MAKERERE UNIVERSITY

COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

SCHOOL OF FORESTRY ENVIRONMENTAL AND GEOGRAPHICAL SCIENCES

ASSESSMENT OF PREMATURE WOOD UTILITY POLE FAILURE IN BUTAMBALA DISTRICT - UGANDA.

BY

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A RESEARCH REPORT SUBMITTED TO THE DEPARTMENT OF FORESTRY BIODIVERSITY AND TOURISM IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF A BACHELOR'S DEGREE OF SCIENCE IN FORESTRY OF MAKERERE UNIVERSITY

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DECLARATION

I **KIYINGI FREDRICK** hereby declare that this research has been my own efforts and findings with the help of the academic supervisors. I therefore affirm that it has been submitted to Makerere University Kampala in the partial fulfillment of the requirements for the degree of Bachelor of Science Forestry.

Signature………………………… Date…25, March, 2022………

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This report has been submitted for examination with approval from the university supervisor

Signature ………………………… Date …25-03-22………………..

Dr. Mugabi Paul

DEDICATION

This research report is dedicated to the electricity transmission agencies and future researchers.

ACKNOWLEDGEMENT

I would like to thank the Almighty for His spiritual and physical strength and Protection that He provided unto me so that I was able to complete the case study internship successfully.

My sincere thanks go to my academic supervisor Dr. Mugabi Paul for his priceless guidance towards the completion of this research assessment.

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Further appreciation goes to my parents for their financial support and encouragement to ensure that I complete the field attachment successfully.

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials.
AWPA	American Wood Protection Association.
CCA	Chromated Copper Arsenate.
FRP	Fibre Reinforced Polymer.
GPS	Global Positioning System.
H.E.P	Hydro Electricity Power.
NESC	National Electric Safety Code.
U E B	Uganda Electricity Board.

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ABSTRACT

A wood pole is a long round timber for use in a free-standing application (Steinar Refsnæs et al, 2015) whereas, Wood utility pole failures are faults that happen in a column or post used to support overhead power lines and other various public utilities such as electrical cable, fiber optic cable and related equipment such as transformers and street lights.

Wood poles are commonly used to support electrical distribution systems due to several factors; Wood is readily available in most places across the country and can relatively be acquired cheaply, they are easy to handle, excellent insulators, renewable and environmentally preferred.

A number of wood utility poles in Butambala district fail prematurely and there is limited data on the likely quantity of utilities that fail, cause of the failures and the service life of the erected utility poles. This is causing a number of challenges to the electricity users and electricity distribution agencies which range from power outage, high utility pole maintenance and replacement costs, accidents.

The objective of this research is to assess the premature wood utility pole failure within Butambala district by determining the minimum service life of the utility poles together with number of utility poles failing per year, determining the failure causes, comparing the failures in utility poles with the preservative chemical used to treat the poles and finding the solution to the failure problem.

Over 200 utility poles were visually surveyed and out of them 120 utility poles were creosote treated and out them 0nly 95 were in good service condition and 25 utility poles needed either replacement or maintenance. The 80 utility poles were CCA treated and a number of them had been installed within a period of less than 10 years.

Through visually inspection conducted, interview with key informants and questionnaire guide it was found out that the minimum service life of the wood utility poles is 30 years. The root cause of the wood utility poles failure in Butambala district are decay due to fungi, insect infestation, inadequate impregnation, insufficient preservative penetration depth, the deep cracks and splits, road accidents, agricultural activities carried out near the utility poles, no inspection and lack of remedial treatments.

Results showed that, Most of the utility pole which do well in Butambala district are creosote treated poles serving to a service of 35 years and above and most of them were installed during UEB reign although there are some which were installed during UMEME time and are also doing well. On the other hand, there are also CCA treated poles and they are the leading in failing prematurely.

Key words: wood utility poles, premature wood utility pole failure, service life, creosote, CCA, decay pole inspection and maintenance.

CHAPTER ONE: INTRODUCTION

Wood utility poles failures are faults that happen in a column or post used to support overhead power lines and other various public utilities such as electrical cable, fiber optic cable and related equipment such as transformers and street lights.

Electrical wires and cables are routed overhead on wood utility poles as an inexpensive way to keep them insulated from the ground and out of the way of people. Wood utility poles are made of two different types of power line;

Sub transmission line which carry higher voltage power between substations and distribution lines which distributes lower voltage power to customers. Electric power systems are the backbone of the complex network of infrastructure systems that support modern societies.

Most civil infrastructure systems such as water and wastewater systems, transportation systems, gas supply networks, and communications systems cannot function properly without reliable power supply. (Yu and Yan, 2017) noted that, Wood utility poles are widely applied to facilitate electricity transmission and distribution all over the world due to easy availability, low cost and environmental protection.

Despite newer developments often opting for underground wiring and using concrete utility poles, wood utility poles remain the most common means of supporting wiring. There are roughly 120 million wood utility poles in service, owned by utility companies, rural electricity associations, telephones and railroads (pine river group, 2018).eucalyptus wooden pole species are the mostly used wood utility poles in Uganda.

Wood poles are preferred over other materials because they are relatively cheaper to purchase, lighter and easier to transport, and are easy to climb and are non-conductive, which makes them safer for utility workers (Mankowski *et al*, 2002). However, because of exposure to severe environmental conditions, together with fungus and termite attack, wood poles may suffer from the internal deterioration, leading to the strength loss which may cause low reliability of power supply to support daily life (Yu and Yan, 2017).

There are various factors causing damages to a pole, including the trees and branches located nearby power lines and poles, structural deterioration of a pole, flooding, storm surges, debris produced by winds, and so on (Ryan *et al*, 2014).

The poles can be attacked by bacteria, insects and fungi and the most employed treatment is the one with water-based chro-drills. The decay of wood poles depends on material properties, soil properties, and local climatic conditions. The main climate parameters that affect the decay of wood are humidity and temperature (wang and wang , 2012).The exposure of wood poles to a humid environment increases the moisture content of the wood.

The increase in the moisture content of wood above the fiber saturation point will provide a viable environment for the establishment of a fungal mycelial mat and further fungal growth ((Viitanen and Ritschkoff, 1991). Moisture content above the fiber saturation point results in the availability of free water in the wood, which is easily accessible to the fungi and leads to rapid decay (wang and wang , 2012).

In Southern Brazil special attention is given to fungi, mated copper arsenate preservative (CCA). Since wood is a renewable resource, the environmental gain must also be taken into account to support the distribution and transmission lines.

The condition of the poles is a critical factor for the performance of the system because aging and deterioration increase the risk of pole failure resulting in power outage, costly maintenance work, and dangers of or the safety of workers, of citizens and the environment in general (CHRISTODOULOUL C.A *et al*, 2009).

This is the consensus among electricity distributors that the extension of the in-service life of wooden poles represents an important factor on cost accounting. The approach given to the program of maintenance and replacement of poles can be decisive in the economic impact of these structures on power distribution systems. Thus, these programs must be accompanied by a probabilistic approach that allows reduction and optimization of costs.

1.1RESEARCH PROBLEM.

The problem to be addressed by this study is, for the past years a number of wood utility poles in Butambala district have been prematurely failing while in service despite their treatment with preservatives and there is limited data on the number of utilities failing and there causes.

This is caused by decay of the poles, wood degraders like beetles, wood pecker birds, falling of trees and branches located nearby the utility poles or along the power distribution lines in general, accidents along the main road, shallow hole installation depth of less than 8 feet and un favorable weather conditions like strong wind and rain and installation of improperly treated wood utility poles.

This premature wood utility pole failure is creating conflicting loyalties to the electricity distribution companies whether the wood utility poles should continuously be used in safe transmission of H.E.P or being replaced by concrete or steel utility poles.

Unless research is conducted to find out the possible ways of combating wood utility pole failure, the district as well as the power transmission companies are likely to continue losing large sums of money as a way of rampart replacing of the failed utility poles.

As a result of premature utility pole failures, Power outage is likely to continue which might interrupt the daily running of various business and other big projects which depend mostly on electricity power supply. In addition, occurrence of accidents due falling of the utility poles and loosening of the electricity wires. To safe guard against the above outcomes, it is important to know the minimum service life of the wood utility pole to have a planned community development while minimizing costs of maintenance and replacement of utilities. Wooden poles should have a minimum service life of 30-35years (Gellerich Antje *et al*, 1937).

Wood being hygroscopic, dimensionally unstable and its susceptibility to degradation and deterioration put wood utility poles to a disadvantage regarding their longevity while in use. These happenings reduce the strength, durability and service life.

It is very important in Uganda to prevent such failures for the utilities poles in service by making sure that these transmission support utility systems have sufficient structural strength to meet the design and code requirements regardless of the magnitude of damage and deterioration that may have accumulated during service. Due to their advantages including low cost, sustainability, dielectric properties, and environmental acceptability, wooden poles remain the best choice to support the electric distribution and transmission systems, and other communication elements.

1.2. GENERAL OBJECTIVES.

To assess the premature wood utility poles failure in Butambala district.

1.3. SPECIFIC OBJECTIVE.

1. To determine pole service life and number of poles failing per year.

2. To determine the causes of premature wood utility pole failure.

3. To compare utility pole failure with the type of treatment preservative used.

4. To find the solution to premature wood utility pole failure in the area.

1.4. RESEARCH QUESTIONS

1. What is the service life of wood utility poles in Butambala?

2. How many poles are failing in the Butambala district per year for the last five years?

3. What are the potential causes of wood utility pole failure in service?

4. Is the failure more in CCA treated or creosote treated wood utility poles?

1.5. SIGNIFICANCE

Requirement for the bachelor's degree. This research is essential for the partial fulfillment of the requirements for the award of bachelor's degree of science in forestry hence enabling me obtain this degree which is essential for my career.

Future research. Country wide there is no clear information on the failure of wood utility poles. This research will therefore lay a foundation for other researchers to venture more into research on wood utility poles so as to avail knowledge and information which is suitable to aid decision making more so in the country's power sector.

1.6. SCOPE.

This assessment focused on assessing the premature wood utility pole failure in Butambala district majorly determining the minimum service life of utilities, causes of premature failure, relationship of failures with preservatives used and establishing the solution to deal with the premature utility failure.

CHAPTER TWO: LITERATURE REVIEW:

2.1. WOOD POLE FAILURE/DEGRADATION.

A wood Pole: Is a long round timber for use in a free-standing application (Steinar Refsnæs *et al*, 2015). (Butch, 2017), Reported that, the first documented use of wood poles was in 1844, with the dawn of the telegraph. The initial effort placed the new telegraph lines underground, but in the first few miles the lines failed. Morse turned to placing the lines overhead, advertising to buy 700 "straight and sound" wood poles.

As the technology to generate and distribute electricity emerged, the success of using poles for telegraph lines was applied to carrying to new electrical lines, insulators, and other necessary items. At the beginning of the twentieth century, standards were developed to create a consistent supply of wood poles.

Today wood poles are commonly used to support electrical distribution systems due to several factors; Wood is readily available in most places across the country and can relatively be acquired cheaply, they are easy to handle, excellent insulators, renewable and environmentally preferred. However, wood is an organic material and is subject to decay and rot, which diminishes its strength over time *(Merschman et al*, 2020).

Under proper conditions, wood will give centuries of service. However, if conditions exist that permit the development of wood-degrading organisms, protection must be provided during processing, merchandising, and use (Madison, 2010).

Several studies have been conducted on the failure of utility poles in the power distribution system. (Shafieezadeh *et al*, 2013) Found that wooden poles often fail due to a wind load greater than the flexural capacity of a pole. (Han, 2008), Examined two mechanisms that cause the failure of poles—flexural failure due to the wind load and foundation failure.

(Goodell Barry *et al*, 2020) , Noted that, Wood is among the most durable cellulosic materials, but it can be degraded by a number of biotic and abiotic agents. These agents often act simultaneously making it difficult to completely separate causal agents. The principal organisms that can degrade wood poles are fungi, insects, bacteria, and marine borers.

According to (Goodell Barry *et al*, 2003), Wood-degrading fungi, insects, bacteria cause damage to wood utility poles resulting in billions of dollars being spent on repair and replacement of wooden structure every year.

Wood decay is largely caused by fungi that fall into categories depending on the appearance of the degraded wood which is in turn related to polymeric materials that are degraded. Brown rot decay is an informal name for the most common type of decay occurring in timber products. Fungi that cause brown rot depolymerize cellulose and hemicellulose (holo-cellulose) for digestion, while lignin is also depolymerized and modified before being rapidly re-polymerized.

The general categories of white rot fungi and soft rot fungi are the other major types of decay and can be quite important in certain environments (Goodell Barry *et al*, 2020).over time, preservatives are depleted from the wood pole, providing food for insects and birds that prey on them. The plentiful supply of moisture and oxygen above and 18inches below the ground line act as catalysts for decay. The same capillary action present in live trees occurs in the bottom of the pole leading to a wicking effect that spreads moisture effect that spreads moisture and decay. As decay proceeds, it reduces pole strength, which over time, can lead to pole failure (Bowmer .N Trevor, 2021).

Precipitation and soil moisture led to the wetting of poles. Wood MC greater than 20% increases the chance of decay, and MC above 25%–30% indicates a high likelihood of extensive decay

2.2. Service life of utility poles.

Wood utility pole service life refers to the time period between the installations of a utility pole to the time of its retirement.

A number of factors impact the service life of wood utility poles which range from the preservatives used, climate conditions, the specification, quality of treatment and how well the pole is maintained (Butch, 2017). Inspection and remediation contributes significantly to longer service life for wooden poles

Utilities are often faced with questions about how long a wood pole lasts once it is placed in the ground. Poles made of alternative materials, such as recycled steel, concrete, composite, or the burying of lines, are all alternatives to wood poles that currently are used. The salvage value of steel poles contrasts sharply with the disposal costs of treated wood utility poles.

Despite the challenges faced in utilization of wood poles as utilities, wooden poles remain popular with utility companies because they are affordable, lighter and easier to transport than steel or concrete poles, they don’t rust, are easy to climb and are non-conductive, which makes them safer for utility workers. Wood poles also have environmental advantages. They store carbon removed from the atmosphere, unlike steel or concrete poles, which are energy-intensive to manufacture (American tree farm foundation, 2013).

According to (Council, 2021),wood utility poles are subjected to the harsh conditions that nature can dish out, from rain, ice, and wind to insects and decay fungi this reduces their service life. Preservatives integrated into the poles through pressure combined with wood's natural resilience, allow wood poles and cross arms to remain in service for more than 50 years. Wood poles and cross arms must meet a series of standards to be used by utilities.

There are a number of important reasons for paying attention to service life of wood utility poles. First, utilities want to maximize their capital dollars and longer service life reduces the need for pole replacements (Morrell, 2016). More recently utilities dealing companies, have begun to examine their carbon footprint.

Actual pole service life is a function of many factors including the specification, the quality of treatment, the conditions to which the pole is exposed, and how well the pole is maintained during use. In a single utility, one can look at pole records to estimate service life.

According to German electric power companies, wooden poles should have a minimum service life of 30-35 years (Gellerich Antje *et al*, 1937). (Bowmer .N Trevor, 2021)The average pole life expectancy is around 45 years, but that varies based on location and related climatic factors. The replacement cost of a wood pole varies between urban or rural locations but the average cost is Shs 500,000 including the costs associated with transferring the supply and communications facilities.

An Electric Power Research Institute study suggested that wood poles lasted 50 years. Most utilities assume that their poles provide 30 to 40 years of service life. Which is really true or are they both wrong (Morrell, 2016). According to research carried out by (Gellerich Antje *et al*, 1937) Investigation of 18 utility poles of Scots pine treated with a copper-chromium wood preservative. Service life of Poles from different lower voltage transmission lines in Germany (states Nordrhein-Westfalen and Rheine land-Pfalz), was found to be between 3 and 13 years.

2.3. Wood pole chemical Treatment.

Wood poles are treated with preservative chemicals with the intention of extending the life of wood in service, treatment with preservatives add many decades to the life of a utility pole to enable it safely carry lines and other equipment necessary for electricity distribution and transmission (Butch, 2017).

One of the greatest challenges to protecting wood from the variety of degradative agents which are found in the environment is the length of time that wood must be protected. Unlike the protection of crops or other commodities where protection against pathogens is normally needed only for a relatively short-term period of weeks to months, wood is expected to last for decades without supplemental protection.

To enhance the durability, fire resistance and prolong the service life of wooden poles, wood is often treated with preservatives such as pentachlorophenol (63%), creosote (16%), and copper chrome arsenate (16%) as reported for the United States (Evgenii Sharapov and Christian Brischke, 21 December 2019).

The mechanical properties of treated wood can be affected by the impregnation method, type of preservative, and uniformity of the treatment. Each set of treatment chemicals and processes has a unique effect on the mechanical properties of the treated wood (Madison *et al*, 2010). Both water- and oil-borne wood preservatives are currently used for the treatment of wood utility poles. The use of long-lasting biocides as wood preservatives is often at odds with the development of environmentally friendly protection strategies.

The three major chemical wood preservatives used are pentachlorophenol (penta), creosote, and arsenicals (copper chromium arsenate, or CCA). A fourth, copper naphthenate, is considered an alternative. Creosote is one of the oldest wood preservatives and is widely used for the treatment of piles, poles, and timbers. Creosote is a black or brownish oil made by distilling coal tar obtained after the high temperature carbonization of coal.

Chromated copper arsenate (CCA), or “green-treated” wood, has been widely used since the early 1940s and was the most widely used type of treated wood from the 1970s through the early 2000s. Although the use of CCA was partially restricted in 2004, CCA Type C (CCA-C) continues to be used for the treatment of poles, piles, and heavy timbers. CCA-C has a slightly different ratio of chromium copper arsenic than the earlier formulations (Types A and B) and became the predominant formulation because it was thought to offer the best combination of efficacy and leach resistance.

The preservatives that are used to extend the poles life can be an environmental burden if they leach out of the wood into the water or soil.

Water-borne chemicals have an advantage in that the water carrier is low-cost, safe, and the wood is normally left with a clean surface. Unfortunately, water swells wood and water-borne preservatives are often used for some wood products like large timbers, where dimensional change during treatment cannot be tolerate (Goodell Barry *et al*, 2003).

Wood treated with preservative oils should generally be installed as soon as practicable after treatment to minimize lateral movement of the preservative, but sometimes cleanliness of the surface can be improved by exposing the treated wood to the weather for a limited time before installation (Madison *et al, 2010)*.The potential for deterioration of a wood pole is higher at the ground line or below, where there is more chance of exposure to water and insects. Butt treated poles have treatment in the section that will be buried, extending just above the ground line

In circumstances where one preservative may serve as effectively as another in any particular setting (e.g., the use of penta- or creosote-treated wood poles in hot, dry climates), other variables such as costs, supply and worker acceptability (e.g., utility linemen may prefer working with one treated wood pole over another) are important factors in selecting the type of treated wood used in a particular setting/ area (jerry Zak *et al*, 2005).

CCA-treated poles are specified for locations where a dry, residue-free surface is required. And/or odors are not acceptable, including, for example, in urban areas where sidewalks are common and poles are set through the sidewalk into the ground. In this setting, CCA-treated poles are frequently specified as the best choice because penta- or creosote treated poles sometimes “bleed.” Bleeding causes oily staining at the base of a pole (Lebow and Trippie, 2001).

Use of CCA treated poles is also specified frequently for residential areas, where contact with the wood surface is more likely than in rural areas and where staining/odors may be a concern. In areas with high soil moisture, where the water table is high, or water is perched at a shallow depth, CCA-treated poles are specified over penta- or creosote-treated poles because the CCA preservatives are “fixed,” or chemically bonded within the wood (Lebow and Trippie, 2001) . Proper fixation minimizes the risk of leaching. Long-term subsurface saturation is less likely to deplete the CCA preservatives, shortening service life, and increasing the risk of early pole failure and unplanned electrical outages. CCA-treated poles are also specified in areas that experience occasional freshwater flooding, because the CCA is fixed and thus helps ensure a longer service life. Further, in these “flooding” environments, creosote and penta poles may cause an unacceptable sheen in the water (Lebow and Trippie, 2001).

Creosote may be specified in areas prone to impact loads such as ice and/or wind. From an operational and functional perspective, one of the highest-valued uses of creosote treated wood poles is along coastal areas. Penta-treated poles cannot be used in these environments because salt spray and salt water will hydrolyze the penta, reducing its effectiveness.

Creosote -treated poles also repel salt water better than CCA. Use of creosote treated poles in this environment ensures the reliable and cost-effective delivery of electricity to the public. From an operational perspective, creosote-treated wood poles (along with penta-treated wood poles) are also specified for use by utilities in hot and dry environments, such as utility service areas in southwest Texas, and parts of Arizona and California. Creosote and penta are better choices as preservatives in these environments over CCA because the carrier oils keep the wood "lubricated" and "soft." As such, there is less splitting/cracking/checking than typically occurs with CCA poles in this environment.

Creosote-treated wood poles are often specified in areas of high alkaline soils. In these environments, penta can be converted to sodium penta, which has higher water solubility than creosote. In settings with alkaline soils and the potential for high soil moisture or a high water table, the effectiveness of penta will be reduced, increasing the risk of early failure and unplanned outages. Thus, in these environments, creosote-treated wood is specified for use by many utilities. Creosote-treated poles may have greater flex (due to the "oil" content) than CCA-treated poles, which are dry and stiffer. Creosote may be specified in areas prone to impact loads such as ice and/or wind. In coastal settings, where poles may experience occasional flooding, creosote poles are more effective at preventing marine borer damage (Lebow and Trippie, 2001).

While all of the three preservatives discussed above are designed to prevent decay, the preservatives are not always interchangeable, because decay is not a function of identical decay-causing organisms or environments. In fact, decay-causing conditions and organisms vary depending on the type of wood that is used and the environment the wood is used in. As a result, the three different wood-preservative formulations have evolved to specifically target a variety of organisms, settings, and wood types (jerry Zak *et al*, 2005)

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CHAPTER THREE: MATERIALS AND MATERIALS

3.1. Materials

A. **GPS**.

For taking the coordinates of the utility poles

B. **Safety gears**.

Like gumboots, helmets for per protection during the course of conducting survey activities.

C. Note book and pens.

For note taking, recording the daily activities and findings and provide a platform for reflection on the day's activities and findings**.**

D. Area of study.

In this study, the wood utility poles located in the various communities of Butambala district were inspected according to BS standards and in each study area about 150 utility poles were investigated in terms of the preservative used, visually inspected by nondestructive test methods and the service lives of the poles

3.2. LOCATION:

The survey was conducted in the district of Butambala which is bordered by Gomba District to the west and north-west, Mityana District to the north-east, Mpigi District to the east and south, and Kalungi District to the south-west. The district is located at latitudes of 0° 11' 60.00" N and longitudes of 32° 05' 60.00" E and crossed through the district is Mpigi-Maddu tarmac road.

DIAGRAM SHOWING THE MAP OF BUTAMBALA INDICATING THE STUDY AREA.

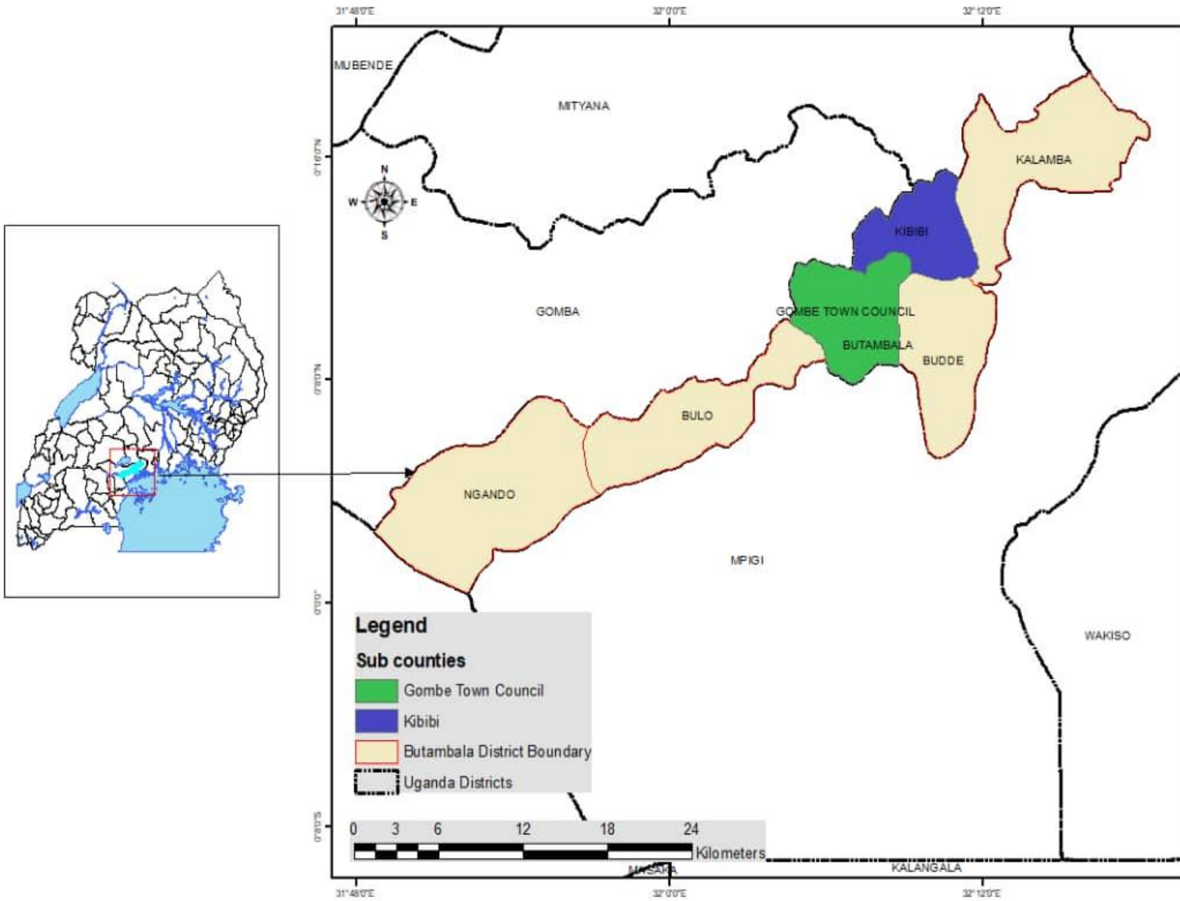


Figure 1 diagram showing the map of Butambala indicating the study area

METHODS

3.4. 0. SAMPLING DESIGN.

3.4.1. Literature review.

Both national and international literature on the utility poles was reviewed to understand the concept of wood utility pole failure .This involved reviewing information available from journeys, articles and e-books on utility poles and any other internationally recognized source.

3.4.2. The supply data

District electricity distribution annual reports for the recent five past years were reviewed to assess the wood utility poles that failed, and the potential causes of the premature failures.

District electricity supply annual reports together with those from electricity distribution companies were reviewed to find the quantity of poles in services in the district, those inspected and those replaced yearly**.**

3.4.3. Visual inspection method.

The utility poles in various villages and sub counties were visually inspected according to AWPA M13-01 [15], a guideline for the physical inspection of poles in service standard method. Poles along the same transmission lines in the district of Butambala were inspected for premature failure, possibility of the utility pole to be maintained and possibility to be replaced and the following information was recorded:

a) Wood species: chemical treatment, age of pole, condition
b) Type of defect and location: External defect; maximum depth of defect and location of the defect

In addition, the pole update condition, and the landscape where they were installed and the climatic and manmade conditions exposed to them were also noted in the field data sheet.

All the data found in the field was collected and compared with that of electricity distribution company database. Deterioration and degradation of wood utility poles.

The conditions to which the various poles are exposed to and the contribution of these conditions to the utility pole failure were put into consideration.

3.4.4. Questionnaire.

Questionnaires were distributed to selected local people especially those living near the utility pole and those who were considered to have better information about the utilities in various communities to obtain their knowledge in regard to causes of utility pole failure in their communities, compare failure to the type of wood preservative used in treating the wood utility poles i.e creosote treated vice CCA treated poles. The failure were compared to the wood preservative used in treating the poles i.e., creosote treated vices CCA treated poles.

The questionnaires were filled within one day and collected on the same day in order to avoid misplacing them by the respondents and this entire activity of distributing and collecting questionnaires took a period of two month to cover all the potential data sources.

3.4.5. Interview guide.

Respondent especially specialists at the district in pole installation and distribution plus the district electricity engineer were interviewed to find out the major cause to pole failure in Butambala district, to ascertain the pole failure in conjunction with the preservative used to treat the installed poles and to find possible solutions to combat the failure causes.

3.4.6. Focused group discussion.

Target group discussions with the utility pole users in communities of not more than ten respondents were conducted to know how many new poles were installed in the area within the community and to know whether the newly installed poles were as a result of pole failure or increased power demand in the community.

In addition to these, focused group discussions with the electricity service providers and pole distributors around the district were conducted to know the quantity of the poles supplied in the region per year for the past five?

3.4.6. Key informants interview guide

In order to collect more accurate information from the various parts of the district about the wood utility pole failure in conjunction to the wood preservative used in treating the poles, key informants especially the district electricity engineers and other experts closer to them were selected and interviewed during the assessment in regard to the questions in the interview guide.

3.5.0. Data source

Both primary and secondary data was collected for this survey. The primary data was gathered using questionnaires, interview guides and visual inspection of utility poles in service. The secondary data was collected by reviewing literature using district annual reports from UMEME.

3.6.0. Data preparation.

Both qualitative and quantitative methods were used to analysis the data. The qualitative data was prepared in three steps;

Data coding. The raw data was coded to ease entry into the SPSS for analysis.

Data validation. The raw data was processed and placed into the entered into the SPSS data base to ease data analysis.

Data editing. Data checking was done to check for outliers and edit the raw research data to identify and clear out any data point that might hamper the accuracy of results.

3.7.0. Data analysis.

Both qualitative and quantitative methods were used to analysis the data. Both descriptive and inferential statistics were used to analyze the data.

The quantitative data were analyzed using both descriptive and inferential methods.

The questionnaires and interview guides were edited, numbered and coded before entering into the computer and was analyzed using SPSS software.

CHAPTER FOUR: RESULTS.

From the results, a total of 90 respondent were interviewed and approximately 49% were males while 51% were females.

Out of the 90 respondents that were interviewed approximately; 34 % of the respondent said wood utility poles in the district prematurely fail, 53% of the respondent said wood utility poles fail sometimes, 2% of the respondent said wood utility poles in Butambala do not prematurely fail while approximately 8% of the respondent were less informed about the wood utility failure as indicated in (table 1 below).

Table 1: Response to whether wood utility poles in Butambala prematurely fail while in service.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	31	34.4	37.3	37.3
	NO	2	2.2	2.4	39.8
	SOMETIMES	48	53.3	57.8	97.6
	DO NOT KNOW	2	2.2	2.4	100.0
	Total	83	92.2	100.0	
Missing	System	7	7.8		
Total		90	100.0		

From table 2,Out of the 90 correspondent that were interviewed, 3% said the minimum service life of installed utility poles is 5 years,23% said it takes 10years,27% said it takes 20years and 38% said it takes 35 years and above for the poles and 9% did not know.

Table 2: Service life of installed poles in Butambala district.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5 YEARS	3	3.3	3.7	3.7
	10 YEARS	21	23.3	25.6	29.3
	20 YEARS	24	26.7	29.3	58.5
	35 YEARS AND ABOVE	34	37.8	41.5	100.0

	Total	82	91.1	100.0	
Missing	System	8	8.9		
Total		90	100.0		

While doing assessment on the period at which utility poles begin to deteriorate after being installed in service, results showed that 14% of the respondent said wood utility poles begin to deteriorate at the age of 1-5 years after being installed in service, 33% of the respondent said they begin deteriorating after 5-10 years, 22% of the respondent it occurs after 10-20years and 20% said it occurs after 30 years and above, 9% out of the respondent did not the exact time period as shown in table 3.

Table 3: Frequencies for the period at which utility poles begin deteriorating after being installed in service.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5 YEARS	13	14.4	16.0	16.0
	5-10 YEARS	30	33.3	37.0	53.1
	10-20 YEARS	20	22.2	24.7	77.8
	30 YEARS AND ABOVE	18	20.0	22.2	100.0
	Total	81	90.0	100.0	
Missing	System	9	10.0		
Total		90	100.0		

From table 4, results showed that the only 20-100 poles have been failing for the past five years and this covers 1%,10% of the respondent said the number of poles which have been failing for the past five years is above 100 poles though were not sure of the exact number, 74% of the respondent were uncertain about the total number of the utility poles which had failed prematurely in the past five years. Only 14% of the respondent had not paid attention about it.

Table 4: Frequencies for number of utility poles which have been failing for the past five years.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20-100 POLES	1	1.1	1.3	1.3
	OTHERS	9	10.0	11.7	13.0
	DO NOT KNOW	67	74.4	87.0	100.0
	Total	77	85.6	100.0	
Missing	System	13	14.4		
Total		90	100.0		

Comparing wood utility pole failure among varying utility poles sizes, it was found out that poles of 9m and 10m often prematurely fail compared to corresponding poles of sizes of 12m and 14m respectively as indicated by the pie chart below.

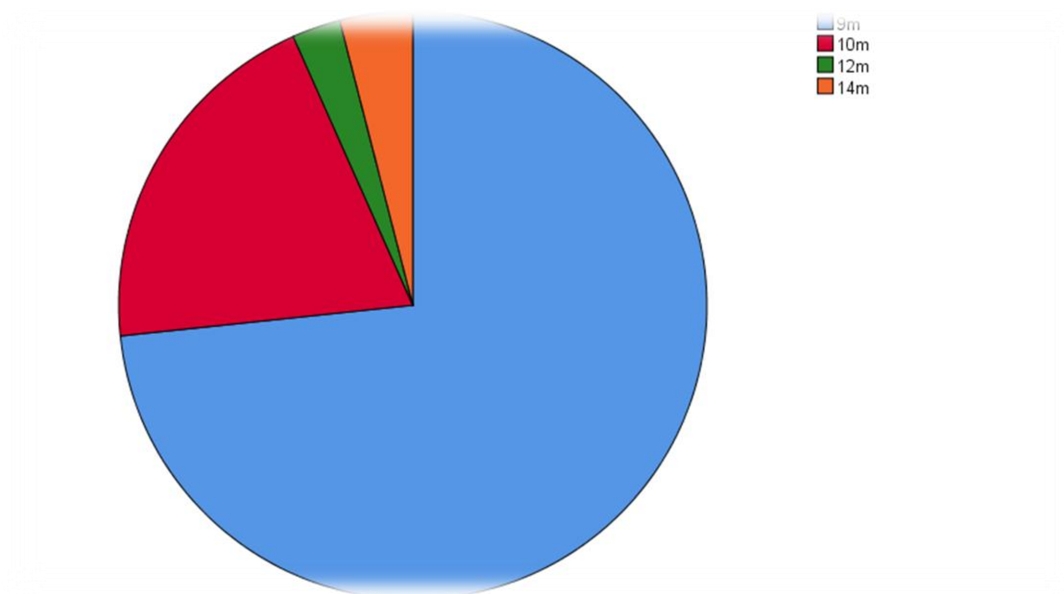


Figure 2 showing comparison of treated utility poles in Butambala.

Assessment of wood utility pole failure on the basis of termite infestation, indicated that, Out of the 90 respondent that were interviewed, 65.6% said wood utility poles deterioration is as a result of termite attack as shown in figure 1, 26.7% said termites do not attack treated poles while 7.8% were not sure as shown in the frequency **table 5.**

Table 5: Assessment of wood utility failure as a result of termite attack.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	TRUE	59	65.6	71.1	71.1
	FALSE	24	26.7	28.9	100.0
	Total	83	92.2	100.0	
Missing	System	7	7.8		
Total		90	100.0		

Figure 3: Wood utility pole in service infested by termites.

Figure 2, shows that wood poles fail as a result of decay and this contributes 84% of the pole failure as shown in table 6, approximately 8 % of the respondents disagreed with this as being the cause of utility pole failure while approximately 8% of the respondent were unaware about deterioration of the utility poles by rotting.

TABLE 6: ASSESSMENT OF WOOD UTILITY POLES FAILURE AS A RESULT OF DECAY.

		Frequency	Percent	Valid Percent	Cumulative Percent

Valid	TRUE	76	84.4	91.6	91.6
	FALSE	7	7.8	8.4	100.0
	Total	83	92.2	100.0	
Missing	System	7	7.8		
Total		90	100.0		

Figure 4: Utility pole that was replaced due to a hollow inside caused by decay

Findings indicated that wood utility poles also fail in the area due to knocking down by the speeding vehicles more especially along the main road, this cause is contributes 21% of the respondent said, 67% of the respondent said it does not occur while 12% of the respondent had never seen any utility pole being knocked down by speeding vehicles as shown in **(table 7).**

Table 7: Assessment of wood utility failure as a result of being knocked down by speeding vehicles along the main road.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	TRUE	19	21.1	24.1	24.1
	FALSE	60	66.7	75.9	100.0
	Total	79	87.8	100.0	
Missing	System	11	12.2		
Total		90	100.0		

Results in table 8 indicate that, 43% of the respondent reported that wood utility poles failure in their communities is caused by bacterial attack, 47% said bacterial decay to utility poles is not often, while 10% of the respondent had no knowledge about this.

Table 8: Assessment of wood utility poles deterioration as a result of bacteria attack.

	Frequency	Percen t	Valid Percent	Cumulative Percent	
Valid	TRUE	39	43.3	48.1	48.1
	FALSE	42	46.7	51.9	100.0
	Total	81	90.0	100.0	
Missing	System	9	10.0		
Total	90	100.0			

From table 9, results indicated that, 74% of the respondent said wood utility poles fail due to aging of the pole as shown in **figure 3**, 14% said poles rarely fail prematurely as a result of aging while 11% of the respondent had no knowledge about pole failure as a result of aging.

Table 9: study of wood utility poles failure as a result of aging.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	TRUE	67	74.4	83.8	83.8
	FALSE	13	14.4	16.3	100.0
	Total	80	88.9	100.0	
Missing	System	10	11.1		
Total		90	100.0		

Figure 5: Aged utility pole in service.

From the frequency table 10, 26 of the respondents said it is true that wood utility poles prematurely fail as a result of splitting and cracking and aging contributes approximately 29% to utility pole failure that occurs in the region as indicated by the utility pole in figure 4, 50% of the respondent said premature failure of wood utility poles caused by other factor except splits and cracks while 21% of the respondent had no idea about this.

Table 10: Frequencies of wood utility pole failure due to splitting and cracking.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	TRUE	26	28.9	36.6	36.6
	FALSE	45	50.0	63.4	100.0
	Total	71	78.9	100.0	
Missing	System	19	21.1		
Total		90	100.0		

Figure 6: CCA treated pole with simple splits beside is the other CCA treated pole cut by locals as a result of power demonstration storage.

From figure 5 shows that wood pecker bird cause wood utility deterioration and this contributes only 73% to premature wood utility failure as reported by the respondent, 13 of the respondents said wood peckers have negligible effect on utility poles as indicated by approximately 14% of the respondents, while only 12% of the respondent were less informed about this as shown in table 11.

Table 11: wood pecker birds cause wood utility pole deterioration.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	TRUE	66	73.3	83.5	83.5
	FALSE	13	14.4	16.5	100.0
	Total	79	87.8	100.0	

Missing	System	11	12.2		
Total		90	100.0		

Figure 7: A hole drilled in a wood utility pole by wood pecker birds.

Table 12 results indicated, approximately 69% of the respondent said that moisture absorption by wood utility poles brings about their premature failure while in service, approximately 19% of the respondent said premature failure is not as a result of moisture absorption but by other factors, while 12% of the respondent were less informed about this.

Table 12: Frequencies on wood utility poles failure as a result of water moisture absorption.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	TRUE	62	68.9	78.5	78.5
	FALSE	17	18.9	21.5	100.0
	Total	79	87.8	100.0	
Missing	System	11	12.2		
Total		90	100.0		

24% the respondent said activities especially agriculture activities carried out along transmission line also utility poles as shown in **figure 8,** 12% of the respondent were not aware of agricultural activities which can affect wood utility poles to failure cause wood utility pole failure, 63% of the respondent said agricultural activities have no effect on wood as shown in table 13.

Table 13: Human activities like agriculture, bush burning, induce pole failure.

T		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	TRUE	22	24.4	27.8	27.8
	FALSE	57	63.3	72.2	100.0
	Total	79	87.8	100.0	
Missing	System	11	12.2		
Total		90	100.0		

Figure 8: Agricultural activities carried out near utility poles

83% of the respondent said wood utility poles in the lowland fail often compared to those in high land, 10% of the respondent said they fail often while 7% of the respondent were unaware as shown in table 14.

		Frequency	Percent	Valid Percent
Valid	TRUE	75	83.3	89.3
	FALSE	9	10.0	10.7
	Total	84	93.3	100.0
Missing	System	6	6.7	
Total		90	100.0	

22% of the respondent said wood utility poles deteriorate in their early stage after installation, 53% of the respondent said wood utility poles don't immediately fail after installation while 24% of the respondent were less informed as shown in table 15.

		Frequency	Percent	Valid Percent
Valid	TRUE	20	22.2	29.4
	FALSE	48	53.3	70.6
	Total	68	75.6	100.0
Missing	System	22	24.4	
Total		90	100.0	

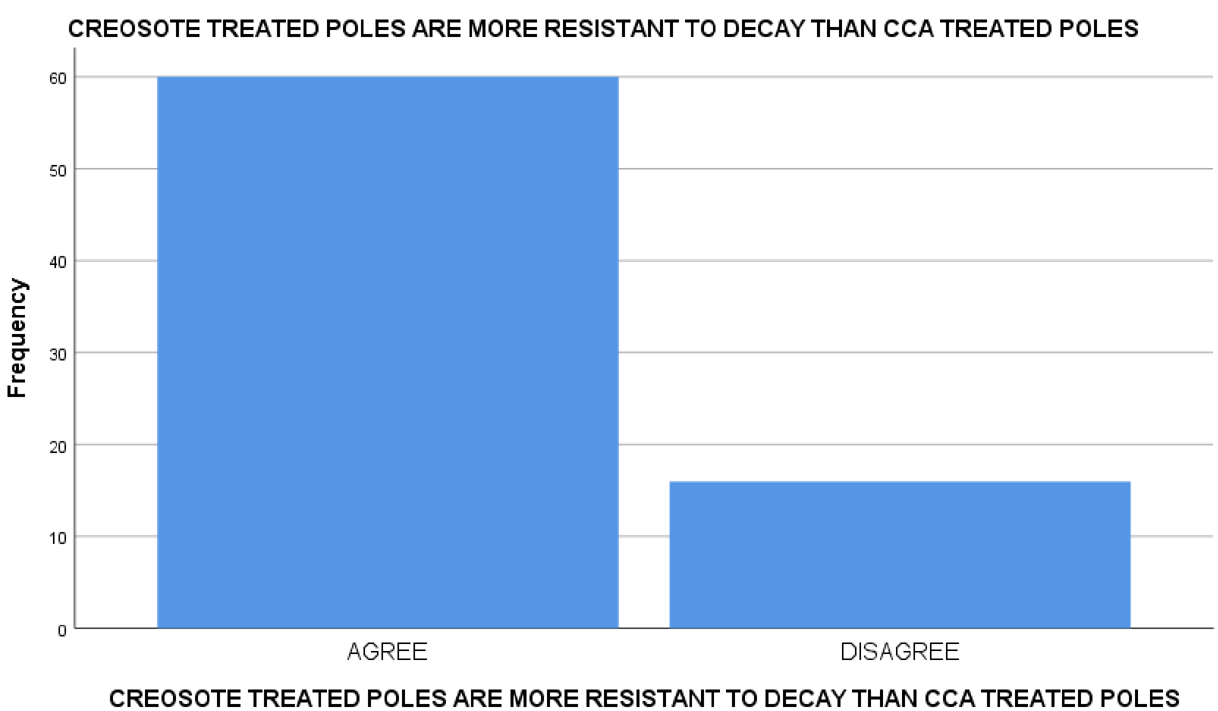
From the frequency table 16, 67% of the correspondent said creosote treated poles are more resistant to deterioration compared to CCA treated pole as shown in **figure 9**, 18% of the correspondent said CCA treated pole are more resistant compared to Creosote treated poles as indicated by **figure 10**, while 16% of the respondent were not sure.

Table 16: Creosote treated poles are more resistant to decay than CCA treated poles.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	AGREE	60	66.7	78.9	78.9
	DISAGREE	16	17.8	21.1	100.0
	Total	76	84.4	100.0	
Missing	System	14	15.6		
Total		90	100.0		

Figure 9: creosote treated poles which has stayed for over 30 years but still in good serving condition.

Figure 10: CCA treated poles in good serving condition.



From the frequency table 17, results indicated that 67 % of the creosote treated poles are more resistant to deterioration than CCA treated poles as reported by the respondent, 18% of CCA treated poles are more resistant to failure than creosote treated poles as said by the respondent while 16% of pole failure is not associated with either creosote treatment or CCA treatment.

Table 17: comparison of resistance of between creosote treated poles and CCA treated poles to deterioration.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	AGREE	60	66.7	78.9	78.9
	DISAGREE	16	17.8	21.1	100.0
	Total	76	84.4	100.0	
Missing	System	14	15.6		
Total		90	100.0		

According to the pie chart below it was noted that, there are both CCA and creosote treated poles in service in Butambala district but most of the poles in service are creosote treated compared to CCA treated poles.

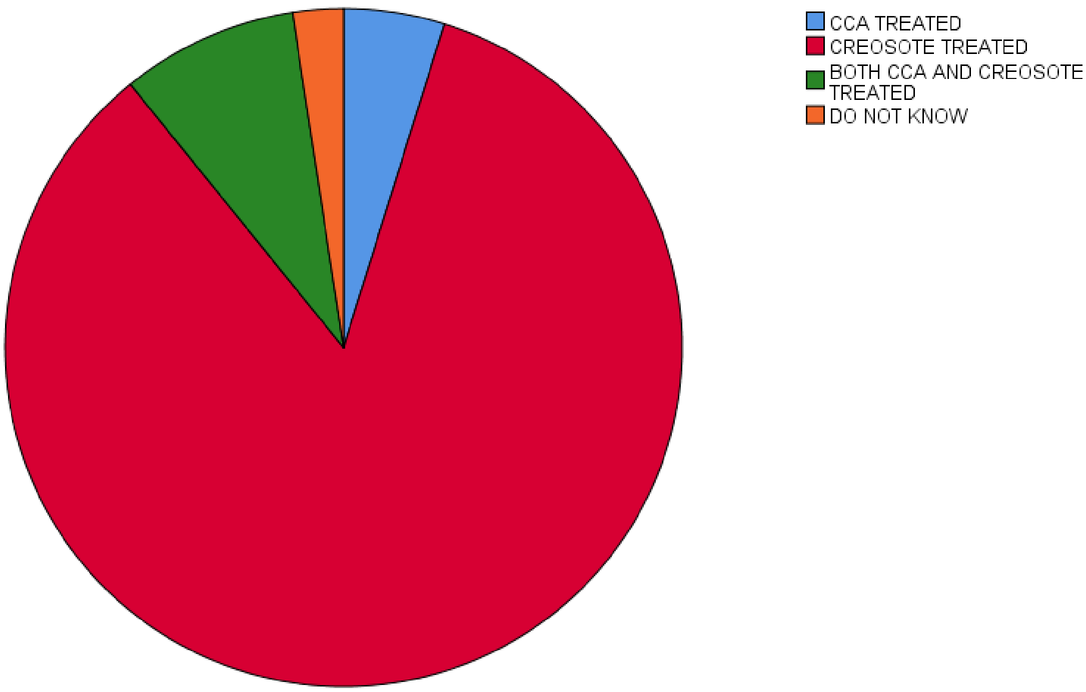


Figure 11: comparison of creosote treated and CCA treated poles

From table 18, a total of 200 utility poles were visually inspected to compare the failures between creosote treated and CCA treated utility poles and out of 200 poles inspected, 120 were creosote treated and only 80 were CCA treated, 25 of the creosote treated needed replacement or maintenance while 33 of the CCA treated need replacement or maintenance. Failure was compared depending on the levels of insect infestation, splits and cracks, age, decay, bacterial infestation, wood pecker activities and fires.

Table 17: Number of utility poles visually investigated with reference to insect infestation, splits and cracks, age, decay, fires.

	Average number of poles surveyed	Number of poles which needed replacement/maintenance	Number of poles in good condition
Creosote treated	120	25	95
CCA treated	80	33	47
Total	**200**		

From table 19, it was found out that approximately; 15% of the respondent said local people need to dig around the utility pole in the efforts to minimize premature utility pole failure, 27% said local people need to timely inform concerned authorities like UMEME in case of a failed utility pole in service, 8% of the respondent said community members need to participate in termite control to limit deterioration of utilities by termites

Approximately 15% of the respondent said planting of trees and crops near and along transmission lines should be avoided by inhabitants and 10% of the respondent said bush burning near utility poles must be controlled.

From the interview of the key informants, 80.5% of the respondent said continuous pole inspection, pole maintenance and replacement of poles should be done as a way of solving premature wood utility poles. These were all males. The females were represented by 19.5% of the total number of respondents agreed with the above solutions.

Table 18: Frequencies of local people to combating wood utility pole failure.

		Responses		Percent
		N	Percent	of Cases
solution to the problem [a]	GENDER	44	25.6%	50.6%
	ACTIONS			
	Digging around poles	25	14.5%	28.7%
	Informing concerned authorities	46	26.7%	52.9%
	Termite control	15	8.7%	17.2%
	Avoid planting crops near utility poles	25	14.5%	28.7%
	Bush burning control near poles	17	9.9%	19.5%

Total	172	100.0%	197.7%

a. Dichotomy group tabulated at value 1.

Results in table 20 indicate that approximately 19% of the respondent said that in order to minimize premature wood utility pole failure, district electricity department need to; conduct pole inspection on a regular basis, 14% of the respondent said strict laws and regulation in regard to human miss conduct towards the utility poles must be put in place and enforced, 8% said obstacles like tree branches and thick vegetation must be cleared off the transmission line by the district agents.

Approximately 15% said the district electricity department need to create sound working relationship with the community members for easy share updates concerning utility poles condition in their villages and 11% of the respondent said that in case of deteriorating utilities the district electricity department must make efforts to ensure that the failed ones are replaced by the new utility poles.

Table 19: **Frequencies for percentage action contributions of district agents to combating wood utility pole failure.**

		Responses	
		N	Percent
Solutions to the premature failure by district [a]	GENDER	44	33.8%
	ACTIONS		
	Pole inspection	24	18.5%
	laws and regulations	18	13.8%
	Clearing obstacles	10	7.7%
	Work relationship with locals	20	15.4%
	Replacing aged poles	14	10.8%
Total		130	100.0%

According to results in table 21, it was found out that approximately; 5% of the respondent said in order to minimize utility poles failure, electricity distribution agencies need to install utility poles in deep holes, 30% said properly treated poles should be installed by the distribution agencies, 7% said poles need to be protected with ant split plates and 3% said utility poles need to be installed at a proper distance from the main road.

Approximately; 13% said continuous pole inspection must be conducted, 9% of the respondents said whenever pole deterioration happens, replacement of a failed utility pole with a new one must be done, 7% said mature poles should be used for utilities and 5% said pole savers will help reduce on premature pole failure.

Table 20: Frequencies for efforts of electricity distribution agencies to combating wood utility pole failure.

		Responses	
		N	Percent
Solutions to minimize premature failure [a]	ACTION	44	21.5%
	installing poles in deep holes	10	4.9%
	installing properly treated poles	62	30.2%
	protecting poles with ant split plates	15	7.3%
	proper distance from main road	6	2.9%
	Pole inspection.	26	12.7%
	pole replacement	18	8.8%
	using mature poles	14	6.8%
	.using pole savers	10	4.9%
Total		205	100.0%

Figure 11: Utility pole reinforced with barbed wire to minimize further splitting and cracking of the utility pole.

CHAPTER FIVE: DISCUSSION OF THE RESULTS.

5.1. Discussion of the results:

5.1.1. Premature wood utility poles failure.

From table 1, it was noted that a total of 90 respondent were interviewed and approximately 49% were males and approximately 51% were females.

Out of the 90 respondents that were interviewed approximately 34 % of the respondent reported that wood utility poles in the district prematurely fail which was evidenced by falling of the utility poles within a short period of time after their installation in service and this is attributed to a number of factors ranging from the maturity of the utility pole used, quality and depth of impregnation of the utility poles with preservatives, wood structure and climatic conditions exposed to the wood utility poles which enhances decay of the poles resulting into faster deterioration as it was reported by (Gezer et al., 2015). From the pie chart above it was found out that poles of 9m and 10m often prematurely fail compared to corresponding poles of 12m and 14m. this is because small size poles have a large sap wood compared to heart wood, sap wood always permits the entry of moisture easily and can easily be attacked by termites and others degraders.

on the other hand large sized poles have a large heart wood compared to sapwood, heartwood resistant to fluid penetration due to absence of void spaces in the wood structure to permit easily moisture entrance, never the less large mature sized poles due to a narrow sapwood layer normally have a narrow preservative penetration depth and retention compared to poles with large sapwood layer this makes them prune to deterioration by the degradation agent this is in line with what (Mugabi & Thembo, 2018) found out.

5.1.2. Minimum service life of wood utility poles in Butambala district.

As indicated by results in table 1, approximately 53% of the respondent reported that wood utility poles fail sometimes after a certain minimum time after their installation in service. Wood as a natural material has a high fibre density depending on the species which makes it stronger and resistant to various loads applied on it, this enables it to reach a certain rapturing stress at the minimum service life, approximately 2% of the respondent said wood utility poles in Butambala do not prematurely fail while approximately 8% of the respondent were less informed about the wood utility failure.

From the comparison of result from table 2, table 3 and key informant interview, it can be noted that the minimum service life of utility poles in Butambala district is 30 years. This was approximated from the responses obtained from field inspection and out of the 90 correspondent that were interviewed as indicated in table 2 and table 3 respectively.

5.1.3. Causes of wood utility pole failure.

Termite infestation. Termites cause profound damage to wood utility poles as indicated by fig 1 and table 5 it was found that out of 90 respondents, 65.6% said wood utility poles deterioration is as a result of termite attack, 26.7% said termites do not attack treated poles while 7.8% were not sure. Most of the respondent agreed that termites cause profound damage to the wood utility poles which is true because termites' mostly subterranean termites pose a significant threat to wooden utility poles especially untreated poles while on the other hand termites don't like eating preservative treated wood as noted by. Wood utility poles also are found of failing because of aging.

Wood being a biodegradable material, dimensionally unstable and hygroscopic in nature as time passes by while in service and having been exposed to various condition has a tendency to fail. This explains as to why74% of the respondent interviewed said wood utility poles fail as a result of pole aging, 14% said poles rarely fail prematurely as a result of aging while 11% of the respondent had no knowledge about pole failure as a result of aging.

From the table 12 approximately 69% of the respondent said that moisture absorption by wood utility poles brings about their premature failure while in service, approximately 19% of the respondent said premature failure is not as a result of moisture absorption but by other factors, while 12% of the respondent were less informed about this.

For wood decay to occur a moisture content greater than 25% is necessary. On a standard pole, the moisture content of the core close to ground level will be relatively high and typically well above the 25% threshold at which decay can start to occur if the moisture content is higher, then the rate of decay generally increases up to a point all else being equal. Once wood decay starts then it can continue at a lower moisture content of 20%, below this level wood decay does not occur.

Pole saver Sleeves are proven to maintain the pole's strength over time. Pole saver sleeves are non-toxic, composite barrier sleeves, they feature a dual layer construction with an outer thermoplastic sleeve and an inner, melt able bituminous liner. Upon heating, the liner melts and the outer sleeve shrinks down tightly onto the pole to create a tough air and watertight seal to the pole surface. This seal permanently excludes all the factors necessary for wood decay to occur, whilst preventing loss of wood preservative. Pole saver makes conventional ground line decay impossible.

Ground line decay means that typical wooden pole loses strength over time and once below the 50% strength threshold; pole replacement will be required.

Pole saver Sleeves make conventional ground line decay impossible, thus ensuring that pole strength is maintained over time.

Decay

Results in table it was found out that 84% of the correspondent said wood utility poles fail prematurely as a result of decay, approximately 8 % disagreed while approximately 8% of the correspondent did not know. This study indicates 84% of pole failure in Butambala region is as a result of decay and basing on the respondent's contribution and visual inspection of the poles in the field, it cannot be denied that poles in Butambala greatly prematurely fail as a result of decay which is brought about by a number of factors.

As a natural material, wood is susceptible to decay over time due to fungal attack. according to (Christodoulou C.A *et al,* 2010), Decaying takes place mainly in the ground level zone, where moisture content, fungi, bacteria, and pollutants may penetrate inside the pole through the natural cracks in the wood or through the passages created by insects.

The rate of decay is site- and material-specific and affected by factors such as wood specie, climatic conditions (temperature, rainfall, and humidity), soil properties, initial preservative treatment, and nature of the fungal attack. The main climate parameters that affect the decay of wood are humidity and temperature (wang and wang , 2012). High average temperature combined with damp ground conditions and regular rainfall create the ideal conditions for wood decay.

Wooden poles are vulnerable to decay at its base where it contacts the soil. Due to abundance of moisture and access to oxygen in the soil, fungal growth and the insect infestation from surrounding areas occur leading to the decrease of the strength of the cross-section of the utility pole. The decay of wood poles can significantly impact their ability to resist weather-related loads, such as strong winds(Salman *et al*., 2020).therefore decayed utility pole require replacement with new ones of the same kind.

Wood peckers.

Premature wood utility pole failure in Butambala district is also caused by wood peckers as indicated by figure 5 and table 11, table 11 as per respondents knowledge indicates, 73% of pole failure in the region is as a result of wood pecker birds activities i.e. in establishing their shelter and food searching, 14% indicates wood pole failure as a result of wood pecker bird is rare, while only 12% of the respondent are unaware about wood utility poles failure as a result of wood pecker activities.

Wood pecker birds often drill holes in the wood pole in search for food and establishment of their shelter, these woodpecker holes often expose wood utility poles to moisture and the spores of fungi resulting into decay that weakens the pole far more than the holes themselves this corresponds with what (Gezer *et al*.,

2015) noted . In most cases one woodpecker can select a pole by chance and drill the first hole which invites further attack by other woodpeckers. In addition to wood pecker damage, some people also drill holes in the wood utility poles when nailing posters on to the wood pole as evidenced in the visual inspection which invite other degraders after these posters are removed.

Split and cracks.

Another cause of wood utility pole failure that was found out for the installed poles in Butambala district is Splits and cracks as indicated by respondents percent response towards it From table 10 which indicated 28% of the respondent said it is true that wood utility poles prematurely fail as a result of splitting and cracking, this is because splits and cracks exposes the wood utility poles to further degradation by creating a water entry points, and lines of weakness which termites, wood peckers can use to cause further deterioration,50% of the respondent said premature failure of wood utility poles is not caused by splitting and cracking this was true especially where the splits and cracks are simple and false if they are severe.

Although utility poles were treated with wood preservatives, because of these deep cracks and splits, fungi mycelium and insects easily get into the interior location of the utility poles where the penetration depth of wood preservative is limited. In addition, these deep cracks and splits could affect mechanical and strength properties of utilities which might cause failure of utility poles. Therefore, it is important to detect the defects inside the utility poles. Filling the splits and cracks with fillers as a maintenance practice can help prolong the service life of the wood utility poles while in service, 21% of the respondent had no idea about this.

Agricultural activities.

Agricultural activities carried out by the local people along electricity transmission lines bring about premature failure of wood utility poles, this cause contributes 24% to utility pole failure as found out from the respondent as shown in table 13. A number of agricultural related activities like tree planting, crop cultivation near the utilities poles were suggested to pioneer premature failure of utilities especially when trees fall against the utility poles during rainy seasons and tree harvesting by the owners, severe cuts made on the utility poles by careless locals do also contribute greatly to premature wood utility pole failure as it exposes the pole to utility pole degraders , this is in line with what was noted according to (Gezer *et al.*, 2015).

On the other hand, 63% of the respondent said agricultural activities have no effect on wood utility poles and if it occurs it is to a lesser extent because they claim that according to the energy law, people are not allowed to do any activity along the transmission line though most people break these laws. 12% of the respondent were not aware of agricultural activities which can bring about utility pole failure.

Wild and man induced fires.

From the visual inspection of poles, a few fire-damaged poles were observed in the study areas in particular poles located out of the residential areas suffered from this damage and It was thought that cattle keepers or some farmers made fire at the bottom of the utility poles in order to burn bush for grass regeneration for their animals or clearing agriculture residues, a similar occurrence was found out by (Gezer *et al*., 2015) during their study survey and they noted that, fire at the bottom of the utility poles, outer zones of utility poles near ground line are more sensitive for fungi and insects attack making them prune to further deterioration damages that shorten their service life.

So, Care should be taken in burning bushes and agricultural residues especially along the electricity transmission line, if not wood utility poles are likely to continue failing in various parts of the district in regard to such causal nature.

Waterlogging.

From the investigation while conducting visual inspection of the utility poles in service it was found out that some of the electricity transmission line pass-through water-logged areas while others on the dry land. Installation area has got a serious impact on the service life of installed wood utility poles more especially water-logged areas which contribute to their failure or dry areas which prolongs their service life.

Water logged areas contribute 83% of wood utility pole failure in Butambala as indicated by the respondent in table 14 who reported that wood poles in the lowland fail often due to accelerated pole decay by moisture absorption factor compared to those in high land, although a number of utility poles in the region which were installed in service approximately 20% of the utility poles are estimated to have stayed in service for over 25 years and above, only 10% of the wood poles installed in water logged areas serve for a long period of time before their deterioration.

This is attributed to mounding of the pole area with murram soils during their installation, pole maturity because as indicated by (Forest Service & Products Laboratory, 2010), a mature utility pole has large heartwood than sapwood, heart wood usually has no pores hence prohibits fluid penetration while sapwood contains numerous pore which permit easily moisture entry into the wood core ceteris pelibus.

Only 7% of failure of poles installed in water logged areas is unknown.

5.1.4. Comparison of the premature wood failure with the preservative used to treat the poles.

From the pie chart it was found out that there are both CCA and creosote treated poles in service in Butambala district but most of the poles in service are creosote treated compared to CCA treated poles, most of the creosote treated poles were installed in U.E.B time during which creosote treated poles were the most popular.

Results in table 16 and from visually inspection conducted, creosote treated poles were found to be more resistant to deterioration compared to CCA treated poles in Butambala district, resistance of creosote treated poles to deterioration is measured by 67% of the respondent feedback whereas the resistance of CCA treated poles is measured by 18% of the respondent feedback who said CCA treated poles are more resistance.16% of the respondent were not sure.

Resistance of creosote treated poles are resistant was affiliated to strong unpleasant smell of creosote which repels degraders like termites, wood species, pole chemical penetration and retention depth while the unsatisfying resistance of the CCA was affiliated to the chemical quality and treatment standards. this is not in agreement with what (Structures & Raton, 2007)found out.

According to the study conducted by(Structures & Raton, 2007), it was found out that CCA-treated wood had a higher ultimate strength than the creosote-treated wood by as much as 63% in average. CCA-treated poles are specified for locations where a dry, residue-free surface is required and if are installed in water logged areas decay is likely to happen in the early stages after their installation. The CCA-treated wood poles provided superior resistance to organism attack, as indicated by the results of the ASTM ratings, as well as lower moisture content and higher specific gravity.

Table 15 results shows that wood utility poles can fail in the early stages of their installation or may serve a much longer period. As indicated in table 15, 22% of the respondent said wood utility poles deteriorate in their early stages after installation which can be true especially were there was zero impregnation of the utility poles with preservatives, usage of immature wood poles followed by moisture absorption, termite infestation and decay or false if the former were conducted to standards as indicated by 53% of the respondent feedback who said wood utility poles don't immediately fail after installation utility poles can serve a much longer period before their failure. 24% of the respondent were less informed.

CCA treated poles have been seen deteriorating within a period of six years and less within the district and most of the poles that failed are 9m and 12 m size.

5.1.5. Solution to the problem.

The local people of Butambala district need to join efforts in solving premature wood utility pole failure by doing the following measures as per the table 18 above;

Digging around pole. Local people especially those residing near and those having utility poles in their gardens should dig around the utility poles to remove obstacles that can contained in the pole area. This will contribute 14.5% to minimize wood pole failure as shown in table 18.

Informing concerned authorities in case of failure. In efforts to minimize wood utility pole failure, local people need to timely inform concerned authorities like the district and electricity transmission and distribution agencies in case of any pole failure signs such that pole maintenance may be timely done to prolong pole service life. This will contribute 26% to solving premature wood utility pole failure in the area.

Termite control, local people especially those residing near the wood utility poles must kill the ant hills to deal with ants and termite attack that attack these utilities. Doing this will contribute 8.7% efforts in solving premature wood utility pole failure.

Agricultural reforms.

Avoid planting, crops trees and grazing near electric transmission lines. Agricultural activities also are found of contributing to wood utility poles therefore local people need to join efforts in minimizing these dangerous activities to wood utility poles by avoiding planting trees, grazing animals and planting other crops near wood utility pole and this is able to contribute 14.5% premature utility pole failure.

Bush burning control near utility poles. Bush burning often exposes the utility poles to further damages and weakness the wood tensile and rapturing strength, the local people need to minimize bushing burning around utility poles which is able to contribute approximately 9.9 % efforts in solving wood utility premature failure in service. Provisions should be put in place to fine a local found burning bush near the utility pole to control further dangers.

According to the assessment study, as indicated by table 20, the following efforts should be carried out by the district electricity department to minimize premature wood utility pole failure;

Continuous pole inspection. from table 20 18.5% of the respondent suggested that district department needs to conduct continuously field inspection to find out the conditions of the utility poles which is vital for further decision of replacement and maintenance of the poles in service. This is needed to ensure timely maintenance and replacement of utility poles which helps in reducing the costs which can be incurred after deterioration worsens.

Putting strict laws and regulations in regard to utility poles. From table 20, approximately 13.8% of the respondent suggested that the district electricity department and rural electrification agencies need to put in place strict laws and regulations to help minimize human activities that expose the installed wood utility poles to further failure and early deterioration.

Electricity transmission lines cleared of obstacles. The district department needs to work hand in hand with locals or pay workers to clear off obstacles like tree branches which extend towards the utility poles, bushes and thickets. This is able to contribute 7.7% solution to premature utility pole failure as suggested by approximately 7.7% of the respondent.

Good working relationship with local people. There is a need for the district electricity department to be in good terms and work with local people to foster information flow about utility pole failure in various villages in the area. Official contacts should be availed to local to ensure they easily notify the department about pole conditions in the field where they are not. This will contribute approximately 15% to solving utility pole failure challenges as suggested by 20 respondents.

Ensure that aged utility poles are replaced. Many aged utility poles which need replacement were encountered in service during visual inspection in the field and are in a worse condition yet they are not yet replace which are likely to cause accidents. The district needs to work hand in hand with the electricity transmission agencies to see that they are replaced. This will contribute 10.8% to solving premature wood pole failure since the falling of these aged poles cause a sage and a pulling in the transmission line which is able to cause weaken other utility poles on along the transmission line.

Electricity distribution agencies

From table 21 the following solutions to minimize wood utility poles are made;

Installing poles in deep holes. 4.9% of the respondent suggested minimization of premature wood utility failure can be done by installing utility poles in deep holes of 2m or 9 feet. The respondent claimed that now days, shallow holes are used for pole installation in service of less than 9 feet which gives the poles less support to withstand wind loads hence easily fall . Installation of utility poles to deep holes provide enough anchorage to the pole which enables it to withstand all forces applied to the utility pole, this is in line with what suggested.

Installing properly treated utility poles. 30.2% of the respondent suggested that wood utility poles should be properly treated with preservative before their installation in service.(Lebow *et al., 2012)* noted that treatment of utility poles with preservative has ability to extend the pole service life.as treatment of wood utility poles to standard preservative penetration depth and retention is reported by(Mugabi & Thembo, 2018) chances will still remain high to be prone to deterioration, unless they are properly treated to standard chemical penetration and retention depth before their use in service.

Protecting poles with ant splits. 7.7% of the respondent suggested that wood utility poles need to be tagged with ant split plates especially at the pole top end, this helps to reduce water entry into the inner wood layers which induces faster decay.

Installing poles at a given distance from main road. From table, it was found out premature wood pole failure occurs but a small extent and hence this risk needs to be addressed through installation of the utility poles to a distance of at least four meters from the main road. This was suggested by 2.9% of the respondent from table 20. Along the main road motor accidents often occur and sometimes vehicles knock down some roadside utility poles which result into their bending or falling depending on the forces applied to the pole in from the vehicle crushing. Similar occurrences of these wood failure accidents were reported by

Inspecting poles in service. 12.8% of the respondent suggested that electricity transmission and distribution agencies need to conduct field inspection of the installed utility poles continuously to study their conditions and to deal with them accordingly. This helps to cope With the costs of replacing poles by fostering pole maintenance to extend the service life favorably (Bureau, 2013) hence inspection of utility poles can pay dividends by extending the serviceable life of the poles. (Christodoulou & Fotis, 2010) suggested that wood utility inspection should be done at least after a period of four years.

Replacement of failed utility poles

(Merschman Eric *et al*, 2020), noted that, NESC recommends the replacement of wood poles once they reach two-thirds of their initial strength due to decay. Rather than replacing the poles outright, it is possible to reinforce the base of the poles with FRP to restore some of the lost strength.

The repair is beneficial if the cost of applying the repair can overcome the costs of replacing the poles when adjusted for labor, materials, and interruption to network performance. If the maintenance cost is high compared to the cost of replacement and the deterioration is severe then pole replacement is of great importance to ensure pole service life.

Using mature poles. From table 20, 6.8% of the respondent suggested that mature wood utility poles need to be used to serve as utility poles. Mature wood utility poles depending on the wood species have a high wood density, high mechanical properties and high heart wood to sapwood ratios as according to(Forest Service & Products Laboratory, 2010) .these provide ability to the wood utility pole to withstand flexural forces and loads and various climate variations that are exposed to the wood utility while in service extending there service life.

Using pole savers. From the table, 4.9% of the respondent suggest the use of pole saver sleeves to control moisture absorption from the ground by the utility poles. Pole saver sleeves are non-toxic, composite barrier sleeves, they feature a dual layer construction with an outer thermoplastic sleeve and an inner, melt able bituminous liner.

Upon heating, the liner melts and the outer sleeve shrinks down tightly onto the pole to create a tough air and watertight seal to the pole surface. This seal permanently excludes all the factors necessary for wood decay to occur, whilst preventing loss of wood preservative

Pole saver Sleeves are proven to maintain the pole's strength over time by making conventional ground line decay impossible, thus ensuring that pole strength is maintained over time.

Others.

Using hole plugs. As a way of minimizing wood pole failure by wood peckers holes plugs should be used to cover the holes. Various materials are available for plugging the holes such as wire mesh and can be used to cover the pluggable holes as well as large areas of a pole. as a preventative measure, wire mesh can be applied to poles in areas where woodpecker activity is expected as it was noted by (Bureau, 2013)

Pole Reinforcement. Pole reinforcement need to be carried out to a deteriorated pole at the ground line. pole reinforcement system supplier for design and installation support which would prevent the line from being taken out of service at the time when the pole may be in danger of failing.

Using fire retardant chemical. The agencies need to apply fire retardant chemicals in villages where pastoral work is conducted to reduce fire attack to wood utility poles.

CHAPTER SIX: CONCLUSION AND RECOMMENDATION.

5.1. Conclusion.

- Wood utility poles in Butambala district often prematurely failure while in service and the minimum service life of erected wood utility poles is 30 years.
- It is very important to increase service lifetime of wood utility poles by treatment with preservatives because of the costs associated with their replacement and environmental concerns. Out of service poles are considered hazardous wastes which must be adequately disposed for recycled.
- The results showed that the most important factors/ reasons for the short service life of utility poles were; the decay due to fungi, insect infestation, inadequate impregnation, insufficient preservative penetration depth, the deep cracks and splits, road accidents, agricultural activities carried out near the utility poles, no inspection and lack of remedial treatments.
- Small wood utility poles especially of size 9m were decay often in Butambala compared to large utility poles.
- Butambala district is dominated by creosote treated poles and were found to serve for quit longer period compared to CCA treated poles. Pending on the soils of Butambala district, CCA treated poles decay often in the region and tend to appear as if untreated.
- Poles exposed to high decay hazard need to be treated to a high preservative penetration and retention depth.
- In order to minimize premature wood utility pole failure in Butambala district continuous pole inspection, use of mature treated poles, use of pole saver sleeves, application of ant split plates on utility poles, change of local people’s agricultural behaviors must be done and good working relationship among locals, district electricity board and electricity transmission agencies must be fostered.

5.2. Recommendation.

- I recommend the power distribution companies to cover the bottom end of the wooden utility poles with pole saver sleeves to minimize moisture absorption which is the starting point for the decay organisms to invade the erected pole.
- I recommend continuous utility pole inspection every after a period of four to five years to ensure the condition of the utility poles in service is known which can help in decision making of either maintaining the existing poles or replacing them with new ones or left at the status quo.
- Pole treatment agencies should test utility poles for age before usage by conducting laboratory tests of the utilities. This can be done by wood scientists through counting the growth rings and

this will help in ensuring that mature wood utility poles are used to minimize utility failure due to usage of immature wood utility pole.

- I recommend application of fire-retardant chemicals to the utility poles in the pastoral areas to make them fire resistant should be carried out.
- The electricity distribution agencies need to use fiber- reinforced polymer (FRP) sleeve to reinforce wood poles subjected to decay to restore their lost strength and extend their useful service life. FRP are strands of carbon-fiber reinforcement arranged in parallel and cast into an epoxy coating and applied to the exterior of structural elements (Merschman Eric *et al,* 2020). Carbon-fiber has exceptional tensile capacity, so the application of FRP to the extreme tension fiber of a structural cross- section can increase the bending capacity of the structural element (Grace *et al*., 1999). The ease of application of FRP makes it an ideal solution to reinforce existing utility poles and repairs using FRP can be carried out by simply excavating around the pole and wrapping it with the FRP.
- I recommend the electricity distribution agencies to Use Vapam fumigant in wood poles at the time of ground line bore test inspection and as a supplemental ground line treatment to arrest and prevent internal wood decay and to destroy insects such as termites' carpenter ants and golden buprestids.
- I recommend intensified rural electrification in Butambala district such that many people get added on to the electricity grid as away lighting of house and promoting development of the trade and other development programs that require availability of electric power to run.
- I recommend further research on an electronic system that can be used to send feedback to those concerned whenever a certain utility pole within an area fall.

5.6. Challenges faced during the survey

a. Moving long distances
b. Language barrier.
c. Unpredicted weather changes.
d. Resistance from the local people to reach some of the areas.
e. Remoteness of some installed poles.
f. Inaccessibility of some installed poles due to some barriers like thick bush/swamps.
g. Limited financial resources.

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APPENDICES

QUESTIONAIRRE INTERVIEW

ASSESSMENT OF PREMATURE WOOD UTILITY POLE FAILURE IN BUTAMABALA DISTRICT, UGANDA.

DEAR RESPONDENT,

I am carrying out a research survey on premature wood utility pole failure in Butambala district with the purpose of writing a dissertation as a requirement for the award of a bachelor's degree of science in forestry.

At the end of this study a report will be compiled and a copy of it will be submitted to the district, I therefore request for your tremendous effort in this work.

SECTION A: BACK GROUND INFORMATION

1. QUESTIONNAIRE NO…………….
2. Name of enumerator ………...
3. Respondent name………….
4. Parish…………………..
5. Village……………….
6. Date of interview,,,,,,,,,,,,,,,,,
7. Telephone number………….
8. Gender [please tick]

- ☐ Male
- ☐ Female
- ☐ **SECTION B: EDUCATION BACKGROUND [please tick]**

- ☐ Primary level
- ☐ Secondary level
- ☐ Tertiary level
- ☐ None

SECTION C: SURVEY ON THE NUMBER OF POLES FAILING PER FOR LAST FIVE YEARS. [Circle the best alternative].

1. Do wood utility poles in your village fail while in service?
   A. Yes
   B. No
   C. Sometimes
   D. Do not know
2. What is the minimum service life of installed poles in Butambala district?
   A. 5 years
   B. 10 years
   C. 20 years
   D. 35 years and above
3. How many wood utility poles are in service in Butambala district?
   A. 100-500
   B. 500-1000
   C. Others specify please…………
   D. Do not know
4. How long does it take for wood utility poles to deteriorate after being installed in your village?
   A. 1-5 years
   B. 5-10 years
   C. 10-20 years
   D. 30 years and above
5. Are the newly installed wood utility poles as a result of replacement of failed ones or addition of new house holds on electricity distribution grid?
   A. As a result of replacement of failed ones
   B. As a result of addition of new households on grid
   C. No new installed poles
   D. Both A and B
6. How many new wood utility poles are installed per year in Butambala?

A. 1500-1000
B. 1000-5000
C. 100-500
D. 1-100
E. None of the above

7. Of the wood utility poles in service how many have been failing for the past five years?
   A. 1 pole
   B. 20-100
   C. Others (please specify) ……………
   D. Do not know
8. Out of those poles which fail how many are maintained in your village?
   A. All
   B. 10-20%
   C. 20-40%
   D. none
9. Out of those poles which fail how many are replaced in your village?
   A. 1-10
   B. 15-30
   C. 35-45
   D. None
   E. Others specify………….
10. According to your observation, which pole size often prematurely fail while in service?

    9m

    10m

    12m

    14m

SECTION D: SURVEY ON CAUSES OF PREMATURE WOOD UTILITY POLE FAILURE

Indicate whether the statement below is true or false [please circle the best alternative]

1. In my village wood utility poles deteriorate as a result of termite attack
   a) True
   b) False
2. In my village most of the wood utility poles fail as a result of decay/ rotting
   a) True
   b) False
3. Wood utility poles deteriorate as a result of bacterial attack
   a) True
   b) False

4. In Butambala district wood utility poles fail as a result of being knocked down by speeding vehicles along the main road
   a) True
   b) False
5. Mostly wood utility poles fail as a result of aging
   a) True
   b) False
6. The splitting and cracking of wood utility poles in service is common in my village
   a) True
   b) False
7. Strong wind and heavy rains also cause the wood utility poles to fail through falling and breaking
   a) True
   b) False
8. Wood pecker birds cause wood utility pole deterioration
   a) True
   b) False

9. Wood utility poles fail as a result of water moisture absorption
    a) True
    b) False
10. Human activities like agriculture, bush burning induce pole failure
    a) True
    b) False
11. Poles installed in low land/ water logged areas deteriorate more frequently compared to those in high land areas
    a) True
    b) false
12. Wood utility poles deteriorate in their early stages of installation
    a) True
    b) False

SECTION E: WOOD UTILITY POLE FAILURE IN REGARD TO CHEMICAL PRESERVATIVE USED. [By circling Indicate whether you are agree or disagree with the statement].

PART 1

13. In Butambala there are both CCA and creosote treated poles in service
    a) Agree
    b) Disagree
14. Among the wood utility poles in Butambala, CCA treated poles are prune to deterioration
    a) Agree
    b) Disagree
15. Among the wood utility poles in Butambala Creosote treated poles often fail
    a) Agree

b) Disagree

16. Deterioration/ failure does not occur to both creosote and CCA treated poles at all

    a) Agree

    b) Disagree

17. CCA treated poles of 9 and 12 m are more resistant to deterioration than corresponding pole sizes which are treated with creosote

    a) Agree

    b) Disagree

18. Depending on the soils of Butambala creosote treated poles are more resistant to decay than CCA treated poles

    a) Agree
    b) Disagree

PART TWO: [Circle the best alternative]

I. Which treated poles installed in Butambala district are dominating the region?

   a. CCA treated

   b. Creosote treated

   c. There are both CCA and creosote treated poles

   d. Do not know

II. What is the average number of creosote treated poles that fail per year?

   a. 50/100

   b. 20/100

   c. 30/100

   d. 75/100

III. What is the proportion of CCA treated poles which fail per year?

a. 20%
b. 50%
c. 80%
d. None

IV. What is the proportion of creosote treated poles that deteriorate per year?

a. 20%
b. 50%
c. 80%
d. None

SECTION F: SOLUTIONS TO THE PREMATURE FAILURE

1. What do you think should be done to minimize premature wood utility poles from deteriorating/failing?

   A. regular pole inspection

   B. maintenance of poles which shows signs of deterioration

   C. replacement failed poles with new ones

   D. all the above

2. What efforts have been put in place to ensure wood utility pole failure is minimized? Fill the answers in the table below

By local people	By the district electricity department	By the electricity distribution agencies