Cost Sealing Programme for LVRs in Lango, Acholi and Teso sub regions of Uganda and other Districts with similar topographic characteristics.

This mix method of both Mechanization and Labour was not tested in cases where the embankment length was more than 10% of the total construction length and the embankment height more than 1 meter. As such the effect on cost reduction by using the VA technique cannot be guaranteed in such cases.

4.11 Chapter Summary

In this chapter, the findings from the study to investigate the effect of the mixed method on the LVRs construction cost were presented and analysed, and a discussion with regard to the findings done. It was found that there was sufficient evidence that the application of the VA technique gave a lesser construction cost than the use of labour intensive method. There was an 8.7% reduction in the cost per metre in comparison with the average cost per metre when the labour intensive technique was employed during the RFP.

In the next chapter, the conclusions and recommendations of this research are discussed.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The previous chapter presented and discussed the finding from the study. The average cost when the mixed method VA technique was applied was seen to be less than the average cost when conventional labour based methods were employed in road formation of LVRs This chapter details the key conclusions drawn from the findings obtained from the entire research process. It also presents the recommendations of the author about the subject researched.

5.2 Conclusions

VA is about removal of unnecessary costs and the researcher managed to remove the extra labour costs that would be incurred by replacing a portion of that labour with a machine. The application of the mix method VA technique during the RFP which constitutes 20-30% of the total cost of the LVR, yielded an 8.7% reduction in the total cost per metre for low cost sealing of LVRs in northern and Eastern Uganda. Cost comparison by testing of the hypothesis that the cost per metre of low cost sealing of LVRs when the mix method VA technique was employed revealed that the average cost per metre UGX 228,157, an amount lower than the average cost per metre when no VA technique was applied, UGX. 250,000.

Therefore, the cost of low cost sealing of LVRs is lower when the mix method technique is applied. The incorporation of the mix method VA technique in LVRs construction during the RFP reduces the overall cost of the construction projects by about 8.7% which therefore, gives better value for money.

The adoption of the mix method techniques for undertaking earthworks and road formation activities yields a lower cost than the conventional labour based techniques and therefore, it should be adopted for better value for money.

Also, the importance of maintaining good workmanship cannot be emphasized more, if quality is to be managed effectively. The mix method reduces the need to manage inconsistencies that arise from having many labourers handling large volumes of earth works like non uniform levels during shaping, as well as problems that may be encountered in dealing with poor soils, such as expansive, collapsible and dispersive soils should be addressed during design with appropriate percentage lime mixture besides adequate compaction.

Finally, the researcher concludes that the cost can be reduced even more significantly when Value analysis is applied to other phases of the LVRs low cost sealing, like in the K 160 application phase.

5.3 Recommendations

Because of the results from this research in terms of cost reduction, the author recommends the application of the mix method VA concept on LVRs particularly in the road formation stage, which according to the study is found to constitute between 20 – 30% of the total cost of LCS.

This research recommends the adoption of the mixed technique for the earth roads and low cost seal roads. Policy makers should consider including the mix method VA concept on all LCS contracts so as to realize saving that can be used to increase coverage of LVRs.

Further Research about VA for LVRs should be done for the alternative material that can be used as a binder but cheaper compared to K160. The author also recommends for Further Research for an Application (Software) that can be used to capture data on cost and quantity of LVRs constructed since LCS started in Uganda and to allow entry of data for some period of time in future. This software is to allow sharing information with interested users on internet search engines.

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APPENDICES

Appendix I.

Photographs of the Different Processes in the Construction of the 800 Metre LVR in Kole District

A completed section of SSD in Kole district using mix method of grader and labour

Road surface appearance before LCS technology

Manual excavation to level to form a levelled road bed

Compaction taking place

Spreading stabilized gravel using a Grader

Watering of road section

Installation of 600mm diameter reinforced concrete culverts taking place

MC30 primer to clean the road surface

10-14mm stone chippings laid on K160

Construction of head and wingwalls in progress

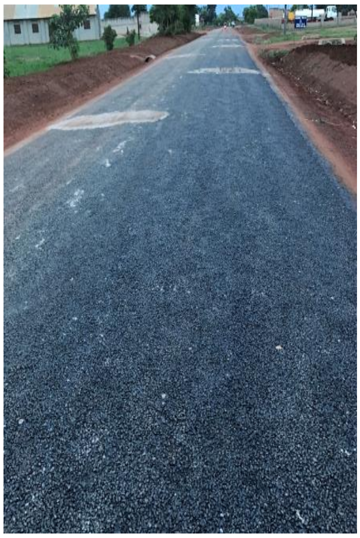
Completed head and wingwalls

A completed SSD section

Compaction of stone chippings

The Researcher inspecting work

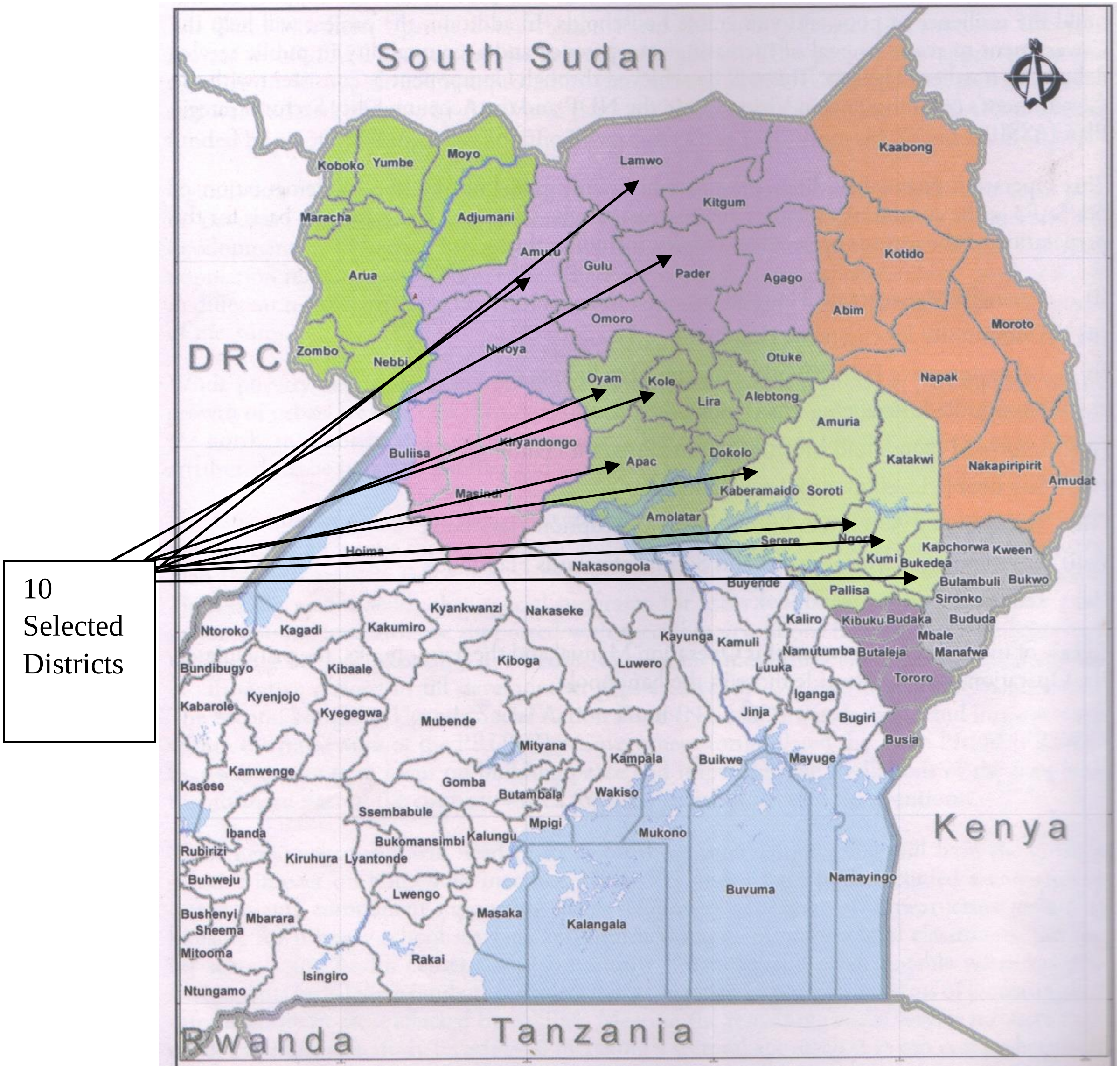
Side drain improved manually



Full width sealed

Appendix II

The Map of Uganda showing the ten (10) selected districts in Lango, Acholi and Teso sub regions in Uganda that the data were collected from for the study


10 Selected Districts
South Sudan
DRC
Kenya
Tanzania
Rwanda
Koboko
Yumbe
Moyo
Maracha
Adjumani
Arua
Zombo
Nebbi
Amuru
Lamwo
Kitgum
Gulu
Pader
Agago
Omoro
Nwoya
Kaabong
Kotido
Abim
Moroto
Napak
Oyam
Kole
Lira
Alebtong
Otuke
Amuria
Katakwi
Nakapiripirit
Amudat
Buliisa
Kiryandongo
Masindi
Apac
Dokolo
Kaberamaido
Soroti
Amolatar
Serere
Ngora
Kumi
Bukedea
Kapchorwa
Kween
Bulambuli
Bukwo
Sironko
Hoima
Nakasongola
Buyende
Pallisa
Kibuku
Budaka
Bududa
Mbale
Manafwa
Butaleja
Tororo
Busia
Ntoroko
Kagadi
Kakumiro
Kyankwanzi
Nakaseke
Kayunga
Kamuli
Kaliro
Namutumba
Luuka
Iganga
Bugiri
Mayuge
Jinja
Buikwe
Kampala
Wakiso
Mukono
Luwero
Kiboga
Mubende
Mityana
Gomba
Butambala
Mpigi
Kalungu
Bundibugyo
Kibaale
Kabarole
Kyenjojo
Kyegegwa
Kamwenge
Kasese
Ssembabule
Bukomansimbi
Lyantonde
Kiruhura
Ibanda
Rubirizi
Buhweju
Bushenyi
Sheema
Mbarara
Mitooma
Ntungamo
Isingiro
Rakai
Lwengo
Masaka
Kalangala
Buvuma
Namayingo

Appendix III

The design extract and cost estimates for Corner Park towards Kole district headquarters.

Section length: (0.8 Km) from ch.0+000 to ch.0+800.

Appendix IV

Data collection questionnaire