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Maintenance of World Bank-Funded Roads in Lira City, Uganda



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## Road Asset Management System and Operation and Maintenance of World Bank-Funded Roads in Lira City, Uganda

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### ABSTRACT

**Purpose:** This study examined the contribution of road asset management to the operations and maintenance of World Bank funded roads in Lira City East division. Specifically, the study focussed on the effect of data collection, data management; and data analysis on operation and maintenance of World Bank funded roads in Lira City East division.

**Methodology:** The study adopted a cross-sectional study design, which employed a mixed methods approach of both quantitative and qualitative methods. The study population consisted of 82 respondents, which involved political leaders, technical staff and city development forum (CDF) members of Lira City East division. Both the Simple random sampling technique and purposive sampling technique were used to select a sample of 71 participants. The researcher adopted Self-Administered Questionnaires to collect quantitative data and an interview guide to collect qualitative data. Both descriptive statistics, and inferential statistics were used to analyse numerical data. Content analysis was used to analyse qualitative data.

**Findings:** The findings revealed a statistically significant positive relationship between road asset management and the operation and maintenance of World Bank funded roads. Further, it was revealed that data collection, data management and data analysis yield a significant effect on operation and maintenance of World Bank funded roads in Lira City East division.

**Unique contribution to theory, policy and practice:** The study concluded that road asset management significantly affects operation and maintenance of World Bank funded roads in Lira City East division. It is encouraged that, for proper functionality and operations of world bank funded roads in Lira City division, the authorities of Lira City east division should do periodic inspection of all the roads, engage knowledgeable personnel in the collection of data on the conditions of all the road assets so that it can be used as a basis of decision making during the development of work plan and budgets for road maintenance. This study contributes an original and empirical-evidence of the contribution of road asset management on the operation and maintenance of roads in Lira City East division.

**Keywords:** *Road asset management, O&M, data collection, data management; data analysis*

## 1. Introduction

Asset management evolved between 1700 and 1960, during which time Keynes' innovative technique was in asset management. In asset management, Keynes advocated for a bottom-up approach (Morecroft, 2017). Construction and management of infrastructure came to light across Canada from the 1950s to the 1970s as a result of the expansion, modernisation, and urbanization that followed the end of World War II. This was due to the construction of numerous roads, bridges, water distribution, wastewater treatment, buildings, schools, hospitals, and other infrastructure for the basic needs of the communities (Canadian Network of Asset Managers Association, 2018). By 1900, asset management had solidly established itself as a unique business in the United Kingdom after having grown and established its profession there after 1700. Thanks to people like Benjamin Graham and companies like Wellington, asset management gained credibility in the United States after 1930. As road deterioration accelerated in Africa in the late 1980s and maintenance was neglected, new ideas about how to manage road assets in a professional manner emerged (Brushett, 2015). With a focus on the support given by the road management initiative, a donor-funded, World Bank-managed program supporting the formulation and implementation of appropriate policies in the road sector, this idea was tailored to institutional arrangements and on the performance of the road networks. Many African nations now have semi-autonomous road authorities as a result of the institutional reforms carried out as part of the Road Management Initiative (RMI), which was launched in the mid-1990s. This led to better maintenance of the nation's roadways, however regional and municipal governments felt less of an influence, particularly on the rural road networks. Countries continued to confront severe capacity shortages in local road agencies and the private sector, and funding for maintenance remained insufficient, particularly at the municipal level.

Only 10% of Ethiopia's rural residents were thought to reside within 2 kilometres of an all-weather road in 2010 (Vivien et al., 2010). As a response, the Ethiopian government mandated that all of the communities be connected by an all-weather road through the Growth and Transformation Plan (2010–2015) (Gongera, 2015). As a result, the government started the Universal Rural Road Access Programme (URRAP), a five-year plan to build and maintain more than 70,000 km of gravel access roads. In order to improve the management of road assets in Malawi, a number of rural road projects were launched in the 1970s (Human Dynamics, 2015). As part of institutional reform in the road industry, Tanzania's National Roads Agency (TANROADS) was founded in 1997 (IT Transport, 2013); meanwhile, in Uganda, the Strategy for Sustainable Maintenance of District, Urban, and Community Roads (DUCAR) was introduced in the 1990s. A unit for light road maintenance work and zonal road re-graveling units were established in each district to serve as plant hire organizations for the districts, but in 2008, the government changed its approach to the maintenance of district roads by reintroducing force on account (Parsons Brinckerhoff Consortium (2010) & Government of Uganda, 2008). A comprehensive asset management toolkit for local governments in poor countries was created in 2017 and is now being supported by the

UN Capital Development Fund (UNCDF) and UN Department of Economic and Social Affairs (UN DESA). Since then, the UN DESA and UNCDF have collaborated with ministry representatives and local government leaders in four pilot countries, Nepal, Tanzania, and Uganda, to put the toolkit to use and refine it in practical settings (United Nations, 2021).

This study was guided by the systems theory which was developed by a German scientist named Ludwig Von Bertalanffy (1940s-50s). According to the theory, all systems in the universe, including living things, are made up of interrelated components, which interact with one another to produce a larger system (Bertalanffy, 1972). The efficiency, effectiveness, and timeliness of road asset management was examined using this theory by examining how various operating and maintenance components interact with one another. This theory is pertinent to the study because it advises management on the necessity to efficiently manage the road asset, which is a resource for Lira City, by doing routine maintenance to improve operations. Hereby, interdependent parts are very significant and indicate that the emphasis of the managers or supervisors shall not be limited to one specific single cause but consider the holistic view as different factors combine to cause a problem (Sridhar, 2017). Mele et al. (2010) argued that system theory applications in management could be found in several dimensions such as it focuses on complexity, adaption, relationships, environment, quality, value and knowledge.

The systems theory application on road asset management systems seeks to simplify management of a road network by breaking a road network down into its various components, such as intersections, traffic signals, signage, culverts, bridges, etc. This makes planning maintenance and repair work and identifying possible problems simple. Additionally, it makes it possible to estimate and plan upcoming road projects and improvements with greater accuracy, leading to increased dependability, safety, as well as increased efficiency and cost savings. It is also simpler to coordinate maintenance and repair tasks among numerous departments and agencies when systems theory is used. This theory is relevant to this study because it makes clear the need for effective methods for managing road assets in order to enhance road management and operations. This theory is relevant to the study in that it helps the management on the need to effectively manage the road asset which are the resources of Lira City through periodic maintenance to enhance their operations.

The concept of road asset management refers to a systematic process of maintaining, upgrading, and operating assets, combining engineering principles with sound business practice and economic rationale, and providing tools to facilitate a more organised and flexible approach to making the decisions necessary to achieve the public's expectations (Geddes, Gongera & Solutions, 2016). Road asset management is based on an analysis of road data related to inventory, condition, traffic, unit costs, and road deterioration models. According to the international standard ISO 55000, road asset management system (RAMS) refers to a set of interrelated and interacting elements of an organization, the function of which is to establish the asset management policy and asset management objectives, as well as the processes needed to achieve those objectives. RAMS is

considered to include any system that is used to collect, store and process road and bridge inventory, condition, traffic, and related data, for road planning and programming purposes (Compendium of Best Practices in Road Asset Management, 2018). RAMS involves a computerized road asset management system, encompassing data collection, data management (database), and data analysis. It is a system that allows data to be analysed and optimal budget levels and allocations to be determined (Compendium of Best Practices in Road Asset Management, 2018).

Studies indicate that effective road asset management systems play a leading role in enhancing the operation and maintenance of road assets like pavement, bridges, culverts, signages, and other traffic equipment (OECD, 2016). A study by Kipkurui and Oura (2018) on the effect of road asset management systems on the performance of road agencies in Kenya revealed that RAM was a positive and significant predictor of road agency performance in Kenya and accounted for 81.7% of variance in performance of the road agencies in Kenya. Similarly, Yetnayet (2020) studied the contribution of road asset management systems in Addis Ababa, Ethiopia. The finding of the study indicated that there was lack of asset management systems with components implementation rated as low except for condition assessment which was rated as medium (45.5%). In Uganda, government officials through the Ministry of Works and Transport (MoWT) manage RAMS. Whereas the Strategy for Sustainable Maintenance of District, Urban, and Community Roads (DUCAR) was introduced by government followed by the reintroduction of force on account, Uganda just like other developing countries still experiences challenges in road asset management (Zanule, 2015). Also, Opio (2018) indicated that the country lacks high-technology equipment for monitoring road assets' condition and this result into decisions on road assets maintenance not being based on sufficient information leading to wrong intervention. This, therefore, presents a debate on the contribution that road asset management system has in the operation and maintenance of roads. It is against the background that provided the rationale to assess the effect of road asset management on the operation and maintenance of World Bank-funded roads in Lira City East Division.

### **1.1 Statement of the Problem**

Even though Uganda has developed and put into practice a number of policies, institutional strategies, and interventions on roads to improve the management of road infrastructure (MoFPED, 2020), there is still growing public concern over the lifespan of road assets as they continue to be cut short by persistent, high-profile infrastructure failure and needless loss of road asset value. This is demonstrated by the growth of potholes, blocked drainage, broken culverts, malfunctioning street lights, and damaged signs, all of which point to a larger issue with the maintenance of road assets (AFCAP, 2017). The country continues to have issues with the operations and maintenance of the road assets despite an increase in budget allocation to the works and transport sector of 35% from the financial year 2018/19 to 2019/20, with the figure representing 16% of the 2019/20 total budget for construction and maintenance of roads (MoFPED, 2018). While Uganda spends about

1.2 % of the value of its road network on asset maintenance each year, the country actually needs to spend between 2.5 and 3.5 % of the replacement value of its road network (MoFPED, 2019). However, it should be noted that, even with maintenance of the unpaved roads, only about 40% of Uganda's current national paved road network can be kept in good condition. Future higher replacement costs of the road assets are a result of the growing backlog in asset maintenance (UNRA, 2017). US\$ 2.9 billion was determined to be the asset value related to the state of the paved road network (UNRA, 2017). However, Uganda's current depreciated replacement cost is 68 % of the current replacement cost, which implies a 32 % asset loss. This shows a decline in the country's ability to maintain its road network's assets. According to Buffie and Balma (2019), Uganda barely invests 10% of its ideal level in road asset maintenance, which results in a 5.9-year reduction in the infrastructure's useful life. Numerous countrywide road assets that require maintenance or replacement have gone unattended due to this situation. The lack of functionality of road assets such as ; street lights, traffic signals, worn-out zebra crossings, fallen signage, broken and obstructed culverts in Lira City is indicative of the issue with road asset management. Further, a number of roads in Lira City are in bad conditions and the situation is made worse when it rains. As a result, it therefore provided a fertile ground for this study to examine the effect of road asset management systems on the operation and maintenance of World Bank funded roads in Lira City East Division.

## **1.2 Purpose of the Study**

The purpose of the study was to examine the contribution of road asset management systems on the operation and maintenance of World Bank funded roads in Lira City East Division. Three hypotheses were tested, namely:

- H<sub>01</sub>: Data collection has no statistically significant contribution on the operation and maintenance of World Bank-funded roads in Lira City East Division
- H<sub>02</sub>: Data management has no statistically significant contribution on the operation and maintenance of World Bank roads funded roads in Lira City East Division
- H<sub>03</sub>: Data analysis has no statistically significant contribution on the operation and maintenance of World Bank-funded roads in Lira City East Division

## **2. Literature survey**

### **2.1 Road Asset Management Systems**

Asset management system for roads and bridges have been recognised as the pillar for the of infrastructure asset management (Hajdin et al. 2019). According to Zimmerman and Ram (2015), road asset management systems make use of data collection processes, prediction models, a set of rules to determine intervention options within maintenance planning, and functionality to generate and evaluate projects and policies. A common road asset management system consists of inventory module, inspection module, maintenance module, and planning module (Hajdin et al. 2019). An

inventory module includes administrative and technical asset data (bridge and road IDs, geolocation, bridge type, and traffic equipment) and optional information such as photos of bridge elements or pavements. An inspection module enhances the asset data according to the inspection findings, i.e., ratings of the structural (deck, piers, and abutments) and non-structural (safety rail, pavement, and drainage system) elements. A forecast of condition deterioration is the basis for estimating future maintenance while the planning module that enables the managing agency to determine what maintenance and rehabilitation actions should be taken given the current and predicted conditions of the pavement sections and bridges (Karlapudi, Prathap & Menzel, 2021).

## 2.2 Operations and Maintenance

Operations and Maintenance refers to all actions necessary for retaining an asset as near as practicable to its original condition but excluding rehabilitation or renewal (United Nations, 2021). Operations and maintenance account for a significant %age of road assets' total life cycle cost, but the cost of poor maintenance is even greater (Gopalakrishnan, 2018). Road performance deteriorates over time like other engineering assets, and the deterioration process could be uncertain if not adequately monitored (Kans, Campos, and Ha°kansson, 2021). Proper road maintenance reduces the deterioration rate, thus postponing costly reconstruction, reducing vehicle operation and maintenance costs, and road failure delays (Kans, Campos, and Ha°kansson, 2021). Road condition assessments are performed to ascertain the road condition with maintenance and rehabilitation decisions, in some cases, based on political and economic factors (Shtayat, Moridpour, Best, Shroff, and Raol, 2020). Denysiuk et al. (2017) used a two-stage approach to address pavement maintenance in an effort to optimize scheduling, particularly for large networks. During the first stage, pavement sections within a network are collected and analysed using a multi-objective approach; in the second stage, maintenance schedules for those sections are combined to develop an optimal maintenance plan. Validating this approach on a sample of Portuguese highways, the framework proved useful, indicating it could be used across other infrastructure asset types.

*H<sub>01</sub>: Data collection has no statistically significant contribution on the operation and maintenance of World Bank-funded roads in Lira City East Division*

While many studies have been conducted in several settings to determine the effect of data collection on operation and maintenance of road, studies carried out by Reeh (2019), Austroads (2018), and Kipkurui, & Obura (2018) were carried out outside the context of this study location. None of these studies were conducted in Uganda and in particular in Lira City East division. It is therefore prudent that a study be carried out in Lira City East division of the relevance of collecting data on road assets in enhancing the operation and maintenance of World Bank funded roads.

*H<sub>02</sub>: Data management has no statistically significant contribution on the operation and maintenance of World Bank roads funded roads in Lira City East Division*

Studies reviewed on the effect of data management on operation and maintenance of road assets, such as Turienzo, Cabanelas, Lampón (2023), Luoma, Toppinen, & Penttinen (2021), Veile, Schmidt, & Voigt (2022), Chinyere and Ikoromasoma (2021), and Benaditta Kemunto Moriasi, and Muturi (2019) were carried out outside the context of this study location. None of these studies were conducted in Uganda and in particular in Lira City East division. It is therefore prudent that a study be carried out in Lira City East division of the relevance of collecting data on road assets in enhancing the operation and maintenance of World Bank funded roads. In addition, studies such as Turienzo, Cabanelas, Lampón (2023), Veile, Schmidt, & Voigt (2022) on used qualitative approach while a study by Chinyere and Ikoromasoma (2021) was quantitative in nature. This particular bridged the gap by making use of a mixed approach.

*H<sub>03</sub>: Data analysis has no statistically significant contribution on the operation and maintenance of World Bank-funded roads*

Studies reviewed on the effect of data analysis on operation and maintenance of road assets, such as Hajdin et al. (2019), Solla et al. (2021), Perrotta, Neves and Mesgarpour (2018), Bahsir, and Masitah (2021), and Yetnayet Bihon Semunigus (2020) were carried out outside the context of this study location. None of these studies were conducted in Uganda and in particular in Lira City East division. It is therefore prudent that a study be carried out in Lira City East division of the relevance of collecting data on road assets in enhancing the operation and maintenance of World Bank funded roads. In addition, a study by Bahsir, and Masitah (2021) on used qualitative approach while a study by Solla et al. (2021), and Perrotta, Neves and Mesgarpour (2018) was quantitative in nature. This particular bridged the gap by making use of a mixed approach.

### 3. Methods and materials

#### 3.1 Research Design

The design of the study was Explanatory Research Design. The advantage of this design is that it is quick and cheap, however it has its disadvantage in that, it is not useful in determining cause-effect and is not useful in analysing behaviours. However, according to Creswell (2012), the design helps in establishing the relationship between two or more aspects of a situation.

**Table 1. Sample Size**

Categories	Target population	Sample size
Mayor (Main and divisions)	03	03
City and division Clerks	03	03
City Engineer	01	01
City road inspector	01	01
City Development Forum	07	07

Councillors (East-52, Main-15)	67	56
<b>Total</b>	<b>82</b>	<b>71</b>

*Source: Researcher's consideration using primary data (2023)*

The study involved collection of primary data from the key informants of Lira City. This was made possible by presenting a letter of introduction from the Dean Faculty of Management Sciences of Lira University, seeking for permission to conduct research. The introductory letter was presented to the gate keepers at Lira City seeking for permission to conduct the study. The letters from the Town Clerk and the city mayor was presented to the respondents. Methods of administration of the instruments was self-administration and then drop and collect method where the researcher and the research assistant left the questionnaire with an informant and thereafter went back to pick it. This method was preferred because it helped in collecting data from the respondents. Self-administered questionnaires were used to gather data from councillors and the city development forum members. Open ended face to face interviews were also used to collect data from key informants to obtain more detailed information concerning the study variables.

### 3.2 Quality Control Methods

Validity determines if the research instrument truly measures that which it is supposed to measure (Kothari, 2011). To ensure content validity, the tools developed were given to expert judges with expertise in the area of study to score the relevance of each question in providing answers to the study. After the expert opinion, a content validity index (CVI) was computed. The average of CVI value above 0.7 was considered satisfactory hence indicating that the instrument satisfies content validity (Kothari, 2011). Reliability indicated the stability of measures administered at different times to the same individuals or using the same standard or the equivalence of sets of items from the same test or of different observers scoring a behaviour or event using the same instrument (Saunders, Lewis, & Thornhill, 2009). Reliability test was done using test re-test method. This was done by administering the questionnaire to ten purposely sampled respondents. Afterwards, the responses on the instrument was analysed using SPSS Version 23, and Cronbach's alpha values (Cronbach Alpha Reliability Coefficients) for each of the variables obtained. Cronbach's alpha can take any value from zero (no internal consistency) to one (complete internal consistency). The reliability coefficients value equal to or above 0.7 shows that the instrument is reliable (Kothari, 2011). The result of the pre-test are indicated in table 2.

**Table 2. Reliability test**

Variables	Cronbach alpha	No. of items
Data collection	0.954	05

Data management	0.936	05
Data analysis	0.974	05
Operation and maintenance	0.972	12
Overall	0.959	27

*Source: Primary Data*

As indicated in table 3.3 above, the Cronbach alpha for all the study constructs is above 0.7. The result of the pilot test also revealed that overall Cronbach alpha of 0.959 which is above 0.7. This indicated that the instrument was reliable.

### 3.3 Quantitative data analysis

Data were coded after which, statistical package for social sciences (SPSS) Version 23, was used to analyse the data collected. Univariate analysis was carried out using descriptive statistic. This was done with the help of %ages mean, standard deviation. Bivariate analysis was carried out as it helps to test the correlation coefficients between independent variables and the dependent variables (Saunders et al, 2009). Pearson correlation analysis was used to measure the correlation between the constructs. Regression analysis was employed to assess the effect of road asset management systems on the operations and maintenance of World Bank funded roads in Lira City.

### 3.4 Ethical Considerations

The ethical considerations pursued during this study focused on what Creswell (2012) upholds in social research, namely: anonymity or confidentiality and informed consent of the respondents. Informed consent was obtained from each research participant. Appropriate time was agreed and place convenient for the respondents and key informants to enhance free interaction. Codes were used for the purpose of the study instead of the actual name of the respondents or the key informants. And interviewees were informed that they were free to leave any time they deem fit even in the middle of the interview if they so wish.

## 4. Results of the study

### 4.1 demographic characteristics of the respondents

Out of the 63 questionnaires administered to the respondents, 63 (100%) were returned while out of 08 respondents interviewed, 08 participants took part. Given that any response rate above 50% is considered appropriate to accomplish the study objectives (Mugenda & Mugenda, 2003), this indicated that the data collected was adequate for carrying out analysis. The demographic characteristics of the study participants were studied in terms of gender, age, level of education, and categories of respondents. Majority of respondents were male (63.5%) while minority was female (31.5%). However the finding revealed that there was gender representation in that study.

This shows that the study captured the views of both male and female participants in relation to road asset management. The findings also indicated that, majority of the respondents were in the age group of 31-40 years (41.3%) while minority were aged above 60 years (4.8%). This indicates that most of the people who took part in the study were in their active ages. On the level of education, the study revealed that most of the study participants had bachelors' degree level of education (73%). They were closely followed by those with diploma and certificate level of education. However, all the study participants had the level of education that could make them to be in position to comprehend the items in data collection instrument since no study participant was below certificate (secondary) level of education. To end, regarding categories of study participant, majority of the study participants (56%) were councillors. They are the people who are supposed to come up with the budget for road maintenance and are also supposed to monitor the operation and maintenance of the roads.

#### 4.2 Data collection

In order to assess on data collection on World Bank funded roads in Lira City East, respondents were assessed on the five (5) items.

**Table 3. Descriptive Statistics for Data collection**

Items	N	Mean	SD
Data on all the road assets are always collected periodically	63	2.90	1.325
Data collection on road assets are done by competent people	63	3.29	1.207
Appropriate data collection techniques are always used during data collection	63	2.95	1.092
Data is always collected on the condition of all the road assets	63	3.19	1.198
Data collection on road assets are always updated frequently	63	2.52	1.094
Valid N (listwise)	63	2.97	1.183

*Source: Primary data (2023)*

The output reveals that most of the items used to assess the activity of data collection on road assets were below average on a Likert scale of 1-5 used by the researcher. This suggested that the respondents were not in agreement with how data collection on road assets of World Bank funded road takes place in Lira City division. According to the finding, there is no periodic collection of data on road assets, appropriate technique is not always used during data collection and the update of data on road assets is not being done. However, the result revealed that competent people are

always involved in data collection and that data is always collected on the condition of road assets. The overall mean of approximately 2.97 suggested that the practice of data collection on road assets in Lira City East division is inadequate. The Standard Deviation of 1.183 indicated divergence in the views of the respondents in relation to data collection on road assets of World Bank funded roads in Lira City East division. However, the interview held with the key informants indicated that;

‘Data collection on road assets in Lira City East is usually collected through road inventory and inventory survey’. (K01)

Another key informant revealed that;

*‘Data collection on all the road in Lira City East is collected annually and it is the responsibility of the road engineers to see that it is collected’.* (K04)

Another key informant reported that;

*‘The type of data collected includes the road surface, walkway, street lights, signage, greening, and drainage systems’.* (KI 08)

According to the key informants, information collected on the road assets in Lira City East includes; the length of the road, width, cross drains, status, surface type, section conditions among others.

#### 4.3 Data management

In an attempt to assess the management of data collected, respondents were asked questions indicated in table 4 below.

**Table 4. Descriptive Statistics for Data management**

Items	N	Mean	SD
There is a database that brings all the data collected on road assets together in a central point	63	2.93	1.206
Data collected on road assets are always readily available for planning purposes	63	2.99	1.219
Data collected are always organised into attributes such as road texture, road names, road length	63	3.16	1.106
Data collected are always protected from unauthorized access	63	3.00	1.067
There is a personnel in place for management of data collected	63	3.16	1.269

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Valid N (listwise)	63	3.05	1.173
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*Source: Primary data (2023)*

Table 4 above reveals that more than half of the items used to assess the level of data management on road assets revealed above performance average on a Likert scale of 1-5 used by the researcher. The finding suggested that data collected covers the attributes of road assets, it is always protected and there is a person in-charge of data collection in Lira City division. However, the result revealed that Lira City East lacks data collection database and because of that, it makes data collected not to be readily available. The overall mean of 3.05 indicated slightly above average performance of the construct. The standard deviation of 1.173 indicated deferring opinion of the respondents in relation to how data collected on road assets is always managed. Qualitative finding from key informants revealed that;

*‘Data which is collected on road assets is managed through the use of pedometer and GPS machines’.* (KI02)

However another key informant revealed that;

*‘The engineering department has a database for coding and storing of data collected on road assets’.* (KI03)

#### 4.4 Data analysis

In order to assess the implementation data analysis, respondents were assessed on the five (5) items indicated in table 5.

**Table 5. Descriptive Statistics for Data analysis**

Items	N	Mean	SD
There is appropriate tool for processing of data collected	63	3.01	1.208
Data collected are processed to show the optimal level of required funding	63	3.16	1.202
Data collected are always processed to indicate the urgency of maintenance work	63	3.23	1.275
The outcome of data analysis is always used in determining the budget need for the road assets maintenance	63	3.32	1.332
The outcome of data analysis are always acted upon immediately and appropriately	63	2.26	1.167

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 Valid N (listwise) 63 2.84 1.037
 

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*Source: Primary data (2023)*

The result of univariate on data analysis in table 5 revealed that whereas the respondents were slightly in support of the items used to assess the practice of data analysis on road assets as indicated that their average mean which were slightly above average on a Likert scale of 1-5 used by the researcher, they also expressed that the output of data analysis is not always acted upon immediately and appropriately (Mean of 2.26). The overall mean of 2.84 implied that the respondents were not in agreement on the level of data analysis of the data collected on road assets found on World Bank funded roads in Lira City East division. The standard deviation of 1.037 indicated divergence in the views of the respondents. The qualitative finding from the key informants revealed that;

*‘The data is extracted from integrated department and analysis to see which road asset needs immediate intervention and the financial implications. (KI04)*

**Another key informant revealed that;**

*‘Data which have been collected is analysed and prioritised for budgeting purpose and maintenance work’. (KI06)*

Another key informant indicated that;

*‘Data collected is processed locally and this sometimes gives misleading information and yet they are supposed to be used for planning purposes’. (KI08)*

#### 4.5 Effectiveness

In order to assess the effectiveness in the operation and maintenance of World Bank funded roads, respondents were assessed on the four (4) items. The result is indicated in Table 6.

**Table 6. Descriptive Statistics for Effectiveness**

Items	N	Mean	SD
Road maintenance in Lira City are always done as stipulated in the bill of quantities	63	2.63	1.399
Maintenance work in Lira City East is always given to the right contractors	63	2.36	1.195
Right equipment are always used during the maintenance of roads in Lira City East	63	2.51	1.192

Right materials are always used during maintenance work of the roads	63	2.37	1.230
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Valid N (listwise)	63	2.47	1.254
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*Source: Primary data (2023)*

The descriptive statistics in table 6 revealed that all the items used to assess the effectiveness in the operation and maintenance of roads assets were below average on a Likert scale of 1-5 used by the researcher. This suggests that the respondents were in support of the items used to assess the efficiency in the operation and maintenance of assets on the World Bank funded roads in Lira City division. This suggests that whereas there could be some maintenance work on the road, it is not done in deviation of bill of quantities due to the fact that the work is always not given to the right contractor and as such right equipment are not always used in addition to poor quality materials as expressed by the respondents with mean scores of below 0.3 which is the average mean. The overall mean of 2.47 indicates that maintenance work of the road assets found on World Bank funded roads in Lira City East division are not always effectively done. The standard deviation of 1.254 indicated divergence in the views of the respondents in regard to the effectiveness of maintenance work of road assets in Lira City East division.

#### 4.6 Efficiency

In order to assess the efficiency in road operation and maintenance of World Bank funded roads in Lira City East, respondents were assessed on the four (4) items. The result is indicated in table 7 below.

**Table 7. Descriptive Statistics for Efficiency**

Items	N	Mean	SD
Road maintenance in Lira City East is always done within the stipulated budget	63	2.37	1.184
There is always value for money in the maintenance work of roads in Lira City East	63	2.04	1.252
Experienced contractors are the one always given maintenance work in Lira City East	63	2.62	1.138
Resources are always rightly allocated during maintenance of roads in Lira City East	63	2.26	1.236

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 Valid N (listwise) 63 2.32 1.203
 

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*Source: Primary data (2023)*

The descriptive statistics in table 7 above revealed that all the items used to assess the efficiency in the operation and maintenance of roads assets were below average on a Likert scale of 1-5 used by the researcher. This suggests that the respondents were in disagreement with the items used to assess the efficiency in the operation and maintenance of assets on the World Bank funded roads in Lira City division. This suggests that whereas there could be some maintenance work on the road, it is not done within the budget making resources not to be rightly channelled. It further suggests that the work is always not done by experience contractor and this make the value of money not to be realised as clearly revealed by the outcome of the study. The overall mean of 2.32 indicates lack of efficiency in the maintenance work of the road assets found on World Bank funded roads in Lira City East division. The standard deviation of 1.203 indicated divergence in the views of the respondents in regard to the efficiency of maintenance work of road assets in Lira City East division.

#### 4.7 Timeliness

In order to assess the timeliness in maintenance of roads, respondents were assessed on the four (4) items.

**Table 8. Descriptive Statistics for Timeliness**

Items	N	Mean	SD
There is always timely maintenance of world bank funded roads in Lira City East	63	2.16	1.118
Periodic inspection of the roads is always done	63	2.58	1.279
Road inspectors always make periodic report about the conditions of roads in Lira City East	63	3.07	1.251
The work plan for road maintenance are always acted on timely	63	2.27	1.182
Valid N (listwise)	63	2.52	1.208

The descriptive statistics in Table 8 revealed that most of the items used to assess the timeliness in the maintenance of road assets were above average on a Likert scale of 1-5 used by the researcher. According to the result, roads are not being periodically inspected. It further revealed that the work plan for road maintenance is not always time acted upon which resulted to untimely maintenance work of the roads as has indicated by the findings. Whereas the finding revealed that road

inspectors make periodic reports on the condition of the road assets, there is the likelihood that the report do not depict the real conditions on the ground as they do not carry out periodic road inspection. The overall mean of 2.52 indicates that the authority of Lira City East division do not carry out timely maintenance work on the World Bank funded roads. The standard deviation of 1.208 indicated divergent views of the respondents in regard to the timeliness in the maintenance of road assets on the work bank funded roads in Lira City East division.

#### 4.8 Road Asset Management and Operation & Maintenance

In order to test the correlation of road assets management on operation and maintenance, correlation analysis was done.

**Table 9. Pearson's Correlation Results**

		DC	DM	DA	OM
Data collection (DC)	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	63			
Data management (DM)	Pearson Correlation	.620**	1		
	Sig. (2-tailed)	.000			
	N	63	63		
Data analysis (DA)	Pearson Correlation	.594**	.746	1	
	Sig. (2-tailed)	.000	.000		
	N	63	63	63	
Operation and maintenance (OM)	Pearson Correlation	.658**	.700**	.690**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	63	63	63	63

\*\* . Correlation is significant at the 0.01 level (2-tailed).

Results of Pearson's correlation analysis presented in table 4.10 reveals that data collection, data management and data analysis are all positive and significant correlated with the operation and

management of road assets of World Bank funded roads in Lira City East division at 99% confidence level. The finding therefore suggests that data collection, data management and data analysis are all important in the operation and maintenance of road assets. It further indicates that a unit increase in the implementation of the measures of road asset management (data collection, data management and data analysis) would positively influence the decision of maintenance activities. This will therefore results to enhancement in the operations of the road assets by scores of 0.658, 0.700 and 0.690 units respectively. A correlation of the constructs of road assets management also revealed a positive significant relation. Also, the result revealed that there was no possibility of multicollinearity as no correlation resulted into a correlation coefficient which was greater than 0.8. According to (Kieu, 2004), if a correlation between any two variables is greater than or equal to 0.80, then a high degree of interrelation can be inferred and the possibility of multicollinearity exists.

#### 4.9 Operation and Maintenance

In order to achieve the first research objective of this study, answer the second research question which was asking the effect of data collection in the operation and maintenance of road assets on World Bank funded roads in Lira City East Division and thereafter test the research hypothesis, a simple linear regression analysis was done. The model summary of the regression test yielded an Adjusted R Square of .425, which meant that data collection contributed about 42.5% to the operation and maintenance of road assets in Lira City. This implies that collection of data on all the road assets of World Bank funded road enables authority of Lira City East division to plan properly on how to do maintenance work. The remaining 57.5% was contributed by other factors like data management, data analysis and others outside the scope of this study.

**Table 10. ANOVA for Data Collection**

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	25.803	1	25.803	54.220	.000 <sup>b</sup>
	Residual	33.788	62	.476		
	Total	59.591	63			

a. Dependent Variable: Operation and maintenance

b. Predictors: (Constant), Data collection

The F-ratio in the ANOVA table 10 tests focussing on the overall regression model revealed that the independent variables statistically and significantly predict the dependent variable,  $F(1, 115) = 54.220$ ,  $p < .05$ . Therefore, the regression model is a good fit of the data. The significance level of 0.000 is less than the significance level for 95% confidence and this implies that data collection

significantly contributes to the operation and maintenance of road assets on World Bank funded roads in Lira City East. Therefore, the null hypothesis that ‘data collection has no significant effect on the operation and maintenance of World Bank funded roads in Lira City division’ is rejected in favour of alternative hypothesis. Additionally, the coefficient of the regression was also determined in this study to establish whether data collection affects the operation and maintenance of road assets and the results are shown in Table 11.

**Table 11. Coefficients for Data Collection**

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
1 (Constant)	.514	.273		1.879	.020
Data collection	.647	.088	.658	7.363	.000

*a. Dependent Variable: Operation and maintenance*

The finding above indicated that data collection had a regression coefficient of 0.647 which is significant at 1% level of confidence. This suggests that that collecting data on the road assets of World Bank funded roads in Lira City East division help in the operation and maintenance work on the road assets. From the finding, it implies that a unit increase in the implementation of data collection increases the score in the operation and maintenance of road assets by 0.647 units. This result answers the first research question which was asking the effect of data collection the operation and maintenance of World Bank funded roads in Lira City East division.

This result is in support of the qualitative of the key informants in the interview held. The interview held with the key informants indicated that;

*‘Data collection helps in planning for intervention on each section of the road or the road asset that may need maintenance work. (KI01)*

Another interview held with the key informants indicated that;

*‘Collecting data on the road assets help in planning and budget allocation and this done according the ones that need immediate attention’. (KI03)*

However, another interview held with the key informants indicated that;

*‘Collecting data on the road asset is not helpful because many of the information or data collected lacks accuracy. (KI05)*

The finding is consistent with that of Reeh (2019) carried out a study on the contribution of collection of data on inventory in Denmark The finding indicated that collection of data on the condition of a road from human surveyors and directional sensors to multisource data modelling

help in coming out with the appropriate budget for the maintenance of the roads and other road assets like street lights, bridges and signage. The finding also concurs with that of Austroads (2018) carried out a study on the effect of collecting data on infrastructural inventories in Australia. The finding also indicated that the use of standards supports the regulatory environment of an infrastructure asset and the operational policies relating to infrastructure, such as procurement, by providing a baseline against which the measurement and comparison of results is possible. The finding also agrees with Kipkurui, and Obura (2018) conducted a study to analyse the effect of road asset management (RAM) on road maintenance in Kenya. The Results showed that having up to date data on road assets had a positive and significant predictor of road maintenance in Kenya and it accounted for 81.7% of variance in performance in road operation and maintenance in Kenya.

#### **4.10 Data management on Operation and Maintenance**

In order to achieve the second research objective of this study, answer the second research question which was asking the effect of data management in the operation and maintenance of road assets on World Bank funded roads in Lira City East Division and thereafter test the research hypothesis, a simple linear regression analysis was conducted. The results from the simple linear regression revealed an Adjusted R Square of .483 which implies that about 48.3% of the variations in the operation and maintenance of road assets on World Bank funded roads in Lira City East division can be explained by data management. The finding therefore suggest that proper management of the data which have been collected on the road assets of world bank funded roads in Lira City East division help in planning and budgeting purpose on how the maintenance work should be done. The F-ratio of ANOVA tests of the overall regression model showed that the independent variables statistically and significantly predict the dependent variable,  $F(1, 63) = 68.353$ ,  $p < .05$ . Therefore, the regression model is a good fit of the data. The significance level of 0.000 is less than the significance level for 95% confidence and this implies that data management significantly contributes to the operation and maintenance of road assets on World Bank funded roads in Lira City East. Therefore, the null hypothesis that ‘data management has no significant effect on the operation and maintenance of road assets on world bank funded in Lira City East division’ is rejected in favour of alternative hypothesis. The finding indicated that data management had a regression coefficient of 0.759 which is significant at 1% level of confidence. This indicated that data management had a significant effect on the operation and maintenance of road assets found on World Bank funded roads in Lira City East division. From the finding, it suggests that a unit improvement in the management of data which have been collected on the road assets increases the score in its operation and maintenance by 0.759 units. This result therefore answers the second research question which was asking the effect of data management in the operation and maintenance of assets found in World Bank funded roads in Lira City East division.

This result is in support of the qualitative of the key informants in the interview held. The interview held with the key informants indicated that;

*'If the data collected on road assets are not tampered with, it makes the city authority of Lira City to use the right information during planning'. (KI03)*

Another interview held with the key informant on the importance of managing data which have been collected indicated that;

*'Proper storage of data collected help to prevent people with ill motive from accessing and distorting the data'. (KI05)*

The finding agrees with that of Turienzo, Cabanelas, and Lamp'ón (2023) carried out a study on the impact of ongoing digitalization in the management of data collected in Spain. The findings suggested that data management help to better understand the needs of the customer and vehicle requirements so that differential value can be provided. The finding is also in line with that of Luoma, Toppinen, and Penttinen (2021) carried out a study on the relevance of data management in the performance of organisation in Denmark. The finding of the study indicated that proper management of the data collected significantly affects the quality of the result of data analysis. The finding of the study also suggested that relevance of data management help to facilitate the design of sustainable business models. The result of the study supports that of Veile, Schmidt, and Voigt (2022) carried out a study on the relationship between organisational management and business transformation in Finland. The finding also indicated that proper management of the data that has been collected help in the maintenance of the quality of the data that has been collected. The finding also concurs with Chinyere and Ikoromasoma (2021) investigated the relationship between data management systems and organizational efficiency of deposit money banks in Port Harcourt, Rivers State, Nigeria. The result revealed that there is a significant positive relationship between data management systems and organizational efficiency of deposit money banks in Port Harcourt. Lastly, the result also relates with that of Benaditta Kemunto Moriasi, and Muturi (2019) carried out a study to investigate the effect of data management on performance of public institutions in Kisii County in Kenya. The results revealed that data management positively affected performance.

#### **4.11 Operation and Maintenance**

In order to achieve the third research objective of this study, answer the second research question which was asking the effect of data analysis in the operation and maintenance of road assets on World Bank funded roads in Lira City East Division and thereafter test the research hypothesis, a simple linear regression analysis was carried out. The model summary of the regression test produced an Adjusted R Square of 0.690, which meant that analysis of data collected on road assets contributed about 69% in Lira City East division. The remaining 31% was contributed by other factors outside the scope of this particular study. The finding therefore implies that analysis of data collected on road assets significantly help in the operation and maintenance of assets on World Bank funded roads in Lira City East division. The F-ratio in the ANOVA in table 4.18 tests whether the overall regression model is a good fit for the data. The result showed that the independent

variables statistically and significantly predict the dependent variable,  $F(1, 115) = 64.407$ ,  $p < .05$ . Therefore, the regression model is a good fit of the data. The significance level of 0.000 is less than the significance level for 95% confidence and this implies that data collection significantly contributes to the operation and maintenance of road assets on World Bank funded roads in Lira City East. Therefore, the null hypothesis that ‘data analysis has no significant effect on the operations and maintenance of World Bank funded roads in Lira City East division’ is rejected in favour of alternative hypothesis. Further, a t-test was carried to draw out the statistical significance between Data Analysis and Operation and maintenance.

**Table 12. Coefficients for Data Analysis**

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
1 (Constant)	.552	.247		2.231	.000
Data analysis	.629	.078	.690	8.025	.000

*a. Dependent Variable: Operation and maintenance*

The finding in table 12 above indicated that data analysis had a regression coefficient of 0.629 which is significant at 1% level of confidence. This indicated that analysis of data which has been collected on road assets had a significant effect the operations and maintenance of road assets on World Bank funded roads in Lira City East division. From the finding, it suggest that a unit increase in the score of analysis of data collected on road assets increases the score in the operations and maintenance by 0.629 units. This finding therefore answers the third and the last research question which was on the effect of data analysis on the operation and maintenance of assets found on World Bank funded roads in Lira City East division.

This result is in support of the qualitative of the key informants in the interview held. The interview held with the key informants indicated that;

*‘Carrying out analysis on the data collected is important in that it help to inform the relevant authority on the current status of the road assets within the city. (KI04)*

The interview held with the key informants indicated that;

*‘Through analysis of the data collected on the road assets, the relevant authorities will be able to know the ones that need maintenance work and the cost of the work’. (KI01)*

The finding is consistent with those of Hajdin et al. (2019) carried out a study on the contribution of assessing data on road conditions on the maintenance of roads. The finding of the study indicated that within the framework of asset management, reliable data analysis help to obtain information about the current condition of the transportation infrastructure and, based on this, to

predict its future state. The finding also agrees with Solla et al. (2021) examined the relationship between analysing data on road condition and the operational ability of the road. The study also indicated that assessing data on the condition of asset infrastructure help in early planning hence making the road to be worked on before its condition gets worse.

The finding is also in support of Perrotta, Neves and Mesgarpour (2018) carried out a study on the impact of examining the data collected on road assets on the performance of the road in India. The finding indicated that analysing the data collected on the condition had a significant effect on the development of strategies for the improvement of the road assets. The finding also concurs with Bahsir and Masitah (2021) carried out a study on the impact of data analysis on organizational performance in Nigeria. The result shows that there is significance correlation between independent variable and dependent variables which resulting the hypotheses developed for this study were accepted. Lastly, the result relates to those of Yetnayet Bihon Semunigus (2020) carried out a study on the effect of Road Asset Management Practices on the maintenance of roads in Ethiopia the Case of Addis Ababa. The findings of the study revealed that there is lack of asset management system components implementation rated as low except condition assessment which rated as medium with a result 45.5%. The finding also indicated that assessing the condition of road assets help to work on the road early enough. To achieve the purpose of this study which was to examine the effect of road asset management on the operation and maintenance of road asset on World Bank funded roads in Lira City, the researcher carried out multivariate regression analysis and the findings are presented in table 13.

**Table 13. Model Summary for Regression for Road Asset Management**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.773 <sup>a</sup>	.597	.580	.58980

*a. Predictors: (Constant), Road asset management (Data collection, data management and data analysis)*

*b. Dependent Variables: Effectiveness, efficiency and timeliness*

The results presented in Table 4.20 revealed that road asset management significantly contribute to the variance in the operation and maintenance in road assets by 58% (Adjusted  $R^2=0.580$ ,  $p<0.01$ ). This implies that collecting data on all the road assets, managing it properly and analysing the data collected contribute to 58% variation in the management of road assets on World Bank funded roads in Lira City.

The finding concurs with studies of OECD (2016) which revealed that effective road asset management systems play a leading role in enhancing the operation and maintenance of road assets like pavement, bridges, culverts, signage, and other traffic equipment. Similarly, a study by Kipkurui and Oura (2018) on the effect of road asset management systems on the performance of

road agencies in Kenya revealed that RAM was a positive and significant predictor of road agency performance in Kenya and accounted for 81.7% of variance in performance of the road agencies in Kenya. Relatedly, a study by Yetnayet (2020) on the contribution of road asset management systems in Addis Ababa, Ethiopia indicated that lack of asset management systems with components implementation affects the operation and functionality of the road assets.

### **Conclusion**

Collection of data on the condition of all the road assets help in planning and budgeting for maintenance work by the relevant authorities of Lira City West division. Proper management of the data, which have been collected on the condition and status of road assets helps to ensure that planning and budgeting activities are done using reliable data. Analysis of data collected on road assets helps to inform the relevant authority on the status of the road assets and for proper planning in regards to maintenance activities.

### **Recommendations**

Based on the finding and conclusions of the study, the researcher made the following recommendation.

- a) There should be regular inspection of all the road assets found on the World Bank funded roads in Lira City East division by the City road inspectors.
- b) Road inspectors should submit regular reports on the road assets detailing their current conditions or status.
- c) Competent people should always be recruited by the authority of Lira City East division to collect data on all the roads assets so as to be in position to gather data which is reliable and can be used for decision making.
- d) Appropriate tools that enable the road asset data collectors capture all the attributes of the road assets and should always be used when collecting data on the road assets.
- e) Further studies could be carried out on the factors affecting the functionality of drainage systems in urban centres in Uganda.

### **REFERENCES**

- AFCAP (2017). Economic Growth through Effective Road Asset Management – Progress Report No. 2 (to 31st July 2017).
- Ahenkora, K., and Peasah, O. (2011). Crafting strategy that measures up. *International Journal of Business and Management*, 6, 278-283. doi:10.5539/ijbm.v6n10p278.
- Amin (2005). *Analysing social research in the present Era* (3rd Edition) New York

- Barney, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, Vol. 17, No. 1, pp. 99-120.
- Barney, J. B. (2001a). Is the resource-based "view" a useful perspective for strategic management research? Yes. *Academy of Management Review*, 26: 41-56.
- Bahsir, and Masitah (2021). The Impact of Big Data Analytics on Organizational Performance. *Journal of Information and Knowledge Management (JIKM) Volume 11 Number 2 (2021)*
- Benaditta Kemunto Moriasi, and Muturi (2019). The study aimed at investigating the effect of information management on performance of public institutions in Kisii County. *Journal of Public Policy and Administration ISSN 2520-5315 (Online) Vol.4, Issue 1, No. 3, pp 33-44, 2019*
- Chinyere, Joy Onyinyechi, and Ikoromasoma, Emmanuel investigated the relationship between data management systems and organizational efficiency of deposit money banks in Port Harcourt, Rivers State, Nigeria. *Nigerian Journal of Management Sciences* Vol. 22, Issue 2 (August, 2021)
- Conner, K.R. (1991). A historical comparison of resource-based theory and five schools of thought within industrial organization economics: Do we have a new theory of the firm? *Journal of Management*, Vol. 17, No. 1, pp. 121-154.
- Cooper, D., and Schindler, S. (2014). *Business research methods*. New York: McGraw-Hill Irwin.
- Creswell J. W. (2012). *Research design (4th edition)*. Sage publications Inc
- Denysiuk, Roman, Andre Moreira, Jose Matos, Joel Oliveira, and Adriana Santos. 2017. Two-Stage Multiobjective Optimization of Maintenance Scheduling for Pavements. *Journal of Infrastructure Systems*, 23(3): 1-12.
- Fahy, J. (2000). The resource-based view of the firm: some stumbling-blocks on the road to understanding sustainable competitive advantage. *Journal of European Industrial Training*, 24/2/3/4 [2000] 94-104.
- Geddes, R., Gongera, K., and Solutions, C. D. (2016). Economic Growth through Effective Road Asset Management. In *International Conference on Transport and Road Research*.
- Gopalakrishnan, M (2018). *Data-Driven Decision Support for Maintenance Prioritisation: Connecting Maintenance to Productivity*. Chalmers Tekniska Hogskola, Gothenburg, Sweden.
- Gongera, K. (2015). *Assessment of Current Road Maintenance Operations at Wereda Level in Ethiopia. Final Report. AFCAP Project No. 12090.*

- Government of Uganda (2008). Draft National Construction Industry Policy. Ministry of Works and Transport. Kampala, Uganda.
- Griffin, R. W., and Moorhead. G. (2012). *Organizational behavior: Managing people and organizations* (10th ed.). Mason, OH: Cengage Learning.
- Hensher, D. A., and Chung, D. (2011). 5 Road infrastructure and institutional reform: Tolling and pricing. In M. Finger and R. W. Kunneke (Eds.) *International Handbook of Network Industries: The Liberalization of Infrastructure*, 252-268. Northampton, MA: Edward Elgar.
- Human Dynamics (2015). Project Identification and Formulation for Rural Roads Infrastructure Development under EDF 11. Final Report (Draft). Lilongwe, Malawi.
- IT Transport (2013). Improved Maintenance Systems for District Roads in Tanzania (AFCAP/TAN/019). Final Report. AFCAP, Tanzania.
- Kans, M., J. Campos, and Ha°kansson, L. (2021). An ICT System for Gravel Road Maintenance–Information and Functionality Requirements. In *International Congress and Workshop on Industrial A.I.* (R. Karim, A. Ahmadi, I. Soleimanmeigouni, R. Kour, and R. Rao, eds.), Springer, Cham, Switzerland, pp. 53–64.
- Kothari, C.R. (2011). *Research Methodology: Methods and Techniques*. Second Edition. WishwaPrakashan, New Delhi.
- Krejcie R.V & Morgan D.W (1970). Determining sample size for research activities, Education and psychological measurement.
- Lichtenthaler, U., Ernst, H., and Conley, J. G. (2011). How to develop a successful technology licensing program. *MIT Sloan Management Review*, 52(2), 17-19.
- Luoma, P., Toppinen, A., and Penttinen, E. (2021). The role and value of data in realising circular business models: A systematic literature review. *Journal of Business Models*, 2 (9), 44–71
- Mills, J., Platts, K. and Bourne, M. (2003). Competence and resource architectures. *International Journal of Operations & Production Management*, 23(9), 977- 94.
- MoFPED (2018). Report on Road Sector in Uganda.
- MoFPED (2019). Report on Road Sector in Uganda.
- Mugenda, A. and O. Mugenda, 2013. *Research Methods: Quantitative and qualitative approaches*. Nairobi: ACTS Press.
- OECD (2016). Asset Management for the Roads Sector. *OECD Publications Service*. 75775 Paris Cedex 16, France

- Opio, H.O. (2018). Analysis of road asset management systems in Uganda: The case of Mount Elgon Region. Unpublished master's thesis. Makerere University, Kampala, Uganda.
- Parsons Brinckerhoff Consortium (2010). Feasibility Study: Building a Uganda Road Sector Policy Support Programme. Sector Budget Support Component (Formulation Stage). Assessment Report (Final). Kampala, Uganda.
- Peteraf, M.A. and Bergen, M.E. (2003). Scanning dynamic competitive landscapes: A Market-based and resource-based framework. *Strategic Management Journal*, 24:1027-41.
- Priem, R. L. and Butler, J. E. (2001a). Is the resource-based "view" a useful perspective for strategic management research? *Academy of Management Review*, 26: 22-40.
- Ritter, T., and Pedersen, C. L. (2020). Digitization Capability and the Digitalization of Business Models in Business-To-Business Firms: Past, Present, and Future. *Industrial Marketing Management*, 86, 180–190. <https://doi.org/10.1016/j.indmarman.2019.11.01>
- Ryals, L. J., and Davies, I. A. (2013). Where's the strategic intent in key account relationships? *The Journal of Business & Industrial Marketing*, 28: 111-24.
- Saunders, M., Lewis, P., and Thornhill, A. (2009). *Research methods for business students* (5<sup>th</sup> Ed.) New York: Prentice Hall.
- Shtayat, A., S. Moridpour, B. Best, A. Shroff, and D. Raol (2020). A Review of Monitoring Systems of Pavement Condition in Paved and Unpaved Roads. *Journal of Traffic and Transportation Engineering (English Edition)*, 7(5), 629–38.
- Turienzo J, Cabanelas P, and Lampón, J.F (2023). Vehicles (uncertain) domino effect *Journal of Business Research* 156 (2023) 113481
- Veile, J. W., Schmidt, M. C., and Voigt, K. I. (2022). Toward a New Era of Cooperation: How Industrial Digital Platforms Transform Business Models in Industry 4.0. *Journal of Business Research*, 143, 387–405. <https://doi.org/10.1016/j.jbusres.2021.11.062>
- Wernerfelt, B. (1984) A Resource-Based View of the Firm. *Strategic Management Journal*, 5, 171-180. - References - Scientific Research Publishing.11 Jul 2017
- UNRA, (2017). Economic Growth through Effective Road Asset Management – Progress Report No. 2 (to 31st July 2017)
- United Nations, (2021). Managing Infrastructure Assets for Sustainable Development: A handbook for local and national governments.

Zanule, P. G. (2015). *Road Management System and Road Safety in Uganda* (Unpublished Doctoral dissertation, Walden University).



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